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Обработка металлов давлением

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МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ УКРАИНЫ
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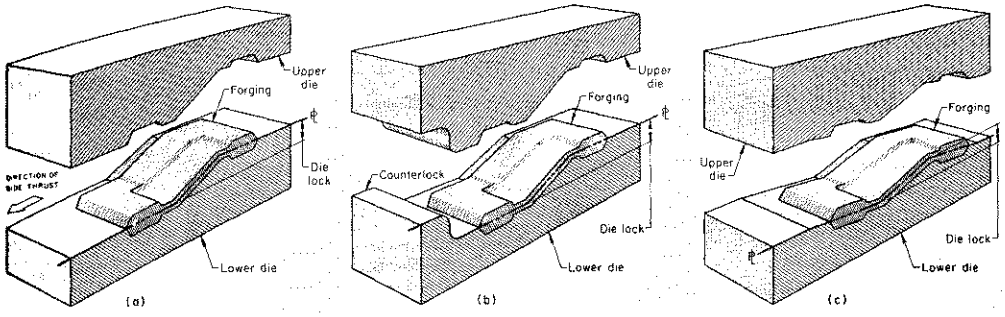
Толковый англо-русский словарь терминов и словосочетаний



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Даны английские определения основных терминов и словосочетаний, применяемых в обработке металлов давлением, теории пластичности и технологии самолето- и вертолетостроения, а также их перевод.

Для студентов, изучающих дисциплины, связанные с самолето- и вертолетостроением, производством летательных аппаратов, а также с системами автоматизированного проектирования.

Библиогр.: 7 назв.

English definition of the main terms and set expressions from original literature on metal working and theory of plasticity are given in this textbook. In addition the Russian translation and equivalent of the terms are given.

For those students who deal with study of the aircraft manufacturing discipline and CAD/CAM/CAE systems.

Библиогр.: 7 назв.

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1. **After-effect.** A particular case of creep when a growth of irrecoverable strains occur under a constant stress.
2. **Age hardening** (**aging**). (1) The latter part of a two-step heat-treating operation applied to certain alloys for strengthening and hardening (see also Solution heat treatment). Aging involves heating to a relatively low temperature for a specified period of time, and results in controlled precipitation of the constituent dissolved during the solution heating treatment. (2) The change in the properties of a metal that occurs at relatively low temperature following a final heat treatment or a final cold working operation; aging tends to restore equilibrium in the metal and eliminate any unstable condition induced by a prior operation.
3. **Air bend die.** Angle-forming dies in which the metal is formed without striking the bottom of the die. Metal contact is made at only three points in the cross section the nose of the male die and the two edges of a V-shaped die opening.
4. **Aircraft quality.** Denotes stock of sufficient quality to be forged into highly stressed parts for aircraft or other critical applications. Such materials are of extremely high quality, requiring closely controlled, restrictive practices in their manufacture in order that they may pass rigid requirements, such as magnetic particle inspection. Stock and forgings for aircraft and other critical applications produced under closely controlled melting and fabricating practices to minimize nonmetallic inclusions, segregation, and surface and internal flaws.
5. **Air-lift hammer.** A type of gravity drop hammer where the ram is raised for each stroke by an air cylinder. Because length of stroke can be controlled, ram velocity and thus energy delivered to the workpiece can be varied. See also drop hammer and gravity hammer.
6. **Alligatoring**. A complex defect (multiple fractures) in rolled plates and sheet caused by nonuniform deformation or by the presence of defects in the original cast ingot.
7. **Alloy.** A material having metallic properties and composed of two or more chemical elements of which at least one is a metal. In practice, the word is commonly used to denote relatively high-alloy grades of material, for example, "alloy" steels as differentiated from "carbon" steels. Materials are alloyed to enhance physical and mechanical properties such as strength, ductility, and hardenability.
8. **Angle of bite**. In the rolling of metals, the location where all of the force is transmitted through the rolls; the maximum attainable angle between the roll radius at the first contact and the line of roll centers. Operating angles less than the angle of bite are termed contact angles or rolling angles.
9. **Angularity.** The conformity to, or deviation from, specified angular dimensions in the cross section of a shape or bar.
10. **Annealing, full.** A heat-treating operation wherein metal is heated

to a temperature above its critical range, held at that temperature long enough to allow full recrystallization, then slowly cooled through the critical range. Annealing removes working strains, reduces hardness and strength of a metal, improves formability, or develops a desired microstructure, and increases ductility. Machinability may be improved or degraded, depending on the material involved.

11. **Anvil (base).** Extremely large, heavy block of metal that supports the entire structure of conventional gravity- or steam-driven forging hammers. It holds the stationary die of a forging hammer. Also, the block of metal on which hand (or smith) forgings are made.
12. **Anvil cap** (**sow block).** A block of hardened, heat-treated steel placed between the anvil of the hammer and the forging die to prevent undue wear to the anvil.
13. **Approach angle**. Zone of the drawing die between the entering angle and the land.
14. **Austenite.** A solid solution of iron and one or more alloying elements that is characterized by a face-centered cubic crystal structure. In the common engineering steels, the high-temperature austenite phase transforms into pearlite, bainite, or martensite, depending on the cooling rate. Certain grades of stainless steel are austenitic at room temperature by virtue of alloying and heat treatment.
15. **Automatic press stop**. A machine-generated signal for stopping the action of a press, usually after a complete cycle, by disengaging the clutch mechanism and engaging the brake mechanism.
16. **Automatic press.** A press with built-in electrical and pneumatic control in which the work is fed mechanically through the press in synchronism with the press action.
17. **Auxiliary operations.** Additional processing steps performed on forgings to obtain properties, such as surface conditions or shapes, not obtained in the regular processing operation.
18. **Axial rolls.** In ring rolling, vertically displaceable, tapered rolls, mounted in a horizontally displaceable frame opposite from but on the same centerline as the main roll and rolling mandrel. The axial rolls control the ring height during the rolling process.
19. **Back relief angle**. Outlet zone of the drawing die.
20. **Back stress**. Stress developed due to prior loading or Bauschinger effect.
21. **Backing arm.** A device for supporting the ring rolling mill mandrel from above during the roll process.
22. **Backup rolls**. Rolls which idle against and support the work rolls.
23. **Backward extrusion.** Forcing metal to flow in a direction opposite to the motion of a punch or die. Same as indirect extrusion. See extrusion.
24. **Bamboo defect.** Extrusion defect caused by periodic sticking of the extruded product along the die land. It causes rapid pressure in-

creasing and its releasing afterwards. The cycle is then repeated continuously, producing periodic circumferential cracks on the surface.

25. **Banded structure.** A chemically segregated or aligned structure that parallels the direction of metalworking.
26. **Bar (1) A** section hot rolled from a billet to a form**,** such as round, hexagonal, octagonal, square, or rectangular, with sharp or rounded corners or edges and a cross-sectional area of less than 105 cm^2 (16 $in.^2$). (2) A solid section that is long in relationship to its cross-sectional dimensions, having a completely symmetrical cross section and a width or greatest distance between parallel faces of 9.5 mm (3\5 in.) or more.
27. **Bar end.** See End loss.
28. **Bar folder**. The device for bending.
29. **Barreling (pancaking).** Convexity of the surfaces of cylindrical or conical bodies, often produced unintentionally during upsetting or as a natural consequence during compression testing. Barreling is caused by frictional forces at the die-workpiece interfaces and rapid cooling of the material near the interfaces that oppose the outward flow of the materials at these interfaces and may be minimized if a lubricant is used. See also compression test.
30. **Barrier effect**. A blockage of the slip bands by the grain boundaries or the pile-up of dislocations against a grain boundary.
31. **Base.** See Anvil.
32. **Batch furnace.** A furnace for heating materials where all loading and unloading is done through a single door or slot.
33. **Bauschinger (reverse loading) effect**. Phenomena when the total strain are not the sum of that in tension and compression for a complete reversal of strain path due to the development of the so called 'back stress'.
34. **Bead.** A narrow ridge in a sheet metal work-piece or part, commonly formed for reinforcement.
35. **Beaded flange.** A flange reinforced by a low ridge, used mostly around a hole.
36. **Beading.** Bending operation when the edge of the sheet metal is bent into the cavity of a die. The bead gives stiffness and eliminates sharp edges.
37. **Bed.** (1) Stationary platen of a press to which the lower die assembly is attached. (2) Stationary part of the shear frame that supports the material being sheared and the fixed blade.
38. **Bell (die bell)**. Entry zone of the drawing die. It may be angle or radius.
39. **Bend angle.** The angle through which a bending operation is performed, that is, the supplementary angle to that formed by the two bend tangent lines or planes.

40. **Bend or twist (defect).** Distortion similar to warpage, but resulting from different causes; generally caused in the forging or trimming operations. When the distortion is along the length of the part, it is called "bend"; when across the width, it is called "twist." Low-draft and no-draft forgings are more susceptible to bending, as they must be removed from the dies by some form of mechanical ejection. Dull trimming tools and improper nesting will cause bending in the trimming operation. When bend or twist exceeds tolerances, it is considered a defect. Corrective action entails either hand straightening, machine straightening, or cold restriking.
41. **Bend radius.** The inside radius of a bent section.
42. **Bend.** Operation to preform (bend) stock to approximate shape of die impression for subsequent forging; also includes final forming.
43. **Bender.** (1) Bends stock in the required directions for preliminary forging to approximate the ultimate shape; the die portion forming the longitudinal axis in one or more planes. (2) A die impression, tool, or mechanical device designed to bend forging stock to conform to the general configuration of die impressions subsequently to be used.
44. **Bending brake or press brake.** A form of open-frame single-action press that is comparatively wide between the housings, with a bed designed for holding long, narrow forming edges or dies. Used for bending and forming strip, plate, and sheet (into boxes, panels, roof decks, and so on).
45. **Bending dies**. Dies used in presses for bending sheet metal or wire parts into various shapes. The work is done by the punch pushing the stock into cavities or depressions of similar shape in the die or by auxiliary attachments operated by the descending punch.
46. **Bending rolls.** Various types of machinery equipped with two or more rolls to form curved sheet and sections.
47. **Bending stress**. A stress involving tensile and compressive forces, which are not uniformly distributed. Its maximum value depends on the amount of flexure that a given application can accommodate. Resistance to bending can be termed stiffness.
48. **Bending.** A preliminary forging operation to change the axis of the workpiece and to give the piece approximately the correct shape for subsequent forming. The straining of material, usually flat sheet or strip metal, by moving it around a straight axis lying in the neutral plane. Metal flow takes place within the plastic range of the metal, so that the bent part retains permanent set after removal of the applied stress. The cross section of the bend inward from the neutral plane is in compression; the rest of the bend is in tension. See also bending stress.
49. **Billet.** (1) A semifinished section hot rolled from a metal ingot, with a rectangular cross section usually ranging from 105 to 230 cm^2 (16 to 36 $in.^2$), the width being less than twice the thickness. Where the

cross section exceeds 36 $in.^2$, the term "bloom" is properly but not universally used. Sizes smaller than 105 cm^2 (16 $in.^2$) are usually termed "bars"; a solid semifinished round or square product which has been hot worked by forging, rolling, or extrusion. (2) A semifinished, cogged, hot-rolled, or continuous-cast round or square metal product of uniform section, usually rectangular with radiused corners. Billets are relatively larger than bars.

50. **Blank.** (1) In forming, a piece of sheet material, produced in cutting dies, that is usually subjected to further press operations. (2) A piece of stock from which a forging is made; often called a slug or multiple.
51. **Blankholder.** The part of a drawing or forming die that restrains the movement of the workpiece to avoid wrinkling or tearing of the metal.
52. **Blanking.** (1) The operation of punching, cutting, or shearing a piece out of stock to a predetermined shape. (2) Sheet metal operations for producing blanks whereby a shear cutting operation produces a workpiece or part of a complete or enclosed contour with a single stroke of the press for further use or processing
53. **Blast cleaning (blasting).** A process for cleaning or finishing metal objects by use of an air jet or centrifugal wheel that propels abrasive particles (grit, sand, or shot) against the surfaces of the work-piece at high velocity.
54. **Blister.** A raised spot on the surface of the metal caused by expansion of gas in a subsurface zone during thermal treatment.
55. **Block and finish.** A preliminary forging operation in which the part to be forged is blocked and finished in one heat through the use of a die having both a block impression and a finish impression in the same die. This also covers the case where two tools mounted in the same machine are used, as in the case of aircraft pistons. Only one heat is involved for both operations.
56. **Block, first and second.** The forging operation in which the part to be forged is passed in progressive order through three tools mounted in one forging machine. Blocking operation performed in a die having two blocking cavities in the same die; the part being forged is successively blocked in each impression all in one heat. As many as three blocker dies are sometimes needed for some forgings and up to three operations are sometimes required in each die.
57. **Block (blocking).** A preliminary forging operation that roughly distributes metal preparatory for finish. In this operation metal is progressively formed to general desired shape and contour by means of an impression die (used when only one block operation is scheduled). This forging operation often used to impart an intermediate shape to a forging, preparatory to forging of the final shape in the finishing impression of the dies so blocking is a forging operation produces the major change in shape. Blocking can ensure proper "working" of the material and contribute to greater die life.

58. **Blocker (blocking impression).** The impression in the die (often one of a series of die impressions) that imparts the general, approximate shape to the part preparatory to forging to the final shape in the finisher dies. Such operation omits any details that might restrict the metal flow, corners are well rounded. The primary purpose of the blocker is to enable the forming of shapes too complex to be finished after the preliminary operations; it also reduces die wear in the finishing impression.
59. **Blocker dies.** A die used for preliminary forming of a die forging. Such dies having generous contours, large radii, draft angles of 7° or more, and liberal finish allowances. See also finish allowance.
60. **Bloom.** A semifinished hot-rolled product, rectangular in cross section, produced on a blooming mill. See also billet. For steel, the width of a bloom is not more than twice the thickness, and the cross-sectional area is usually not less than about 230 cm^2 (36 $in.^2$). Steel blooms are sometimes made by forging.
61. **Blooming mill.** A primary rolling mill used to make blooms.
62. **Blow.** The impact or force delivered by one work stroke of the forging equipment.
63. **Board hammer.** A gravity drop hammer where the ram is raised by attached wood boards. The boards are driven upward by action of contra-rotating rolls, then released. Energy for forging is obtained by the mass and velocity of the freely falling ram and the attached upper die.
64. **Bolster plate.** A plate to which dies can be fastened; the assembly is secured to the top surface of a press bed. In press forging, such a plate may also be attached to the ram.
65. **Boss.** A relatively short protrusion or projection on the surface of a forging, often cylindrical in shape.
66. **Bottom Dead Center (BDC).** The location at which the machine has the maximum stroke.
67. **Bottom draft.** Slope or taper in the bottom of a forge depression that tends to assist metal flow toward the sides of depressed areas.
68. **Bottoming bending (bottoming, setting).** Press-brake bending process in which the upper die (punch) enters the lower die and coins or sets the material to eliminate springback.
69. **Boundary lubricants**. Lubricants which under certain conditions may be worn away.
70. **Bow.** (1) The tendency of material to curl downward during shearing, particularly when shearing long narrow strips. (2) Longitudinal curvature
71. **Box annealing.** A heat-treating process whereby metal to be annealed is packed in a closed container to protect its surfaces from oxidation. Sometimes used to describe the process of placing forgings in a closed container immediately after forging operations are

completed, permitting forgings to cool slowly.

72. **Bravais space lattices**. Part of a lattice where each point has identical surroundings when it has the same number of nearest neighbors that have the same spacing and the same angular relationship as any other point in the lattice.
73. **Breakdown (breaking down).** (1) An initial rolling or drawing operation, or a series of such operations, for reducing an ingot or extruded shape to desired size before the finish reduction. (2) A preliminary press-forging operation to changing the microstructure of the workpiece from a cast to a wrought structure when the ingot, which may be square in cross section, rests lengthwise on a flat die and is reduced in diameter a little at a time. The workpiece is rotated intermittently after each step of deformation. Ring-shaped parts are reduced in thickness in this manner with the use of an internal mandrel.
74. **Bridge dies**. Special dies for extrusion of intricate hollow shapes. in which metal divides and flows around the supports for the internal mandrel into strands. These strands are then rewelded under the high pressures in the welding chamber before exiting through the die.
75. **Brinell hardness testing.** Method of determining the hardness of materials; involves impressing a hardened ball of specified diameter into the material surface at a known pressure (10-mm ball, 500-kg load for aluminum alloys). The Brinell hardness number results from calculations involving the load and the spherical area of the ball impression. Direct-reading testing machines designed for rapid testing are generally used for routine inspection of forgings, and as a heat treat control function.
76. **Brittleness**. The ability of a material to fracture without any appreciable permanent deformation.
77. **Broken surface.** Surface fracturing, generally most pronounced at sharp corners.
78. **Buckling ratio**. The ratio of the flange overhang to the material thickness for deep drawing.
79. **Buckling.** A bulge, bend, kink, or other wavy condition of the workpiece caused by compressive stresses. See also compressive stress.
80. **Bulge Correction Factor Method**. Method when the flow stress of the material is determined by the analysis of the stress distribution of the midsection of the cylindrical specimen undergoing compression between parallel platens.
81. **Bulging.** The process of increasing the diameter of a cylindrical shell (usually to a spherical shape) or of expanding the outer walls of any shell or box shape whose walls were previously straight.
82. **Bulk forming.** Forming processes, such as extrusion, forging, rolling, and drawing, in which the input material is in billet, rod, or slab form and a considerable increase in surface-to-volume ratio in the formed part occurs under the action of largely compressive loading.

In bulk forming a significant change in the thickness of the workpiece usually occurs as compared to a sheetmetal process.

83. **Bull block.** A machine with a power-driven revolving drum for cold drawing wire through a drawing die as the wire winds around the drum.
84. **Bull-block drawbenches.** The equipment for drawing which employed in cases when the material being drawn and the product obtained can be wound on reels (wire, etc.). The process of drawing the work through the die is powered by an electric motor which drives the drawing block on which the wire or other similar product is wound up. Bull-block machines may be either of the single- or multiple-die type; their application being determined by the required number of passes.
85. **Bulldozer.** Slow-acting horizontal mechanical press with a large bed used for bending and straightening. The work is done between dies and can be performed hot or cold. The machine is closely allied to a forging machine.
86. **Burgers vector**. Vector showing the direction and amount of distortion caused dislocation in crystal structure.
87. **Burnt.** Permanently damaged metal caused by heating conditions that produce incipient melting or intergranular oxidation.
88. **Burr.** A thin ridge or roughness left on forgings by cutting operation such as slitting, shearing, trimming, blanking, or sawing.
89. **Buster (preblocking impression).** A type of die impression or a pair of shaped dies sometimes used to combine preliminary forging operations such as edging and fullering with the blocking operation to eliminate blows.
90. **Butt end**. A small portion of the end of the extruded billet which remains in the chamber after the extrusion has been completed and which is removed by cutting off the extrusion at the die exit. This the consequence of the presence of a die angle.
91. **Calculus of variations**. The mathematical procedure used to select the correct solution from a number of tentative solutions.
92. **Cam plastomeler.** A special compression testing machine for compressing the specimen at a constant true strain rate to a strain limit.
93. **Cam press.** A mechanical press in which one or more of the slides are operated by cams; usually a double-action press in which the blankholder slide is operated by cams through which the dwell is obtained.
94. **Camber**. (1) The tendency of material being sheared from sheet to bend away from the sheet in the same plane. (2) Roll deflection, when the diameter of the rolls is slightly larger than at their edges.
95. **Canning.** (1) A dished distortion in a flat or nearly flat sheet metal surface, sometimes referred to as oil canning. (2) Enclosing a highly reactive metal within a relatively inert material for the purpose of hot working without undue oxidation of the active metal.

96. **Capstan**. Draw block.
97. **Carbon steel.** Steel that derives its properties mainly from the addition of carbon, without substantial amounts of other alloying elements.
98. **Carbonitriding.** A process of case hardening a ferrous material in a gaseous atmosphere containing both carbon and nitrogen.
99. **Carburizing (carburization).** Adding carbon to the surface of low-carbon steel by heating the metal below its melting point (usually 1600 to 1800 °F) while in contact with carbonaceous solids, liquids, or gases.
100. **Caring.** The formation of ears or scalloped edges around the top of a drawn shell, resulting from directional differences in the plastic-working properties of rolled metal with, across, and at angles to the direction of rolling.
101. **Case hardening.** A heat treatment or combination of processes in which the surface layer of a ferrous alloy is made substantially harder than the interior or "core." Carburizing, cyaniding, nitriding, carbonitriding and heating and quenching techniques (induction and flame hardening) are commonly used. Case hardening can provide a hard, wear-resistant surface on a forging, while retaining a softer, tougher core.
102. **Case.** The surface layer of an alloy that has been made substantially harder than the interior by some form of hardening operation.
103. **Cast.** See Die proof
104. **Cavity, die.** The machined recess in a die that gives the forging its shape.
105. **Centering arms**. In ring rolling, externally mounted rolls, adjusted to the outside diameter of the ring during rolling. The rolls maintain and guide the ring in a centerline position to achieve roundness.
106. **Ceramic fiber.** A lightweight, soft fiber available in blanket and other forms in various temperature grades up to 3000 °F for insulating furnaces, producing quick heating due to low thermal conductivity.
107. **Chamfer.** (1) A beveled surface to eliminate an otherwise sharp corner. (2) A relieved angular cutting edge at a tooth corner. (3) Break or remove sharp edges or corners of forging stock by means of straight angle tool or grinding wheel.
108. **Channel forming**. Bending operation in a press brake when a flat sheet metal plate is bent across three or more straight line so depressing is obtained.
109. **Charpy test.** A pendulum-type impact test where the specimen is supported as a simple beam and is notched opposite the point of impact. The energy required to break the beam is used as an index of impact strength measurement.
110. **Chattering.** The process for which a body oscillates between two

equilibrium states. This often occurs when a body separates and then recontacts a body.

111. **Check.** (1) A crack in a die impression corner, generally due to forging strains or pressure, localized at some relatively sharp corner. Die blocks too hard for the depth of the die impression have a tendency to check or develop cracks in impression corners. (2) One of a series of small cracks resulting from thermal fatigue of hot forging dies.

112. **Chevron cracking (center cracking, center-burst, cupping or arrowhead fracture**). A defect when the center of the extruded product develops cracks which are attributed to a state of hydrostatic tensile stress at the centerline in the deformation zone in the die an which increase with increasing die angle and amount of impurities and decrease with increasing extrusion ratio and friction.

113. **Chip-mill.** An intermediate inspection and repair operation in which surface defects in forgings are located and removed by means of chipping hammers, rotor mills, and similar tools (not to be confused with final inspection, where similar operations are performed).

114. **Chipping.** A method for removing seams and other surface defects with a chisel or gouge, so that the defects will not be worked into the finished product.

115. **Chisel.** Forging tool used to cut metal by notching. Cold chisels are used to notch cold metal so that it can be broken by a hammer blow; hot chisels are often used to make a complete cut in hot metal.

116. **Chop.** A die forging defect; metal sheared from a vertical surface and spread by the die over an adjoining horizontal surface.

117. **Chord modulus.** The slope of the chord drawn between any two specific points on a stress-strain curve. See also modulus of elasticity.

118. **Chucking lug.** A lug or boss to the forging so that "on center" machining and forming can be performed with one setting or chucking; this lug is machined or cut away on the finished item.

119. **Circle grid.** A regular pattern of circles, often 2.5 mm (0.1 in.) in diameter, marked on a sheet metal blank.

120. **Circle-grid analysis.** The analysis of deformed circles to determine the severity with which a sheet metal blank has been deformed.

121. **Circumscribing-circle diameter (CCD).** A parameter describing the shape of the extruded product which is the diameter of the circle into which the extruded cross-section will fit.

122. **Cladding (coaxial extrusion)**. An extrusion operation when the coaxial billets are extruded together when the strength and ductility of the two metals are compatible.

123. **Cleaning.** The process of removing scale, oxides, or lubricant— acquired during heating for forging or heat treating— from the surface of the forging. See also Blasting, Pickling, Tumbling.

124. **Closed dies.** Forging or forming impression dies designed to re-

strict the flow of metal to the cavity within the die set, as opposed to open dies, in which there is little or no restriction to lateral flow.

125. **Closed pass.** A pass of metal through rolls where the bottom roll has a groove deeper than the bar being rolled and the top roll has a collar fitting into the groove, thus producing the desired shape free from flash or fin.

126. **Closed-die forging** (**impression die forging**). The shaping of hot metal completely within the walls or cavities of two dies that come together to enclose the workpiece on all sides. The impression for the forging can be entirely in either die or divided between the top and bottom dies. Impression-die forging, often used interchangeably with the term closed-die forging, refers to a closed-die operation in which the dies contain a provision for controlling the flow of excess material, or flash, that is generated. By contrast, in flashless forging, the material is deformed in a cavity that allows little or no escape of excess material.

127. **Close-tolerance forging.** A forging held to unusually close dimensional tolerances. Often little or no machining is required after forging. See also precision forging.

128. **Closure, die.** A term frequently used to mean variations in thickness of a forging.

129. **Cluster (Sendzimir) mills.** A rolling mill in which each of two small-diameter work rolls is supported by two or more backup rolls. Based on the principle that small-diameter rolls lower roll forces and power requirements and reduce spreading. It is suitable for cold rolling thin strips of high-strength metals.

130. **Cockroft-Latham.** A material damage model used to predict failure.

131. **Coefficient of elongation**. Parameter of dimensional changes during cogging which is equal to ratio of the length elongation to the thickness reduction.

132. **Coefficient of spread**. Parameter of dimensional changes during cogging which is equal to ratio of the width elongation to the thickness reduction.

133. **Coefficients of anisotropy.** Constants, which characterize the current state of anisotropy.

134. **Cogging.** The systematic reducing forging operation for working the ingot into a billet by the use of a forging hammer or a forging press. See also drawing out.

135. **Coin sizing.** A cold squeezing operation for refining face distance dimensions on forgings.

136. **Coin straighten,** a combination coining and straightening operation performed in special cavity dies so designed as to also impart a specific amount of working in specified areas of the forging to relieve stresses developed during heat treatment.

137. **Coining dies.** Dies in which the coining or sizing operation is performed.

138. **Coining.** (1) A closed-die squeezing operation in which all or some portion of the surfaces of a workpiece are confined or restrained, to obtain closer tolerances or smoother surfaces or to eliminate draft or resulting in a well-defined imprint of the die on the work. (2) A restriking operation used to sharpen or change an existing radius or profile. Coining can be done while forgings are hot or cold and is usually performed on surfaces parallel to the parting line of the forging.

139. **Cold coined forging.** A forging that has been restruck cold in order to hold closer face distance tolerances, sharpen corners or outlines, reduce section thickness, flatten some particular surface, or, in non-heat-treatable alloys, increase hardness.

140. **Cold forming.** See cold working.

141. **Cold heading.** Working metal at room temperature such that the cross-sectional area of a portion or all of the stock is increased. See also heading and upsetting.

142. **Cold inspection.** A visual (usually final) inspection of the forgings for visible defects, dimensions, weight, and surface condition at room temperature. The term may also be used to describe certain nondestructive tests, such as magnetic particle, dye penetrant, and sonic inspection.

143. **Cold lap (shut).** (1) A folding back of metal onto its own surface during flow in the die cavity; a forging defect. Such flaw results when a workpiece fails to fill the die cavity during the first forging. A seam is formed as subsequent dies force metal over this gap to leave a seam on the workpiece surface. See also cold shut. (2) A fissure or lap on a forging surface that has been closed without fusion during the forging operation.

144. **Cold trimming.** Removing flash or excess metal from the forging in a trimming press when the forging is at room temperature.

145. **Cold working.** Permanent plastic deformation of a metal at a temperature below its recrystallization point—low enough to produce strain hardening. Usually, but not necessarily, conducted at room temperature. Also referred to as cold forming or cold forging. Contrast with hot working.

146. **Cold-rolled sheet.** A mill product produced from a hot-rolled pickled coil that has been given substantial cold reduction at room temperature. The usual end product is characterized by improved surface, greater uniformity in thickness, and improved mechanical properties as compared with hot-rolled sheet.

147. **Combination die.** See compound die.

148. **Coming dies.** Dies in which the coining or sizing operation is performed.

149. **Compact** (noun). The object produced by the compression of metal powder, generally while confined in a die.
150. **Compact** (verb). The operation or process of producing a compact; sometimes called pressing.
151. **Compatibility condition**. The condition that strains must satisfy in order to be compatible. It is expressed mathematically by the compatibility equations. Such condition impose restriction in the strain functions and that displacement components must be single-valued, continuous functions.
152. **Compound die**. Any die designed to perform more than one operation on a part with one stroke of the press, such as blanking and piercing, in which all functions are performed simultaneously within the confines of the blank size being worked.
153. **Compression bending**. Method of bending tubes
154. **Compression strength.** The maximum load per unit of cross-sectional area obtained, before plastic deformation or rupture, by compressing.
155. **Compression test.** A method for assessing the ability of a material to withstand compressive loads.
156. **Compressive strength**. The maximum compressive stress a material is capable of developing. With a brittle material that fails in compression by fracturing, the compressive strength has a definite value. In the case of ductile, malleable, or semi-viscous materials (which do not fail in compression by a shattering fracture), the value obtained for compressive strength is an arbitrary value dependent on the degree of distortion that is regarded as effective failure of the material.
157. **Compressive stress**. A stress that causes an elastic body to deform (shorten) in the direction of the applied load. Contrast with tensile stress.
158. **Concavity.** A concave condition applicable to the width of any flat surface.
159. **Concentricity.** Adherence to a common center.
160. **Constitutive equations**. Equations which relate stress to strain and to other variables of interest for different materials.
161. **Contact tolerance.** The distance at which two bodies are considered in contact.
162. **Contact.** The process by which a body interfaces with another body. A body should not penetrate another body.
163. **Continuous mill**. Mill in which the metal such as a continuous strip in either hot or cold rolling is under more than one stand at the same time.
164. **Continuum**. Material which has no voids such as shrinkage cavities or other discontinuities such as grain boundaries.
165. **Contour forming.** See roll forming, stretch ***J*** forming, tangent bending, and wiper forming.

166. **Conventional compression test.** Test when the specimen is compressed axially between two polished, well-lubricated parallel platens so a barreling is eliminated.
167. **Conventional flow limit (offset).** It is a stress corresponding to some fixed permanent deformations, such as 0.1 or 0.2% offset from the modulus slope. Conventional flow limit or offset used for materials that have no obvious yield point (if there isn't horizontal segment of a stress-strain curve). The distance along the strain coordinate between the initial portion of a stress-strain curve and a parallel line that intersects the stress-strain curve at a value of stress (commonly 0.2%) is used as a measure of the yield strength.
168. **Conventional forging design.** A forging characterized by design complexity and tolerances that fall within the broad range of general forging practice. These designs often require little or no machining, except where precision detail is required.
169. **Convergence checking.** The testing process to determine whether the solution is accurate. An iteration process is used to solve the nonlinear equations of motion. The convergence checking is based either on examining the residuals, displacements, strain energy, or temperatures.
170. **Converging flow process**. Corresponding to mass-increasing processes such as assembly or joining, e.g., welding.
171. **Core.** The softer interior portion of an alloy piece that has been surface (case) hardened; or, that portion of a forging removed by trepanning or punching.
172. **Coring.** (1) A central cavity at the butt end of a rod extrusion; sometimes called extrusion pipe. (2) A condition of variable composition between the center and surface of a unit of microstructure (such as a dendrite, grain, or carbide particle); results from nonequilibrium solidification, which occurs over a range of temperature.
173. **Corrugating.** (1) The forming of sheet metal into a series of straight, parallel alternate ridges and grooves with a rolling mill equipped with matched roller dies or a press brake equipped with specially shaped punch and die. (2) Transverse ripples caused by a variation in strip shape during hot or cold reduction (**Corrugations**).
174. **Coulomb Friction.** A friction model for the resisting shear friction that is proportional to the normal stress.
175. **Counterblow forging equipment.** A category of forging equipment in which two opposed rams are activated simultaneously, sinking repeated blows on the workpiece at a midway point. Action may be vertical, as in the case of counterblow forging hammers, or horizontal, as with an "impacter."
176. **Counterblow hammer.** A forging hammer in which both the ram and the anvil are driven simultaneously forward each other by air or steam pistons.

177. **Counterlock.** A jog in mating surfaces of dies to prevent lateral die shift caused by side thrust during forging of irregularly shaped pieces.
178. **Cowper-Symonds model.** A plasticity model where the yield surface size is scaled based upon the strain rate to a power.
179. **Crank length.** The length of the rod between the crack and the punch for a crank or eccentric press.
180. **Crank press.** A mechanical press whose slides (motion of the tool) are actuated by a crankshaft (by the rotation of a crank). The velocity of tool has a sinusoidal variation in time.
181. **Crank.** Forging shape generally in the form of a "U" with projections at more or less right angles to the upper terminals. Cranks shapes are designated by the number of throws (for example, two-throw crank).
182. **Creep.** Flow or plastic deformation of a metal subjected to long-term stresses below its normal yield strength.
183. **Crimping.** The forming of relatively small corrugations in order to set down and lock a seam, to create an arc in a strip of metal, or to reduce an existing arc or diameter. See also corrugating.
184. **Critical (temperature) range.** Temperatures at which changes in the phase of a metal take place. Changes are determined by absorption of heat when the metal is heated, and liberation of heat when it is cooled.
185. **Critical point.** The temperature in metal at which recrystallization or other phase transformation (allotropic transformation –changes in structure) takes place.
186. **Critical resolved shear stress (CRSS).** The shear stress required to produce slip on a crystal plane in a slip direction at an appreciable rate.
187. **Crop end.** See end loss.
188. **Cropping.** The cutting of the forging multiples (slugs or billets) for closed-die forging. See also shearing.
189. **Cross forging.** Preliminary working of forging stock in alternate planes, usually on flat dies, to develop mechanical properties, particularly in the center portions of heavy sections.
190. **Cross hatch.** Light broken surface; see also Broken surface.
191. **Cross, long.** Cross-shaped forging with two opposite arms longer than the other two. Abbreviation is "LC."
192. **Cross.** Forged shape of a general four-pointed star or cross; may have hole in center. If one arm is much longer, the shape is termed "Y." Abbreviation is "C."
193. **Crown.** (1) The upper part (head) of a press frame. On hydraulic presses, the crown usually contains the cylinder; on mechanical presses the crown contains the drive mechanism. See also hydraulic press and mechanical press. (2) A shape (crown) ground into a flat

roll to ensure flatness of cold (and hot) rolled sheet and strip. (3) Roll deflection, when the rolled strip tends to be thicker at its center than at its edges.

194. **Crystal structure**. Ordered, geometric arrangement of atoms.

195. **Crystallographic texture (preffered orientation or texture).** Alignment of certain preferred crystallographic directions and planes which occur during cold rolling when the grains of the metal rotate in a certain way so that certain crystal directions rotate parallel to the direction of rolling and certain planes rotate so as to be parallel to the surface of the sheet.

196. **Cup fracture (cup-and-cone fracture).** A mixed-mode fracture, often seen in tensile test specimens of a ductile material, in which the central portion undergoes plane-strain fracture and the surrounding region undergoes plane-stress fracture. One of the mating fracture surfaces looks like a miniature cup; it has a central depressed flat-face region surrounded by a shear lip. The other fracture surface looks like a miniature truncated cone.

197. **Cup.** (1) A sheet metal part; the product of the first drawing operation. (2) Any cylindrical part or shell closed at one end.

198. **Cupping test.** A mechanical test used to determine the ductility and stretching properties of sheet metal. It consists of measuring the maximum part depth that can be formed before fracture. The test is typically carried out by stretching the test piece clamped at its edges into a circular die using a punch with a hemispherical end. See also cup fracture, Erichsen test, and Olsen ductility test.

199. **Cupping.** (1) The first step in deep drawing. (2) Fracture of severely worked rods or wire in which one end looks like a cup and the other a cone.

200. **Cutoff.** (1) A pair of blades positioned in dies or equipment (or a section of the die milled to produce the same effect as inserted blades) used to separate the forging from the bar after forging operations are completed. (Used only when forgings are produced from relatively long bars instead of from individual, precut multiples or blanks.) (2) A sheet metal operations for producing blanks where the shear cutting action is along a line, which not necessarily straight as opposed to shearing.

201. **Cutters.** Cutters are used with power hammers, instead of chisels. They often have long, straight blades, but sometimes the blades are curved or in the shape of a 90° angle; blades are attached to handles of varying lengths.

202. **Cutting.** Cutting stock to specified length or weight on circular saws, band hacksaws, or shear presses.

203. **Cyaniding.** A process for surface hardening by absorption of carbon or nitrogen by an iron-base alloy brought about by heating to a suitable temperature in contact with a cyanide salt, followed by quenching.

204. **Daylight.** The maximum clear distance between the pressing surfaces of a press when the surfaces are in the usable open position. Where a bolster plate is supplied, it is considered the pressing surface. See also shut height.
205. **Dead-metal zone**. A nonmoving zone where the metal is essentially stationary.
206. **Decarburization.** The loss of carbon from the surface of steel by heating above lower critical temperature or by chemical action. Decarburization is usually present to a slight extent in steel forgings. Excessive decarburization can result in defective products.
207. **Decoupled.** A procedure to analyze deformable tools, where the tools are treated as rigid during the deformation of the workpiece, but then treated as deformable to determine the die stresses.
208. **Deep drawing.** Characterized by the production of a parallel-wall cup from a flat blank of sheet metal. The blank may be circular, rectangular, or a more complex shape. The blank is drawn into the die cavity by the action of a punch. Deformation is restricted to the flange areas of the blank. No deformation occurs under the bottom of the punch – the area of the blank that was originally within the die opening. As the punch forms the cup, the amount of material in the flange decreases. Also called cup drawing or radial drawing.
209. **Deflection.** The amount of deviation from a straight line or plane when a force is applied to a press member. Generally used to specify the allowable bending of the bed, slide, or frame at rated capacity with a load of predetermined distribution.
210. **Deformable tool.** The tool which is used to shape the workpiece. Deformation of the tool will occur, and the user will obtain the stress distribution in the tool. A deformable tool is composed of elements.
211. **Deformation limit.** In drawing, the limit of deformation is reached when the load required to deform the flange becomes greater than the load-carrying capacity of the cup wall. The deformation limit (limiting drawing ratio, ***LDR***) is defined as the ratio of the maximum blank diameter that can be drawn into a cup without failure, to the diameter of the punch.
212. **Deformation theory**. Theory in which the strain increment is replaced by the total strain and proportional loading is assumed.
213. **Deformed.** The geometry of the structure after the boundary conditions have been applied.
214. **Demarest process.** A fluid forming process in which cylindrical and conical sheet metal parts are formed by a modified rubber bulging punch. The punch, equipped with a hydraulic cell, is placed inside the workpiece, which in turn is placed inside the die. Hydraulic pressure expands the punch.
215. **Dendrites.** "Pine tree-shaped" crystals produced during freezing of an ingot.

216. **Descaling.** The process of removing oxide scale from heated stock prior to or during forging operations, using such means as extra blows, wire brushes, scraping devices, or water spray.
217. **Developed blank.** A sheet metal blank that yields a finished part without trimming or with the least amount of trimming.
218. **Die angle**. The angle of the tapered part of the die inlet for extrusion or wire drawing.
219. **Die assembly.** The parts of a die stamp or press that hold the die and locate it for the punches.
220. **Die block.** A block, often made of heat-treated steel, into which desired impressions are machined or sunk and from which closed-die forgings or sheet metal stampings are produced using hammers or presses. In forging, die blocks are usually used in pairs, with part of the impression in one of the blocks and the rest of the impression in the other. In sheet metal forming, the female die is used in conjunction with a male punch. See also closed-die forging.
221. **Die cavity.** The machined recess that gives a forging or stamping its shape.
222. **Die check.** A form of die wear, die check is a crack in a die impression due to forging and thermal strains at relatively sharp corners. Upon forging, these cracks become filled with metal, producing sharp ragged edges on the part. Usual die wear is the gradual enlarging of the die impression due to erosion of the die material, generally occurring in areas subject to repeated high pressures during forging.
223. **Die clearance.** Clearance between a mated punch and die; commonly expressed as clearance per side. Also called clearance or punch-to-die clearance.
224. **Die closure.** A term frequently used to mean variations in the thickness of a forging.
225. **Die cushion.** A press accessory placed beneath or within a bolster plate or die block to provide an additional motion or pressure for stamping or forging operations; actuated by air, oil, rubber, springs, or a combination of these.
226. **Die forging.** A forging that is formed to the required shape and size by working in machined impressions in specially prepared dies.
227. **Die forming.** The shaping of solid or powdered metal by forcing it into or through the die cavity.
228. **Die height.** The distance between the fixed and the moving platen when the dies are closed.
229. **Die holder.** A plate or block, on which the die block is mounted, having holes or slots for fastening to the bolster plate or the bed of the press.
230. **Die impression.** The portion of the die surface that shapes a forging or sheet metal part.

231. **Die insert.** A relatively small die that contains part or all of the impression of a forging or sheet metal part and is fastened to the master die block. The inserts can be made of stronger and harder materials and can be changed easily in case of wear or failure in a particular section of the die.
232. **Die land**. Constant cross-sectional die orifice or bearing surface which determines the cross-section of an extruded or drawn product.
233. **Die layout.** The transfer of the forging drawing or sketch dimensions to templates or die surfaces for use in sinking dies.
234. **Die life.** The productive life of a die impression, usually expressed as the number of units produced before the impression has worn beyond permitted tolerances.
235. **Die line.** A line or scratch resulting from the use of a roughened tool or the drag of a foreign particle between tool and product.
236. **Die lock.** For locked dies, a dimension expressing extreme variation in parting line level measured in a direction parallel to ram stroke.
237. **Die lubricant.** A compound sprayed, swabbed, or otherwise applied on die surfaces or forging during forging to reduce friction between the forging and the dies. Lubricants may also ease release of forgings from the dies and provide thermal insulation.
238. **Die match.** The alignment of the upper (moving) and lower (stationary) dies in a hammer or press. After having been set up in the forging equipment, where every point in one die half is within specified alignment with every point in the mating die half. An allowance for misalignment (or mismatch) is included in forging tolerances.
239. **Die number.** The number assigned to a die for identification and cataloging purposes, usually the same number that is assigned for the same purpose to the product made from that die.
240. **Die pad.** A movable plate or pad in a female die; usually used for part ejection by mechanical means, springs, or fluid cushions.
241. **Die proof (cast).** A casting of a die impression made to confirm the accuracy of the impression.
242. **Die radius.** The radius on the exposed edge of a deep-drawing die, over which the sheet flows in forming drawn shells.
243. **Die set**. (1) A die holder with built-in guides to ensure alignment of mating dies and tools during operation. The assembly of the upper and lower die shoes (punch and die holders), usually including the guide pins, guide pin bushings, and heel blocks. This assembly takes many forms, shapes, and sizes and is frequently purchased as a commercially available unit. (2) Two (or, for a mechanical upsetter, three) machined dies used together during the production of a die forging.
244. **Die shift.** Misalignment of the top and bottom dies in the plane of the parting line that can occur during forging. The condition occurring

after the dies have been set up in the forging unit, and in which a portion of the impression of one die is not in perfect alignment with the corresponding portion of the other die. This results in "mismatch" in the forging, a condition that must be held within the specified tolerance. This condition must be corrected to maintain forging tolerances.

245. **Die shoes**. The upper and lower plates or castings that constitute a die set (punch and die holder). Also a plate or block upon which a die holder is mounted, functioning primarily as a base for the complete die assembly. This plate or block is bolted or clamped to the bolster plate or the face of the press slide.

246. **Die sinking.** Machining the die impressions for producing forgings of required shapes and dimensions.

247. **Die space.** The maximum space (volume), or any part of the maximum space, within a press for mounting a die.

248. **Die stamping.** The general term for a sheet metal part that is formed, shaped, or cut by a die in a press in one or more operations.

249. **Die straighten.** A straightening operation performed in either a hammer or a press using flat or cavity dies to remove undesired deformation and bring the forging within the straightness tolerance.

250. **Die.** A tool, usually containing a cavity, that imparts shape to solid, molten, or powdered metal primarily because of the shape of the tool itself. Used in many press operations (including blanking, drawing, forging, and forming), in die casting, and in forming green powder metallurgy compacts. Die-casting and powder metallurgy dies are sometimes referred to as molds. See also forging dies.

251. **Die-closing swaging machines**. Forging machines in which die movements are obtained through the reciprocating motion of wedges. The dies can be opened wider than rotary swaggers, thus accommodating large-diameter or variable-diameter parts. In another type of machine the dies do not rotate bet move radially in and out.

252. **Dies, forging.** Forms for the making of forgings; generally consist of a top and bottom die. The simplest will form a completed forging in a single impression; the most complex, made up of several die inserts, may have a number of impressions for the progressive working of complicated shapes. Forging dies are usually in pairs, with part of the impression in one of the blocks and the balance of the impression in the other block.

253. **Dies, gripper.** Clamping or lateral dies used in a forging machine or mechanical upsetter.

254. **Diffused necking**. For which the reduction in cross-sectional area extends over an appreciable length of the specimen and is not affected appreciably by the adjacent elements of the specimen.

255. **Diffusion.** The movement of atoms within a material, usually from regions of high concentration to regions of low concentration, to achieve greater homogeneity of the material.

256. **Dimensional inhomogeneity factor (ratio).** A value which defines the severity of the inhomogeneity and which is equal to the ratio of original area of the inhomogeneity (neck) to the original area of the homogeneous specimen.
257. **Dimpling.** (1) The stretching of a relatively small, shallow indentation into sheet metal. (2) In aircraft, the stretching of metal into a conical flange for a countersunk head rivet.
258. **Direct (forward) extrusion.** See extrusion.
259. **Directional properties.** Mechanical properties that vary with the direction when a material or part is tested, resulting from structural fibering.
260. **Discontinuities.** Includes cracks, laps, folds, cold shuts, and flow-through, as well as internal defects such as inclusion, segregation, and porosity; internal discontinuities can be detected and evaluated using ultrasonic testing equipment.
261. **Discrete problems**. Problems which may be modeled by using a finite number of well-defined components or elements.
262. **Disk.** Blanks for gears, rings, or hubs are examples of this type of forging; parts may or may not have holes. Abbreviation is "D."
263. **Dislocation**. Defects which exist in all crystals.
264. **Distribute load.** An external force applied to the structure over either an edge, face, or the volume. Load is generally entered as a force per unit area or force per unit length.
265. **Diverging flow process**. Corresponding to mass-reduction processes such as metal cutting.
266. **DOF.** Degree of freedom.
267. **Double forging.** A forging designed to be cut apart and used as two separate pieces.
268. **Double-action mechanical press.** A press having two independent parallel movements by means of two slides, one moving within the other. The inner slide or plunger is usually operated by a crankshaft; the outer or blankholder slide, which dwells during the drawing operation, is usually operated by a toggle mechanism or by cams. See also slide.
269. **Dowel.** A metal insert placed between mating surfaces of the die shank and die holder in the forging equipment to ensure lengthwise die match.
270. **Draft angle.** The angle of taper, usually 5 to 7°, expressed in degrees, given to the sides of the forging and the side walls of the die impression. See also draft.
271. **Draft.** Taper on the sides of a forging (and the forging die impression) that is necessary for removal of the workpiece from the dies – commonly between 5 and 7°. Also, the corresponding taper on the sidewalls of the die impressions. In open-die forging, draft is the amount of relative movement of the dies toward each other through

the metal in one application of power. See also draft angle.

272. **Draftless forging.** A forging with zero draft on vertical walls.

273. **Draw bead.** An insert or riblike projection on the draw ring or hold-down surfaces that aids in controlling the rate of metal flow during deep draw operations. Draw beads are especially useful in controlling the rate of metal flow in irregularly-shaped stampings.

274. **Draw forming.** A method of curving bars, tubes, or rolled or extruded sections in which the stock is bent around a rotating form block. Stock is bent by clamping it to the form block, then rotating the form block while the stock is pressed between the form block and a pressure die held against the periphery of the form block.

275. **Draw marks.** See scoring, galling, pickup, and die line.

276. **Draw plate.** A circular plate with a hole in the center contoured to fit a forming punch; used to support the blank during the forming cycle.

277. **Draw radius.** The radius at the edge of a die or punch over which sheet metal is drawn.

278. **Draw ring.** A ring-shaped die part (either the die ring itself or a separate ring) over which the inner edge of sheet metal is drawn by the punch.

279. **Draw stock.** The forging operation in which the length of a metal mass (stock) is increased at the expense of its cross section; no "upset" is involved. The operation covers converting ingot to pressed bar using "V," round, or flat dies.

280. **Drawability.** A measure of the formability of a sheet metal subject to a drawing process. The term usually used to indicate the ability of a metal to be deep drawn. See also drawing and deep drawing.

281. **Drawbench (chain drawbench).** The equipment for drawing where the rod is drawn through the die with the aid of a motor whose rotary motion is converted by a system of gearing into straight-line motion of a chain and the pliers (drawing carriage). The pulling force is supplied by a chain drive or is activated hydraulically. The front end of the work, protruding from the die, is gripped by the jaws of the pliers and the work is drawn through the die so that it acquires the specified cross section.

282. **Drawing (tempering).** A heat-treating process where metal is reheated, after hardening or normalizing, to a temperature below the lower limit of the critical range, then cooled to secure desired properties – particularly toughness. Tool hardeners generally prefer the term "tempering."

283. **Drawing compound.** A substance applied to prevent pickup and scoring during deep drawing or pressing operations by preventing metal-to-metal contact of the workpiece and die. Also known as die lubricant.

284. **Drawing out.** A forging operation in which the cross section of stock of any shape is reduced and the stock lengthened between flat

or simple contour dies. See also cogging.

285. **Drawing.** (1) A term used for a variety of forming operations, such as deep drawing a sheet metal blank; redrawing a tubular pan; and drawing rod, wire, and tube. (2) The usual drawing process with regard to sheet metal working in a press is a method for producing a cuplike form from a sheet metal disk by holding it firmly between blankholding surfaces to prevent the formation of wrinkles while the punch travel produces the required shape. (3) A forging operation in which the cross section of forging stock is reduced and the stock lengthened between flat or simple contour dies (drawing out**)**. See also Fuller. (4) An operation in which the cross-section of solid rod, wire, or tubing is reduced or changed in shape by pulling it through a die.

286. **Driven slitting equipment**. When the blades are powered.

287. **Drop forging.** A forging produced by hammering metal between dies containing impressions designed to produce the desired shape in a drop hammer or the pans thus made; forging method requiring special dies for each shape. See also Impression die forging.

288. **Drop hammer forming.** A process for producing shapes by the progressive deformation of sheet metal in matched dies under the repetitive blows of a gravity-drop or power-drop hammer. The process is restricted to relatively shallow parts and thin sheet from approximately 0.6 to 1.6 mm (0.024 to 0.064 in.).

289. **Drop hammer.** A general term applied to forging hammers where the energy for forging is provided by gravity, steam, or compressed air. See also air-lift hammer, board hammer, and steam hammer.

290. **Dry drawing**. Drawing in which the surface of the rod to be drawn is coated with a lubricant such as soap by passing it through a box filled with the lubricant.

291. **Ductility.** The relative ability of metals to deform under stress without fracture.

292. **Dummy block**. Part of the extruding facility (a thick unattached disk or plate placed between the ram and the billet) which serves to avoid formation of oxide films on the extruded product and to prevent overheating of the ram. It is made a little smaller in diameter than the container.

293. **Dwell.** Portion of a press cycle during which the movement of a member is zero or at least insignificant. Usually refers to (1) the interval when the blankholder in a drawing operation is holding the blank while the punch is making the draw or (2) the interval between the completion of the forging stroke and the retraction of the ram.

294. **Dye penetrant testing.** Inspection procedures for detecting surface irregularities using penetrating liquids containing dyes or fluorescent substances. See also Zyglo.

295. **Earing**. Drawing defect when the edges of cap become wavy. It is caused by the planar anisotropy of the sheet.

296. **Eccentric gear.** A main press-drive gear with an eccentric(s) as an integral part. The unit rotates about a common shaft, with the eccentric transmitting the rotary motion of the gear into the vertical motion of the slide through a connection.
297. **Eccentric press.** A mechanical press in which an eccentric, instead of a crankshaft, is used to move the slide. The motion of the tool is driven by the rotation of a crank. This is similar to a crank press, but the rod can be positioned along the radius of the crank. The velocity of tool has a sinusoidal variation in time.
298. **Eccentric.** The offset portion of the drive-shaft that governs the stroke or distance the crosshead moves on a mechanical or manual shear.
299. **Edge dislocation.** A line defect formed across the depth of the crystal at the terminus of the extra plane formed.
300. **Edge formability (of material).** The ability of a material to resist necking or fracture at the edge of the hole.
301. **Edger (edging impression).** The portion of the die impression that distributes metal, during forging, into areas where it is most needed to facilitate filling the cavities of subsequent impressions to be used in the forging sequence. See also Fuller (fullering impression).
302. **Edging.** (1) In sheet metal forming, reducing the flange radius by retracting the forming punch a small amount after the stroke but before release of the pressure. (2) In rolling, the working of metal in which the axis of the roll is parallel to the thickness dimension. Also called edge rolling. (3) The forging operation of working a bar between contoured dies while turning it 90° between blows to produce a varying rectangular cross section. This operation serves for gathering and rearranging the material so that it is properly distributed to fill the cavities
303. **Effective (flow) stress**. A function of the applied stresses used to extend the material behavior determined in uniaxial tension to that existing in more complex loading situations. The effective stress is defined in terms of the yield locus, which is the locus of all possible combinations of states of stress that will initiate yielding or plastic flow in a material characterized by a given set of strength properties.
304. **Effective draw.** The maximum limits of forming depth that can be achieved with a multiple-action press; sometimes called maximum draw or maximum depth of draw.
305. **Efficiency factor**. Coefficient which equals the energy available for workpiece deformation divided by energy supplied to the machine
306. **Ejector (ejector rod).** A mechanism for removing (pushing out) work or material from between the dies.
307. **Elastic deformation.** A change in dimensions that is directly proportional to and in phase with an increase or decrease in applied force; deformation which is recoverable when the applied force is removed.

308. **Elastic limit.** The maximum stress a material can sustain without any permanent strain (deformation) remaining upon complete release of the stress. See also proportional limit.
309. **Elasticity.** The property of a material by which the deformation caused by stress disappears upon removal of the stress. A perfectly elastic body completely recovers its original shape and dimensions after the release of stress.
310. **Electrical conductivity.** The capacity of a material to conduct electrical current, sometimes used to measure the degree of aging in aluminum alloys.
311. **Electromagnetic forming.** A process for forming metal by the direct application of an intense, transient magnetic field. The workpiece is formed without mechanical contact by the passage of a pulse of electric current through a forming coil. Also known as magnetic pulse forming.
312. **Electroslag remelting (ESR).** A metal refining process in which the metal in the form of a consumable electrode is remelted through a layer of slag. **ESR** alloys have fewer inclusions, greater uniformity, increased soundness, improved forgeability, and superior properties.
313. **Elongation.** A term used in mechanical testing to describe the amount of extension of a testpiece when stressed or a measure of the ability of a material to deform plastically in a uniform manner. Usually expressed as the percentage of permanent stretch before rupture in a tensile test (of the original gage length).
314. **Embossing die.** A die used for producing embossed designs.
315. **Embossing.** A process for producing raised or sunken designs in sheet material by means of male and female dies, theoretically with no change in metal thickness. Examples are letters, ornamental pictures, and ribs for stiffening. Heavy embossing and coming are similar operations.
316. **Embrittlement.** A loss of ductility that can occur in metals as a result of mechanical or chemical defects introduced during processing or environmental exposure.
317. **End loss (crop end).** Bar end left over after cutting bar lengths of stock into forging multiples. See also Multiple.
318. **Endurance (or fatigue) limit.** The maximum stress a metal can withstand without failure under prolonged cyclic loading; above this limit, failure occurs by the generation and growth of cracks until fracture results.
319. **Energy Control Press.** A forging machine, where an initial energy is transmitted to the workpiece. A hammer press is an energy control press.
320. **Energy efficiency.** The percentage of energy that is transmitted to the workpiece.
321. **Engineering (conventional) stress.** Stress defined as the ratio of

the load to the original, cross-sectional area of deformed specimen.

322. **Engineering (or "simple") shear strain**. Strain defined here as the change in a unit right angle.

323. **Entering angle**. Zone of the drawing die right after the die bell.

324. **Equiaxed structure.** Grains, that are essentially spherical in shape (Typical Ingot Crystallization Zones).

325. **Equivalent plastic strain.** A monotonically increasing scalar measure of the plastic strain. It is used to determine the work or strain hardening in the material.

326. **Equivalent stress.** In general, it is a scalar representation of a three-dimensional state of stress. Usually, what is meant is the J_2 equivalent stress which is the second invariant of the deviatoric stress. For unixaxial behavior, it has the characteristic that it is equal to the uniaxial stress.

327. **Erichsen test.** A cupping test used to assess the ductility of sheet metal. The method consists of forcing a conical or hemispherical-ended plunger into the specimen and measuring the depth of the impression at fracture.

328. **Explosive forming.** The shaping of metal parts in which the forming pressure is generated by an explosive charge. See also high-energy-rate forming.

329. **Extreme pressure lubricants**. Lubricants which can withstand very high pressures during operation.

330. **Extrusion billet.** A metal slug used as extrusion stock.

331. **Extrusion defect.** See extrusion pipe.

332. **Extrusion forging.** (1) Forcing metal into or through a die opening by restricting flow in other directions. (2) A part made by the operation.

333. **Extrusion pipe.** A central oxide-lined discontinuity that occasionally occurs in the last 10 to 20% of an extruded bar. It is caused by the oxidized outer surface of the billet flowing around the end of the billet and into the center of the bar during the final stages of extrusion. Also called coring.

334. **Extrusion ratio**. The ratio of the cross-sectional area of the billet to that of the extruded product.

335. **Extrusion stock.** A rod, bar, or other section used to make extrusions.

336. **Extrusion.** The conversion of an ingot or billet into lengths of uniform cross section by forcing metal to flow plastically through a die orifice. In forward (direct) extrusion, the die and ram are at opposite ends of the extrusion stock, and the product and ram travel in the same direction (in the same direction in which energy is being applied). Also, there is relative motion between the extrusion stock and the die. In backward (indirect) extrusion, the die is at the ram end of the stock and the product travels in the direction opposite that of the

ram, either around the ram (as in the impact extrusion of cylinders such as cases for dry cell batteries) or up through the center of a hollow ram. The extrusion principle is used in many impression die forging applications. See also hydrostatic extrusion and Impact extrusion.

337. **Eyeleting.** The displacing of material about an opening in sheet or plate so that a lip protruding above the surface is formed.

338. **F.A.O.** An abbreviation of "finish all over"; it designates that a forging must have sufficient size over the dimensions given on the drawing so that all surfaces may be machined in order to obtain the dimensions shown on the drawing. The amount of additional stock necessary for machining allowance depends on the size and shape of the part, and is agreed on by the vendor and the user.

339. **Failure initiation.** Process of linking-up of the voids or holes resulting in a sudden loss of load-bearing cross section.

340. **Fatigue.** The tendency of metals to crack and break when subjected to cyclic stresses well below the ultimate tensile strength (or the progressive fracture of a metal by means of a crack that enlarges under repeated cycles of stress). Failure by fatigue is the most frequent cause of mechanical failure of structural and machine components.

341. **Feather** (**fin**). The thin projection formed on a forging by trimming or when the metal under pressure is forced into hairline cracks or die interfaces.

342. **Ferrite.** A solid solution of iron and one or more alloying elements that is characterized by a body-centered cubic crystal structure. Ferrite is the principal constituent of cast irons and steels with very small amounts of carbon and other alloying elements.

343. **Fiber stress.** Localized stress at a point or line on a section over which stress is not uniform, such as the cross section of a beam under a bending load.

344. **Fiber.** A characteristic of wrought metal, including forgings, indicated by a fibrous or woody structure of a polished and etched section, and indicating directional properties. Fiber is chiefly due to the extension of the constituents of the metal synonymous with flow lines and grain flow in the direction of working.

345. **Fillet.** (1) The concave intersection of two surfaces. (2) The radius at the concave intersection of two surfaces. In forging, the desired radius at the concave intersection of two surfaces is usually specified.

346. **Film Coefficient.** The thermal convective coefficient.

347. **Films.** A convective thermal boundary condition. The flux is dependent on the difference between the surface temperature and an environment *(sink)* temperature.

348. **Fine blanking**. Die cutting operation when a very smooth and square edges can be produced. A V-shaped stinger, or impingement,

locks the sheet metal tightly in place and prevents distortion of the material.

349. **Finish allowance.** (1) Amount of stock left on the surface of the forging for machining. (2) The amount of excess metal surrounding the intended final shape; sometimes called clean-up allowance, forging envelope, or machining allowance.

350. **Finish forging.** See Conventional forging.

351. **Finish trim.** Flash removal from a forging; usually performed by trimming, but sometimes by band sawing or similar techniques

352. **Finish.** (1) The surface appearance of a product. (2) The surface condition of the component resulting from machining. (3) (**Finishing**) The forging operation in which the part is forged into its final shape in the finish die. (4) A nonstandard (and typically nonuniform) surface finish on mill products that are delivered without being subjected to a special surface treatment (other than a corrosion-preventive treatment) after the final working or heat-treating step. (5) The material machined off the surface of a forging to produce the finish machine component. If only one finish operation is scheduled to be performed in the finish die, this operation will be identified simply as finish; first, second, or third finish designations are so termed when one or more finish operations are to be performed in the same finish die.

353. **Finisher (finishing impression).** The die impression that imparts the final shape to a forged part.

354. **Finishing dies.** The die set used in the last forging step.

355. **Finishing temperature.** The temperature at which hot working is completed.

356. **First block, second block, and finish.** The forging operation in which the part to be forged is passed in progressive order through three tools mounted in one forging machine; only one heat is involved for all three operations.

357. **Fir-tree cracking (speed cracking).** Extrusion defect which is intergranular cracks caused by hot shortness.

358. **Fishtail**. (1) In roll forging, the excess trailing end of a forging. Before being trimmed off, it is often used as a tong hold for a subsequent forging operation. (2) In hot rolling or extrusion, the imperfectly shaped trailing end of a bar or special section that must be cut off and discarded as mill scrap.

359. **Fittability**. Workability limit criterion which confines ability of a ready part to satisfy demand concerning assembling.

360. **Fixed Displacement.** The process of prescribing the value of one or more degree of freedom. The value may be either zero or nonzero.

361. **Flakes.** Short, discontinuous internal fissures in ferrous metals caused by localized internal stresses during cooling after hot working. In some nonferrous metals, such as aluminum, flakes are small

voids caused by hydrogen in the metal.

362. **Flame hardening.** A process of surface hardening a ferrous alloy by heating it above the transformation range with a high-temperature flame, followed by rapid cooling.

363. **Flame straightening.** The correction of distortion in metal structures by localized heating with a gas flame.

364. **Flange.** A projecting rim or edge of a part; usually narrow and of approximately constant width for stiffening or fastening. See Rib.

365. **Flanging**. Process of bending the edges of sheet metals.

366. **Flaring**. (1) Process of bending the edges of sheet metals when the angle of bend is less than 90°, as in fittings with conical ends (2) The forming of an outward acute-angle flange on a tubular part

367. **Flash extension.** Portion of flash remaining on a forged part after trimming; usually included in the normal forging tolerances. Flash extension is measured from the intersection of the draft and flash at the body of the forging to the trimmed edge of the stock.

368. **Flash land.** Configuration in the blocking or finishing impression of forging dies designed to restrict or to encourage the growth of flash at the parting line, whichever may be required in a particular case to ensure complete filling of the impression.

369. **Flash line.** The line left on a forging after the flash has been trimmed off (See Parting line.)

370. **Flash pan.** The machined-out portion of a forging die that permits the flow through of excess metal.

371. **Flash.** Excess metal that is extruded in a thin layer between the dies at the parting line and later removed by trimming. (Necessary metal in excess of that required to completely fill the finishing impression of the dies. Flash extends out from the body of the forging as a thin plate at the line where the dies meet and is subsequently removed by trimming.) Flash helps control the flow of metal into the die cavities. Because it cools faster than the body of the component during forging, flash can serve to restrict metal flow at the line where dies meet, thus ensuring complete filling of the impression. See also closed-die forging.

372. **Flat (simple) rolling.** The basic operation in rolling, where the rolled products are flat plate and sheet.

373. **Flat die forging (open die forging**). Forging between flat or simple contour dies by repeated strokes and manipulation of the workpiece. Also known as "hand" or "smith" forging.

374. **Flattening dies.** Dies used to flatten sheet metal hems; that is, dies that can flatten a bend by closing it. These dies consist of a top and bottom die with a flat surface that can close one section (flange) to another (hem, seam).

375. **Flattening.** (1) A preliminary operation performed on forging stock to position the metal for a subsequent forging operation or an

operation of flattening the forging stock prior to further working. (2) The removal of irregularities or distortion in sheets or plates by a method such as roller leveling or stretcher leveling.

376. **Flatter.** Forging tool used to make a smooth, flat surface. See also Set hammer.

377. **Flex roll.** A movable roll designed to push up against a sheet as it passes through a roller leveler. The flex roll can be adjusted to deflect the sheet any amount up to the roll diameter.

378. **Flex rolling.** Passing sheets through a flex roll unit to minimize yield-point elongation in order to reduce the tendency for stretcher strains to appear during forming.

379. **Floating die.** (1) A die mounted in a die holder or a punch mounted in its holder such that a slight amount of motion compensates for tolerance in the die parts, the work, or the press. (2) A die mounted on heavy springs to allow vertical motion in some trimming, shearing, and forming operations.

380. **Floating plug.** In tube drawing, an unsupported mandrel that locates itself at the die inside the tube, causing a reduction in wall thickness while the die is reducing the outside diameter of the tube.

381. **Floor space**. Area which is occupied by the facility.

382. **Flop forging**. A forging in which the top and bottom die impressions are identical, permitting the forging to be turned upside down during the forging operation.

383. **Flow curve**. A plastic stress-strain curve.

384. **Flow lines.** (1) Texture showing the direction of metal flow during hot or cold working or patterns in a forging resulting from the elongation of nonhomogeneous constituents and the grain structure of the material in the direction of working during forging. Flow lines can often be revealed by etching (macroetching) the surface or a section of a metal part. (2) In mechanical metallurgy, paths followed by minute volumes of metal during deformation.

385. **Flow plot.** A display of the motion of a material particle, represented by the original nodal position.

386. **Flow rules**. Stress-strain relationships that describe the path of plastic deformation of a material.

387. **Flow stress.** The stress required to cause plastic deformation of metals.

388. **Flow through.** A forging defect caused by metal flow past the base of a rib with resulting rupture of the grain structure.

389. **Fluid forming**. A modification of the Guerin process, fluid forming differs from the fluid-cell process in that the die cavity, called a pressure dome, is not completely filled with rubber, but with hydraulic fluid retained by a cup-shaped rubber diaphragm. See also rubber-pad forming.

390. **Fluid-cell process.** A modification of the Guerin process for

forming sheet metal, the fluid-cell process uses higher pressure and is primarily designed for forming slightly deeper parts, using a rubber pad as either the die or punch. A flexible hydraulic fluid cell forces an auxiliary rubber pad to follow the contour of the form block and exert a nearly uniform pressure at all points on the workpiece. See also fluid forming and rubber-pad forming.

391. **Fluid-to-fluid extrusion.** An operation of hydrostatic extrusion when a billet is extruded through a die by pressurized fluid into a second pressurized chamber, which is under lower pressure.
392. **Flying rolling mandrel.** A rolling mandrel not supported at the top for rolling rings with lower rolling forces. An increased production rate is achieved by omitting the use of the backing arm.
393. **Flying shear.** A machine for cutting continuous rolled products to length that does not require a halt in rolling, but rather moves along the runout table at the same speed as the product while performing the cutting, and then returns to the starting point in time to cut the next piece.
394. **Foil.** Metal in sheet form less than 0.15 mm (0.006 in.) thick.
395. **Fold.** A forging defect caused by folding metal back onto its own surface during its flow in the die cavity.
396. **Follow die.** A progressive die consisting of two or more parts in a single holder; used with a separate lower die to perform more than one operation (such as piercing and blanking) on a part in two or more stations.
397. **Footprint**. The contact area between die and workpiece.
398. **Forgeability.** Term used to describe the relative ability of material to deform without fracture. Also describes the resistance to flow from deformation. See also formability.
399. **Forging billet.** A wrought metal slug used as forging stock.
400. **Forging dies.** Forms for making forgings; they generally consist of a top and bottom die. The simplest will form a completed forging in a single impression; the most complex, consisting of several die inserts, may have a number of impressions for the progressive working of complicated shapes. Forging dies are usually in pairs, with part of the impression in one of the blocks and the rest of the impression in the other block.
401. **Forging envelope.** See finish allowance.
402. **Forging machine (upsetter or header).** A type of forging equipment, related to the mechanical press, in which the main forming energy is applied horizontally to the workpiece, which is gripped and held by prior action of the dies.
403. **Forging plane.** In forging, the plane that includes the principal die face and is perpendicular to the direction of ram travel. When the parting surfaces of the dies are flat, the forging plane coincides with the parting line. Contrast with parting plane.

404. **Forging quality.** Term describing stock of sufficiently superior quality to make it suitable for commercially satisfactory forgings.
405. **Forging rolls.** Power-driven rolls used in preforming bar or billet stock that have shaped contours and notches for introduction of the work.
406. **Forging stock.** A wrought rod, bar, or other section suitable for subsequent change in cross section by forging
407. **Forging strains.** Strains that have been set up in the metal by the process of forging; they are usually relieved by subsequent annealing or normalizing.
408. **Forging stresses.** Elastic stresses caused by forging, or cooling from the forging temperature. These stresses can be removed by subsequent heat treatment.
409. **Forging.** (1) The process of working metal to a desired shape by impact or pressure in hammers, forging machines (upsetters), presses, rolls, and related forming equipment. (2) The product of work on metal formed to a desired shape by impact or pressure in hammers, forging machines etc. Forging hammers, counterblow equipment, and high-energy-rate forging machines apply impact to the workpiece, while most other types of forging equipment apply squeeze pressure in shaping the stock. Some metals can be forged at room temperature, but most are made more plastic for forging by heating. Specific forging processes include closed-die forging, high-energy-rate forging, hot upset forging, isothermal forging, open-die forging, powder forging, precision forging, radial forging, ring rolling, roll forging, rotary forging, and rotary swaging.
410. **Form block.** Tooling, usually the male part, used for forming sheet metal contours; generally used in rubber-pad forming.
411. **Form die.** A die used to change the shape of a sheet metal blank with minimal plastic flow.
412. **Form rolling.** Hot rolling to produce bars having contoured cross sections; not to be confused with the roll forming of sheet metal or with roll forging.
413. **Formability (malleability or ease of working).** The ease with which a metal can be shaped through plastic deformation. Evaluation of the formability of a metal involves measurement of strength, ductility, and the amount of deformation required to cause fracture. The term workability is used interchangeably with formability; however, formability refers to the shaping of sheet metal, while workability refers to shaping materials by bulk forming. See forgeability.
414. **Former.** Part of a master used in machining impressions in dies. See Master, Model, Template.
415. **Forming dies.** Dies in which a rough impression has been machined or gouged, for use between the flat dies of a steam hammer; used when the quantity of forgings required does not warrant

the cost of drop forging dies and a closer shape than can be obtained with flat dies.

416. **Forming limit diagram (FLD).** (1) A diagram in which the major strains at the onset of necking in sheet metal are plotted vertically and the corresponding minor strains are plotted horizontally. The onset-of-failure line divides all possible strain combinations into two zones: the safe zone (in which failure during forming is not expected) and the failure zone (in which failure during forming is expected). (2) Testing the formability of sheet metals when the sheet is marked with a grid pattern of circles and the stretched over a punch. After this the specimens are cut to varying widths.

417. **Forming.** (1) The plastic deformation of a billet or a blanked sheet between tools (dies) to obtain the final configuration. (2) A process whereby planes of a definite shape are changed without materially changing the cross section. Also referred to as metalworking. (3) Changing the shape of an existing solid body.

418. **Forward extrusion.** Same as direct extrusion. See extrusion.

419. **Foundation.** The mass of structural material on which forging equipment is placed to support the weight and to absorb residual energy of the forging operation.

420. **Four-high mill.** A type of rolling mill, commonly used for flat-rolled mill products, in which two large-diameter backup rolls **are** employed to reinforce two smaller work rolls, which are in contact with the Product. Either the work rolls or the backup rolls may be driven. Compare with two-high mill and cluster mill.

421. **Fracture strength**. Stress at which a fractures occur in specimen subjected to tension during uniaxial testing.

422. **Fracture stress.** The maximum load at fracture divided by the actual fracture area.

423. **Fracture test.** Examination of the broken surface of a test specimen or forging to determine the structure of the metal or certain of its properties.

424. **Frame.** The main structure of a press.

425. **Free forming**. Here the transfer medium does not contain the desired geometry, such as in upsetting where the workpiece is unsupported.

426. **Free machining.** A term used to describe metals that have alloying additions which reduce the tool force required in machining operations. Sulfur or lead in small amounts is used in "free machining" steels.

427. **Freebody equilibrium method**. See slab method.

428. **Friction hill**. Distribution of normal pressure across the die-material interface.

429. **Friction coefficient.** The experimentally obtained value that relates the amount of normal stress to shear stress (Coulomb model)

or the material flow stress to shear stress (Shear model).

430. **Friction.** The process by a shear force is generated which resists relative sliding between bodies.

431. **Frictionhill method**. See slab method.

432. **Fuller (fullering impression).** Portion of the die that is used in hammer forging primarily to reduce the cross section and lengthen a portion of the forging stock. The fullering impression is often used in conjunction with an edger (or edging impression).

433. **Fullering**. Open-die hot-forging process involving compression between rounded or convex dies to reduce a middle section of a bar while at the same time increasing the length of the drawn down portion. In hammer forging, this is accomplished by giving repeated blows to the bar between the horizontal faces of the fuller dies, while rotating the bar, usually after each blow.

434. **Gage**. (1) The thickness of sheet or the diameter of wire. The various standards are arbitrary and differ with regard to ferrous and nonferrous products as well as sheet and wire. (2) An aid for visual inspection that enables an inspector to determine more reliably whether the size or contour of a formed part meets dimensional requirements.

435. **Gap-frame press.** A general classification of press in which the uprights or housings are made in the form of a letter ***C***, thus making three sides of the die space accessible.

436. **Gate (sprue).** A portion of the die that has been removed by machining to permit a connection between multiple impressions or between an impression and the bar of stock.

437. **Gathering stock.** Any operation whereby the cross section of a portion of the forging stock is increased above its original size.

438. **German die.** A die in which a rough impression has been machined or gouged and used between the flat dies of the steam hammer. Primarily used to obtain a relative closer shape in the forging than can be obtained with flat dies when the quantity of forgings required is not sufficient to permit investment in production forging dies (see **forming dies**).

439. **Gibs**. Guides or shoes that ensure the proper parallelism, squareness, and sliding fit between press components such as the slide and the frame. They are usually adjustable to compensate for wear and to establish operating clearance.

440. **Gouge.** A gross type of scratch.

441. **Grain flow.** Fiber-like lines appearing on polished and etched sections of forgings that are caused by orientation of the constituents of the metal in the direction of working during forging. Grain flow produced by proper die design can improve required mechanical properties of forgings.

442. **Grain separation.** In forging aluminum, rapid metal flow some-

times causes a separation or rupture of grain. Metal flow is affected by lubricant, die and metal temperature, part shape, alloy, and hammer operator technique; consequently, any one or combination of these factors can cause grain separation. The irregular crevices are seldom more than a few thousandths of an inch deep and can be removed by grinding or polishing.

443. **Grain size.** The average area or volume of grains in polycrystalline metals; usually expressed as average diameter or number of grains per unit of area or volume. The typical size of a homogeneous piece of crystalline metal with the same orientation

444. **Grain.** An individual crystal in a metal or alloy.

445. **Gravity hammer**. A class of forging hammer in which energy for forging is obtained by the mass and velocity of a freely falling ram and the attached upper die. Examples are the board hammer and air-lift hammer.

446. **Green compact.** An unsintered compact.

447. **Green strength**. (1) The ability of a green compact to maintain its size and shape during handling and storage prior to sintering. (2) The tensile or compressive strength of a green compact.

448. **Green.** Unsintered (not sintered).

449. **Grinding.** Process of removing metal by abrasion from bar or billet stock to prepare stock surfaces for forging. Occasionally used to remove surface irregularities and flash from forgings.

450. **Gripper dies.** The lateral or clamping dies used in a forging machine or mechanical upsetter.

451. **Guerin process.** A rubber-pad forming process for forming sheet metal.

452. **Guide pin bushings.** Bushings, pressed into a die shoe, that allow the guide pins to enter in order to maintain punch-to-die alignment.

453. **Guide pins.** Hardened, ground round pins or posts that maintain alignment between punch and die during die fabrication, setup, operation, and storage. If the press slide is out of alignment, the guide pins cannot make the necessary correction unless heel plates are engaged before the pins enter the bushings. See also heel block.

454. **Guide.** The parts of a drop hammer or press that guide the up-and-down motion of the ram in a true vertical direction.

455. **Gutter.** A depression around the periphery of a forging die impression outside the flash pan that allows space for the excess metal; surrounds the finishing impression and provides room for the excess metal used to ensure a sound forging. A shallow impression outside the parting line.

456. **Hammer forging.** A forging that is made on the flat die of a steam hammer. A forged piece produced in a forging hammer, or the process of forming such a piece. See also Board hammer. Power-

drive hammer. Rope hammer.

457. **Hammer Press.** An energy controlled press, where the initial energy is based upon the potential energy of the hammer falling.

458. **Hammer.** A machine that applies a sharp blow to the work area through the fall of a ram onto an anvil. The ram can be driven by gravity or power. See also gravity hammer and power-driven hammer.

459. **Hammering.** The working of metal sheet into a desired shape over a form or on a high-speed hammer and a similar anvil to produce the required dishing or thinning.

460. **Hand forge (smith forge).** (1) A forging operation in which forming is accomplished on dies that are generally flat. The piece is shaped roughly to the required contour with little or no lateral confinement; operations involving mandrels are included. (2) A forging made by hand on an anvil or under a power hammer without dies containing an exact finishing impression of the part. The term hand forge refers to the operation performed, while hand forging applies to the part produced. Such forgings approximate each other in size and shape but do not have the commercial exactness of production die forgings. Used where the quantity of forgings required does not warrant expenditure for special dies, or where the size or shape of the piece is such as to require means other than die forging. A forging worked between flat or simply shaped dies by repeated strokes and manipulation of the piece. Also known as smith forging or flat die forging.

461. **Hand straightening.** A straightening operation performed on a surface plate to bring a forging within the straightness tolerance. Frequently, a bottom die from a set of finish dies is used instead of a surface plate. Hand tools used include mallets, sledges, blocks, jacks, and oil gear presses in addition to regular inspection tools.

462. **Handling holes.** Holes drilled in opposite ends of the die block to permit handling by the use of a crane or bar.

463. **Handling marks.** Nicks and gouges formed on forgings if improperly handled; most prevalent for forgings in the as-forged condition prior to heat treatment.

464. **Hardenability.** In ferrous and age-hard-enable alloys, the property that determines the depth and distribution of hardness induced by heating above the transformation temperature and quenching.

465. **Hardening.** Any process or treatment that increases the hardness and strength of a metal. The two most common methods are heat treatment and cold working. A heat treatment consisting of heating an alloy to a temperature within or above the critical range, maintaining that temperature for the prescribed time (usually 15 to 30 min), then quenching or otherwise rapidly cooling. For age-hardening alloys, a two-stage process consisting of solution heat treatment and aging.

466. **Hardie.** Forging tool resembling a chisel, except that it is supported in the anvil and the metal to be cut rests on its cutting edge.
467. **Hardness testing.** See Brinell hardness testing, Rockwell hardness testing, Scleroscope hardness testing.
468. **Hardness.** (1) General term, covering the resistance of metal to plastic deformation by force (resistance of a metal to indentation). (2) Hardness numbers obtained by use of any of the several hardness tests for metals.
469. **Hartniann lines.** See Luders lines.
470. **Header.** See Forging machine.
471. **Heading.** An upsetting process involving only a part of the billet and used to form heads on the ends of rods or wire, as in bolt or rivet making or process used to form parts that usually contain portions that are greater in cross-sectional area than the original wire, rod, or bar. Heading may be done by heating only a part of the billet (the end or the middle) or by restricting deformation of a section of the billet by means of a ring-shaped tool
472. **Heat (forging).** Amount of forging stock placed in a batch-type furnace at one time.
473. **Heat checking**. Thermal cracks (in the dies) caused by temperature cycling usually in the areas rich in carbides.
474. **Heat of metal (heat).** A term used to identify the material produced from a melting operation – the quantity of material manufactured from one melt at the metal producer's facility. Metal from a single heat is extremely uniform in chemical analysis. Different heats of the same material can vary in chemical composition within prescribed limits. Stock from a single heat will have a consistent analysis and more uniform properties.
475. **Heat treatment.** A combination of heating, holding, and cooling operations applied to a metal or alloy in the solid state to produce desired properties.
476. **Heat-treat stain.** Discoloration of the metal surface caused by oxidation during thermal heat treatment
477. **Heel block.** A block or plate usually mounted on or attached to a lower die that serves to prevent or minimize the deflection of punches or cams.
478. **Helve hammer.** A power hammer in which power is delivered through a helve or handle; used in light work, tool making, and supplementary operations.
479. **Hemming (flattening).** A bend of 180° made in two steps. First, a sharp-angle bend is made; next, the bend is closed using a flat punch and a die.
480. **High-energy-rate forging (high-velocity or high-speed forging).** The process of producing forgings on equipment capable of extremely high ram velocities resulting from the sudden release of a

compressed gas against a free piston. Forging is usually completed in one blow. Also known as ***HERF*** processing, high-velocity forging, and high-speed forging.

481. **High-energy-rate forming.** A group of forming processes that applies a high rate of strain to the material being formed through the application of high rates of energy transfer. See also explosive forming, high-energy-rate forging, and electromagnetic forming.

482. **High-energy-rate-machines**. The machines in which the ram is accelerated by inert gas at high pressure, and the part is forged in one blow at very high speeds.

483. **Hog out.** A product machined from bar stock or from a hand forging rather than from an impression die forging. The process is commonly known as "hogging out" material.

484. **Hold-down plate (pressure pad).** A pressurized plate designed to hold the workpiece down during a press operation. In practice, this plate often serves as a stripper and is also called a stripper plate.

485. **Hole flanging.** The forming of an integral collar around the periphery of a previously formed hole in a sheet metal part.

486. **Homogeneous**. Material of body which consists of one phase and has identical properties at all points.

487. **Homogenizing.** A heat treatment at high temperature to reduce chemical segregation by diffusion of alloying elements.

488. **Homologous temperature.** The ratio of the metalworking temperature (T) to the melting point of the metal (Tm), both expressed in Kelvin (°C + 273). This ratio can be used to classify forging processes: cold, T/Tn, < 0.3; warm, T/Tn, = 0.3 to 0.5; and hot, T/Tn, > 0.5.

489. **Hooken material**. Isotropic elastic material.

490. **Hooke's law.** A material in which the stress is linearly proportional to strain is said to obey Hooke's law. See also modulus of elasticity.

491. **Hot forming.** See hot working.

492. **Hot inspection.** An in-process visual examination of forgings, using gages, templates, or other nondestructive inspection equipment to ensure quality.

493. **Hot isostatic pressing (HIP).** A process for simultaneously heating and forming a power metallurgy compact in which metal powder, contained in a sealed flexible mold, is subjected to equal pressure from all directions at a temperature high enough for sintering to take place.

494. **Hot shortness.** Brittleness in hot metal.

495. **Hot stamp.** Impressing markings in a forging while the forging is in the heated, plastic condition.

496. **Hot trimming.** The removal of flash or excess metal from a hot part (such as a forging) in a trimming press.

497. **Hot upset forging.** A hulk forming process for enlarging and reshaping some of the cross-sectional area of a bar, tube, or other

product form of uniform (usually round) section. It is accomplished by holding the heated forging stock between grooved dies and applying pressure to the end of the stock, in the direction of its axis, by the use of a heading tool, which spreads (upsets) the end by metal displacement. Also called hot heading or hot upsetting. See also heading and upsetting.

498. **Hot working.** The mechanical working of a metal at a temperature above its re-crystallization point – a temperature high enough to prevent strain hardening so the plastic deformation of metal at such a temperature and strain rate that recrystallization takes place simultaneously with the deformation, thus avoiding any strain hardening. Contrast with cold working

499. **Hot-twist test**. Test for determination of the forgeability when a round specimen is twisted at various temperatures continuously in the same direction until it fails so the optimum forging temperature is determined.

500. **Hourglass Mode.** Spacious kinematic mode which derives its name from the shape of the modes that result due to the under-integration of the stiffness matrix.

501. **H-shape forging.** A forging in the approximate form of an "H."

502. **Hub.** A boss that is in the center of a forging and forms a part of the body of the forging.

503. **Hubbing.** The production of die cavities by pressing a male master plug, known as a hub, with particular tip geometry into the surface of a block of metal. The cavity produced is then used as a die for forming operations.

504. **Hydraulic hammer.** A gravity-drop forging hammer that uses hydraulic pressure to lift the hammer between strokes.

505. **Hydraulic press brake.** A press brake in which the ram is actuated directly by hydraulic cylinders.

506. **Hydraulic Press.** A forging machine that is driven by the pressure of a fluid (usually oil). While the motion is actually load controlled, it can usually be modelled by stating that it is velocity controlled.

507. **Hydraulic shear.** A shear in which the cross-head is actuated by hydraulic cylinders.

508. **Hydraulic-mechanical press brake.** A mechanical press brake that uses hydraulic cylinders attached to mechanical linkages to power the ram through its working stroke.

509. **Hydroform press**. Press using a thin flexible diaphragm for hydroforming.

510. **Hydroforming (fluid-forming).** Sheet metal working process when a thin flexible diaphragm sealed against high pressure and backed by hydraulic fluid. The material blank is held in position and the punch is moved up by hydraulic pressure into the die cavity, forc-

ing the diaphragm pad and the blank to take the shape of the punch

511. **Hydrostatic component**. Mean stress which may be defined as simple mean of the principal stresses.

512. **Hydrostatic extrusion.** A method of extruding a billet through a die by pressurized fluid instead of the ram used in conventional extrusion. The billet is smaller in diameter than the chamber. Unlike in conventional extrusion, there is no friction to overcome along the container walls.

513. **Idealized stress-strain curve**. Simplified forms of stress-strain curves.

514. **Impact extrusion.** The process (or resultant product) in which a punch strikes a slug (usually unheated) in a confining die. It is a relatively rapid extrusion. The metal flow may be either between punch and die or through another opening. The impact extrusion of unheated slugs is often called cold extrusion.

515. **Impact line.** A blemish on a drawn sheet metal part caused by a slight change in metal thickness. The mark is called an impact line when it results from the impact of the punch on the blank; it is called a recoil line when it results from transfer of the blank from the die to the punch during forming, or from a reaction to the blank being pulled sharply through the draw ring.

516. **Impact strength.** A measure of the ability of a material to sustain high-velocity loading in the presence of a notch, T notched-bar impact strength of an all is the best single indicator of its engineering serviceability. Fiber structure developed in forging significantly influence the impact strength of the metals

517. **Impact testing.** Tests to determine the energy absorbed in fracturing a test bar at high velocity. See also Charpy test.

518. **Impression die forging.** A forging that is formed to the required shape and size by machined impressions in specially prepared dies that exert three-dimensional control on the workpiece, so the shaping of metal by compression take place completely within the cavities of two dies that enclose workpiece on all sides

519. **Impression.** A cavity machined into a forging die to produce a desired configuration in the workpiece during forging.

520. **Inclusions.** Particles of nonmetallic compounds of metals and impurity elements that are present in ingots and are can over in wrought products. The shape distribution of inclusions are changed by plastic deformation and contribute directionality in metals.

521. **Increment of the distortion intensity (increment of equivalent strain).** The fundamental concept in the theory of plastic flow which represents the square root of a second invariant of the deviatoric. It represents the increment of distortion intensity accumulated in a particle of material in a short period of time between two consecutive stages of the advancing process of plastic flow.

522. **Indirect (backward) extrusion.** See extrusion.
523. **Induction hardening.** Process of hardening the surface of a forging by heating it above the transformation range by electrical induction, followed by rapid cooling.
524. **Ingot.** A casting intended for subsequent rolling, forging, or extrusion.
525. **Initial Stress.** The stress in the workpiece before any processing this stage. This stress may be due to some previous mechanical or thermal process.
526. **Initial Temperature.** The temperatures at the beginning of a coupled analysis.
527. **Insert, die.** A relatively small die containing part or all of the impression of a forging, and which is fastened to the master die block.
528. **Insert.** A piece of steel that is removable from a die. The insert may be used to fill a cavity, or to replace a portion of the die with a grade of steel better suited for service at that point.
529. **Inspection.** The process of checking a forging for adherence to standards given in the specifications.
530. **Intrinsic (true) ductility**. Term which is associated with the ease of plastic deformation and or the extent of plastic deformation of a material without fracture in a process.
531. **Invariants of the state of stress.** The coefficients of a cubic equation whose roots are the principal stresses. Such coefficients are independent of the orientation of the axes.
532. **Ironing.** (1) A press operation used to obtain a more exact alignment of the various parts of a forging, or to obtain a better surface condition. (2) An operation to increase the length of a tube by reduction of wall thickness and outside diameter. See also Coining, Swaging.
533. **Isostatic pressing.** A process for forming a powder metallurgy compact by applying pressure equally from all directions to metal powder contained in a sealed flexible mold. See also hot isostatic pressing.
534. **Isothermal annealing.** A process of heating ferrous material above its critical temperature, then cooling to and holding a fixed temperature until transformation to a desired microstructure.
535. **Isothermal forging (hot-die forging).** A hot-forging process in which a constant and uniform temperature is maintained in the workpiece during forging by heating the dies to the same temperature as the workpiece.
536. **Isothermal.** Constant and uniform temperature.
537. **Isotropic.** A material which has identical material properties in all directions.
538. **Izod test.** A pendulum-type impact test in which the specimen is supported at one end as a cantilever beam and the energy required

to break off the free end is used as a measure of impact strength.

539. **Jacketing.** See canning.

540. **Joggle**. Bending operation in a press brake when a flat sheet metal plate is bent across two or more edge so the beveled area is obtained.

541. **Jominy.** A hardenability test for steel to determine the depth of hardening obtainable by a specified heat treatment.

542. **Key.** A wedge used to secure dies into the forging equipment.

543. **Killed steel.** Steel treated with additions of silicon or aluminum to the melt to minimize the oxygen content so that no reaction occurs between carbon and oxygen during solidification.

544. **Kinematic element method**. Method for analyzing plastic flow based on the upper-bound approach for obtaining an acceptable velocity field by minimizing the power dissipated during plastic deformation. A cross section of the workpiece is divided into kinematic elements which can be rectangular, triangular or trapezoidal. By use of this method the forging load, etc., can be predicted for the plane strain and the axisymmetric forging processes.

545. **Kinematically admissible displacement**. Displacement which are the continuous functions of the spatial coordinates and satisfy kinematic boundar conditions on the portion of the surface for which such conditions are prescribed.

546. **Kneading.** See swaging.

547. **Knockout (kickout) pin.** A power-operated plunger installed in a die to aid removal of the finished forging.

548. **Knockout mark.** A small protrusion, such as a button or ring of flash, resulting from the depression of a knock out pin from the forging pressure, or the entrance of metal between the knockout pin and the die.

549. **Knockout.** A mechanism for releasing work-pieces from a die.

550. **Knuckle-joint press**. Forging machine which is equipped with a knuckle-joint mechanism to activate the slide. As the two knuckle-joint links are brought into a straight-line position a tremendous force is exerted by the slide. The knuckle causes a rapid ram approach for die closing and then a slow ram. This arrangement enables a high tonnage to be exerted at the bottom of the stroke with a comparatively low torque on the drive shaft. Rated tonnages of coining presses range from 100 to 8000 tons

551. **L shape.** Right-angle pieces, or those similar to a crank arm.

552. **L, spread.** When projections of an "L" shape are not necessarily at 90° angles, when angles vary, or when a cross shape has adjacent arms that are longer than the other two, it becomes a spread L. Abbreviation is "SL."

553. **Lancing**. Die cutting operation when a tab is leaved without removing any material.

554. **Lap.** A surface defect appearing as a seam, caused by the folding over of hot metal (material folds upon itself), fins, or sharp corners and by subsequent rolling or forging (but not welding) of these into the surface. See also Fold.
555. **Laser beam cutting.** A cutting process that severs material with the heat obtained by directing a laser beam against a metal surface. The process can be used with or without an externally supplied shielding gas.
556. **Lateral extrusion.** An operation in which the product is extruded sideways through an orifice in the container wall.
557. **Laying reel**. Type of the reel for receiving finished rod during rod drawing when the reel is stationary and the feeding mechanism winds the rods around the stationary reel.
558. **Layout sample.** A plaster, lead, or forged alloy sample taken from new dies to verify accuracy by layout and precise measurement. See also Cast.
559. **Layout.** (1) Transferring drawing or sketch dimensions to templates or dies for use in sinking dies. (2) A detailed inspection operation in which significant dimensions of a forging are checked against blueprint specifications.
560. **Lead proof.** A reproduction in lead, or a lead alloy, of the die impression, obtained by clamping the two dies together in alignment and pouring molten metal into the finish impression.
561. **Leveler lines.** Lines on sheet or strip running transverse to the direction of roller leveling. These lines may be seen upon stoning or light sanding after leveling (but before drawing) and can usually be removed by moderate stretching.
562. **Leveling.** The flattening of rolled sheet, strip, or plate by reducing or eliminating distortions. See stretcher leveling and roller leveling.
563. **Liftout.** The mechanism also known as knockout.
564. **Limit analysis.** Method which utilizes the extremum principle involving the method of virtual work. In this method, a virtual hypothetical displacement field is imposed on the body while the stress is maintained constant.
565. **Limiting drawing ratio (LDR).** See deformation limit.
566. **Linearly elastic.** Material in which deformation is sensibly recoverable and is directly proportional to the applied load.
567. **Liners.** Thin strips of metal inserted between the dies and the units into which the dies are fastened.
568. **Load.** (1) The external forces that act on a body. (2) Apply an excitation to a structure.
569. **Loadcase. (1)** The processor that defines the loadcases. (2) A set of parameters which govern the analysis, including the type of analysis to be performed and the load and state ids that are active as a minimum.

570. **Loads.** Distributed mechanical loads applied to an element.
571. **Localized (pronounced) necking**. In which appreciable interaction between adjacent elements of the specimen occurs leading to a superimposed triaxial state of stress and to a gradual departure from uniaxiality of loading.
572. **Lock.** One or more changes in the plane of the mating faces of the dies. In a compound lock, two or more changes are in the mating faces. A counterlock is a lock placed in the dies to offset a tendency for die shift caused by a necessary steep lock, a condition in which the parting line is not all in one plane.
573. **Locked dies.** Dies with mating faces that lie in more than one plane.
574. **Long transverse (LT) specimen**. The specimens taken from a hot rolled plate, in which the longitudinal axis of each specimen is parallel to the width and perpendicular to the direction of rolling.
575. **Longitudinal.** The direction in a wrought metal product parallel to the principal direction of working. In forgings, this is usually the direction of the grain flow or fiber structure. See Directional properties.
576. **Loose material.** During forging operations, pieces of flash often break loose, necessitating cleaning of the dies between forging blows; this is usually accomplished by lubricating the die while air is blown on it. Insufficient cleaning results in pieces of flash becoming imbedded in the surface of the forging.. Such forgings are often salvaged by removing the loose pieces and hot reforging to fill out the depressions.
577. **Lower bound**. A load which is too small to cause plastic deformation to begin.
578. **Lower punch.** The lower part of a die, which forms the bottom of the die cavity and which may or may not move in relation to the die body; usually movable in a forging die.
579. **Lubricant residue.** The carbonaceous residue resulting from lubricant that is burned onto the surface of a hot forged part.
580. **Lubricant.** A material applied to dies, molds, plungers, or workpieces that promotes the flow of metal, reduces friction and wear, and aids in the release of the finished part.
581. **Luders lines (bands.).** Elongated surface markings or depressions, often visible with the unaided eye, that form along the length of a round or sheet metal tension specimen at an angle of approximately 55° to the loading axis. Caused by localized plastic deformation, they result from discontinuous (inhomogeneous) yielding. Also known as Luders bands, Hartmann lines, Piobert lines, or stretcher strains.
582. **M- value.** See strain-rate sensitivity.
583. **Machine forging (upsetter forging).** The process of forging in a forging machine (upsetter), in which the metal is moved into the die

impression by pressure applied in a horizontal direction by the moving die in the ram.

584. **Machining allowance.** See Finish allowance.

585. **Macroetch.** A testing procedure for conditions such as porosity, inclusions, segregations, caburization, and flow lines from hot working. After applying a suitable etching solution to the polished metal surface, the structure revealed by the action of the reagent can be observed visually.

586. **Macrostructure.** The structure and internal condition of metals as revealed on a polished and etched sample, examined either by the naked eye or under low magnification (up to 10 diameters).

587. **Magnaglo.** A type of magnetic particle testing where the magnetic powder is fluorescent and the inspection is performed under black light. See also Magnetic particle testing. Trade name of Magnaflux Corp.

588. **Magnetic particle testing (magnaflux test).** A nondestructive test method of inspecting areas on or near the surface of ferromagnetic materials. The metal is magnetized, and coated with iron powder (iron powder is applied). The powder adheres to lines of flux leakage, revealing surface and near-surface discontinuities. Magnetic particle testing is used for both raw material acceptance testing and product inspection. Quality levels are usually agreed on in advance by the producer and purchaser. Commonly used to inspect forgings for seams, cold shuts, cracks, etc.

589. **Malleability**. See formability.

590. **Malleable.** The ability of a metal to be deformed by rolling or forging.

591. **Mandrel forging.** The process of rolling and forging a hollow blank over a mandrel in order to produce a weldless, seamless ring or heavy-wall tube.

592. **Mandrel.** (1) A blunt-ended tool or rod used to retain the cavity in a hollow metal product during working. (2) A metal bar around which other metal can be cast, bent, formed, or shaped. (3) A shaft or bar for holding work to be machined.

593. **Manipulator.** A mechanical device for handling an ingot or billet during forging.

594. **Mannesmann process.** A process for piercing tube billets in making seamless tubing. The billet is rotated between two heavy rolls mounted at an angle and is forced over a fixed mandrel.

595. **Marforining process.** A rubber-pad forming process developed to form wrinkle-free shrink flanges and deep-drawn shells. It differs from the Guerin process in that the sheet metal blank is clamped between the rubber pad and the blankholder before forming begins.

596. **Martempering.** The process of quenching an austenitized ferrous alloy in a medium at a temperature in the upper portion of the tem-

perature range of martensite formation, or slightly above that range, and holding in the medium until the temperature throughout the alloy is substantially uniform. The alloy is then allowed to cool in air throughout the temperature range of martensite formation.

597. **Martensite**. A hard, brittle, metastable, unstable, nonequilibrium structure, supersaturated solid solution of cementite, Fe3C, in a body-centered tetragonal iron (quench-hardened steel) resulting from process when the austenite is suddenly quenched in water, the carbon cannot escape and thus is trapped within the lattice structure.

598. **Mass density.** The value of the mass per unit volume.

599. **Master block.** A forging die block used primarily to hold insert dies. See also die insert.

600. **Master.** Wood, metal, or plastic reproduction of one side of a proposed forged shape, used to control cutters on tracer-controlled die sinking equipment. See also Former, Plaster.

601. **Match.** A condition in which a point in one die half is aligned properly with the corresponding point in the opposite die half within specified tolerance.

602. **Matched edges (match lines).** Two edges of the die face that are machined exactly at 90° to each other, and from which all dimensions are taken in laying out the die impression and aligning the dies in the forging equipment.

603. **Matching draft.** (1) Adjustment of draft angles (usually increased) on parts with unsymmetrical ribs and side walls to make the surfaces of the forging meet at the parting line. (2) Increased draft used on the shallow side of a forging to match its surface at the parting line with a similar surface of less draft on the deeper side.

604. **Mathematical material model**. An equation that describes the flow behavior of a material under the influence of external forces.

605. **Mechanical press brake.** A press brake using a mechanical drive consisting of a motor, flywheel, crankshaft, clutch, and eccentric to generate vertical motion.

606. **Mechanical press.** A forging press with an inertia flywheel and with a crank and clutch or other mechanical device to operate the ram.

607. **Mechanical properties.** Those properties of a material that reveal the elastic and inelastic reaction when force is applied, or that involve the relationship between stress and strain; for example, the modulus of elasticity, tensile strength, and fatigue limit. Mechanical properties are dependent on chemical composition, forging, and heat treatment.

608. **Mechanical twinning**. The ultimate irreversible shear displacement of planes of a section of a crystal in the same direction and in an amount proportional to the distance of the plane from the twin plane and in such a manner so as to cause the twinned portion to be

the mirror image of the untwinned portion

609. **Mechanical upsetter.** A three-element forging press, with two gripper dies and a forming tool, for flanging or forming relatively deep recesses.

610. **Mechanical working.** Subjecting metal to pressure, exerted by rolls, hammers, or presses, in order to change the shape or physical properties of the metal,

611. **Metal discountinuities.** See Discontinuities, metal.

612. **Metalworking.** See forming.

613. **Microstructure.** The structure and internal condition of metals as revealed on a ground and polished (and sometimes etched) surface when observed at high magnification (over 10 diameters).

614. **Mill product.** Any commercial product of a mill.

615. **Mill scale.** The heavy oxide layer that forms during the hot fabrication or heat treatment of metals.

616. **Mill.** (1) A factory in which metals are hot worked, cold worked, or melted and cast into standard shapes suitable for secondary fabrication into commercial products. (2) A production line, usually of four or more stands, for hot or cold rolling metal into standard shapes such as bar, rod, plate, sheet, or strip. (3) A single machine for hot rolling, cold rolling, or extruding metal; examples include blooming mill, cluster mill, four-high mill, and Sendzimer mill. (4) A shop term for a milling cutter. (5) A machine or group of machines for grinding or crushing ores and other minerals.

617. **Minimill**. A machine tool in which scrap metal is melted in electric-arc furnaces, cast continuously, and rolled directly into a specific line of products.

618. **Minimum bend radius**. The radius at which a crack appears on the outer surface of the bend.

619. **Mismatch.** The misalignment or error in register of a pair of forging dies; also applied to the condition of the resulting forging. The acceptable amount of this displacement is governed by blueprint or specification tolerances. Within tolerances, mismatch is a condition; in excess of tolerance, it is a serious defect. Defective forgings can be salvaged by hot-reforging operations.

620. **Model.** See Former, Master, Plaster.

621. **Modulus of elasticity, *E***. The measure of rigidity or stiffness of a metal; the ratio of stress, below the proportional limit, to the corresponding strain. In terms of the stress-strain diagram, the modulus of elasticity is the slope of the stress-strain curve in the range of linear proportionality of stress to strain. Also known as Young's modulus. For materials that do not conform to Hooke's law throughout the elastic range, the slope of either the tangent to the stress-strain curve at the origin or at low stress, the secant drawn from the origin to any specified point on the stress-strain curve, or the chord connecting

any two specific points on the stress-strain curve is usually taken to be the modulus of elasticity. In these cases, the modulus is referred to as the tangent modulus, secant modulus, or chord modulus, respectively.

622. **Monotonic stress-strain curve.** Curve obtained by continuous loading rather than by cyclic loading as used in fatigue testing.

623. **Moving mandrel**. The mandrel which is moved in the same direction as tube during tube-drawing operation.

624. **Multiple.** A piece of stock for forging that is cut from bar or billet lengths to provide the exact amount of material needed for a single workpiece.

625. **Multiple-part die**. A die to forging of more than one part in a single die.

626. **Multiple-slide press**. A press with individual slides, built into the main slide or connected to individual eccentrics on the main shaft, that can be adjusted to vary the length of stroke and the timing. See also slide.

627. **Natural draft.** Taper on the sides of a forging, due to its shape or position in the die, that makes added draft unnecessary.

628. **Near-net-shape (net-shape) forging**. Operations in which the part formed is close to the final dimensions of the desired component.

629. **Necking.** (1) The reduction of the cross-sectional area of metal in a localized area by uniaxial tension or by stretching. (2) The reduction of the diameter of a portion of the length of a cylindrical shell or tube.

630. **Negative stress (strain).** Compressive stress (strain) caused by compression.

631. **Nibbling**. Shearing operation when a machine called a nibbler moves a straight punch up and down rapidly into a die. The sheet metal is fed through the gap, and a number of overlapping holes are made.

632. **Nitriding.** Producing surface hardness in ferrous metals by adding nitrogen to the outside layer while heating the metal, in contact with ammonia gas or other suitable nitrogenous material, below the critical temperature range.

633. **No-draft (draftless) forging**. A forging with extremely close tolerances and little or no draft that requires minimal machining to produce the final part. Mechanical properties can be enhanced by closer control of grain flow and by retention of surface material in the final component.

634. **Nodular iron**. Iron with free graphite in the form of spheres rather than flakes.

635. **Nonferrous.** Metals or alloys that contain no appreciable quantity of iron; applied to such metals as aluminum, copper, magnesium,

and their alloys.

636. **Nonfill (underfill).** Occurs when the die impression is not completely filled with metal. Some causes are: improper distribution of metal in preforming operations such as fullering, edging, and blocking; excessive removal of material by chipping defects prior to finish forging; improper lubrication of die impression; low forging pressure; rough or uneven die finish; inadequate hammer or press capacity.

637. **Normal anisotropy (plastic anisotropy).** Property of sheet metal that influence drawability. It may be found as ratio of width strain to the thickness strain.

638. **Normal stress**. The normal component of a force per unit area of a plane on which it acts.

639. **Normalizing.** A heat treatment for steels that involves heating above the transformation temperature and cooling in air to refine grain size for better response to hardening heat treatments, to improve machinability, or to provide desired mechanical properties.

640. **Nosing.** Preliminary forging of the noses, projections or edges of the stock.

641. **Notch sensitivity.** The reduction in the impact, endurance, or static strength of a metal, caused by stress concentration as a result of scratches or other stress raisers on the surface.

642. **Notch toughness.** The resistance of a metal to crack propagation under applied stress. In fracture mechanics, notch toughness measurements help predict the type and size of flaw that will cause fracture in service.

643. **Notching.** Sheet metal operations involving restricted or partial cutting where a piece of scrap metal is removed from the edge of a blank or strip to form a notch.

644. **Null edge.** The normal edge produced in rolling. Can be contrasted with a blanked or sheared edge which has a burr.

645. **N-value.** See strain-hardening exponent.

646. **Off gage.** Deviation of thickness or diameter of a solid product beyond the standard or specified dimensional tolerances.

647. **Offal (**scrap). Wasted material obtained during metal working. See also skeleton.

648. **Offset forming**. Bending operation in a press brake when overall shape of sheet metal plate is changed by means of bending across several straight lines.

649. **Offset yield strength.** The stress at which the strain exceeds by a specified amount (the offset) an extension of the initial proportional portion of the stress-strain curve; expressed in force per unit area.

650. **Offset.** The distance along the strain coordinate between the initial portion of a stress-strain curve and a parallel line that intersects the stress-strain curve at a value of stress (commonly 0.2%) that is used as a measure of the yield strength. Used for materials that have

no obvious yield point.

651. **Oil canning.** Same as canning.

652. **Oil stain.** A stain produced by the incomplete burning of lubricant on the surface of a product.

653. **Olsen ductility test**. A cupping test in which a piece of sheet metal, restrained except at the center, is deformed by a standard steel ball until fracture occurs. The height of the cup at the time of fracture is a measure of the ductility.

654. **One-dimensional forming**. Here the medium of transfer contains the surface generating element a line or a surface area along the line of the desired surface which means that one relative motion is required to produce the surface, such as in direct or indirect extrusion or cogging.

655. **Open dies.** Dies with flat surfaces that are used for preforming stock or producing hand forgings.

656. **Open-die forging.** The hot mechanical forming of metals between flat or shaped dies in which metal flow is not completely restricted or there is no lateral constraint except for friction. Also known as hand or smith forging. See also flat die forging and hand forge (smith forge).

657. **Optical pyrometer.** An optical viewing device used to measure elevated temperature.

658. **Orange peel.** A surface roughening encountered in forming sheet-metal products from material that has a coarse grain size.

659. **Orbital forging.** See rotary forging.

660. **Originating process.** The process is one that produces the general configuration of the workpiece.

661. **Overbending**. Methods of bending to obtain the desired angle after springback.

662. **Overetch.** In the normal processing of aluminum forgings, a caustic etch operation is employed for the dual purpose of cleaning parts and emphasizing defects to facilitate visual inspection. Immersion of parts for too long or use of a too concentrated solution will produce a rough, slightly pitted surface.

663. **Overheated.** Metal with an undesirable coarse grain structure due to exposure to an excessively high temperature. Unlike a "burnt" structure, the metal is not permanently damaged but can be corrected by heat treatment and/or mechanical working.

664. **Overheating.** Can occur in preheat furnaces prior to forging or in the heat-treating operation. The condition results when metal temperature exceeds the critical temperature of the alloy involved and a change in phase occurs; this is also known as the transformation temperature. Externally, overheated material will often form blisters or a web of fine cracks; internally, overheating causes precipitation of melted constituents around grain boundaries and the formation of

rounded pools of melted constituents often called "rosettes."

665. **Pack rolling**. A flat-rolling operation in which two or more layers of metal are rolled together, thus improving productivity.

666. **Pad.** The general term used for that part of a die which delivers holding pressure to the metal being worked.

667. **Pancake forging.** A rough forged shape, usually flat, that can be obtained quickly with minimal tooling. Considerable machining is usually required to attain the finish size.

668. **Partially elastic body**. Body in which deformation produced by external forces does not disappear completely after unloading.

669. **Parting line.** (1) The dividing plane between the two dies used in forging metal. (2) The line along the edge of a forging where the dies meet, usually at the largest cross section of the part, or the line along the corresponding edge of the die impression. Flash is formed at the parting line.

670. **Parting plane.** The plane that includes the principal die face and is perpendicular to the direction of ram travel. When parting surfaces of the dies are flat, the parting plane coincides with the parting line. Also referred to as the forging plane.

671. **Parting**. (1) Sheetmetal operations for producing blanks whereby the shear cutting operation produces a small, scrap section. (2) The line around the periphery of a forging at which the flash has been forced out of the impression.

672. **Pass.** (1) A single transfer of metal through a stand of rolls. (2) The open space between two grooved rolls through which metal is processed. (3) A single step in multistep forging operation called cogging when the ingot, billet or bar is moved from one end toward the other during forging.

673. **Patenting**. Heat treating of the high-carbon steel wires for springs when the microstructure obtained is fine pearlite.

674. **Pearlite.** An iron-carbon alloy (about 0.80% carbon in a plain carbon steel) with a structure of alternate layers of ferrite and iron carbide.

675. **Peen forming**. Sheet metal working process used to produce curvatures on thin sheet metals by shot peening one surface of the sheet.

676. **Perforating.** The punching of many holes, usually identical and arranged in a regular pattern, in a sheet, workpiece blank, or previously formed part. The holes are usually round, but may be any shape. The operation is also called multiple punching. See also piercing.

677. **Permanent set.** The deformation or strain remaining in a previously stressed body after release of the load.

678. **Phase.** A physically homogeneous form of a metal or alloy.

679. **Physical properties.** Characteristics of materials that are of a

basic nature, such as density and electrical conductivity.

680. **Pickling.** The process of removing oxide scale from forgings by treating in a heated acid bath.

681. **Pick-up.** Small particles of oxidized metal adhering to the surface of a product (mill product).

682. **Pierce.** In ring rolling, the process of providing a through hole in the center of an upset forging as applied to ring blank preparation.

683. **Piercing.** (1) General term for cutting (shearing or punching) openings, such as holes and slots, in sheet material, plate, or parts. This operation is similar to blanking; the difference is that the slug or piece produced by piercing is scrap, while the blank produced by blanking is the useful part. (2) Open-die forging operation involving impressing an indentation into the workpiece.

684. **Pilger mill**. The operation of tube rolling when the tube and mandrel undergo a reciprocating motion. The rolls are specially shaped and re rotated continuously.

685. **Pilger tube-reducing process.** See tube reducing.

686. **Pilot**. To locate the strip accurately before punches start cutting or forming.

687. **Pinch trimming.** The trimming of the edge of a tubular part or shell by pushing or pinching the flange or lip over the cutting edge of a stationary punch or over the cutting edge of a draw punch.

688. **Pipe.** A cavity formed in metal (especially ingots) during the solidification process by the contracting of that part of the liquid metal which is the last to solidify.

689. **Pit.** A sharp depression or hole in the surface of metal.

690. **Plan view area.** The area of the plan view of a forging; sometimes used to indicate the relative size of the forging.

691. **Planar.** A two-dimensional structure in X-Y space with no variation in the third direction. The mechanics conditions may be either plane stress, plane strain, or generalized plane strain.

692. **Plane strain.** The mechanics characteristic defined by no variation in the thickness direction, with the direct strains in the thickness direction equal to zero (one of the normal strains and the two related shearing strains are equal to zero).

693. **Plane stress.** A biaxial state of stress (sheetmetal stretching) when one of the normal stresses and the two associated shear stresses are equal to zero.

694. **Plane, forging.** The plane that includes the principal die face and that is perpendicular to the direction of the ram stroke; when the parting is flat, the forging plane coincides with the parting line. See also Forging plane.

695. **Plane-Strain Compression Test**. In this test, a thin sheet is indented between long narrow dies.

696. **Plane-strain sidepressing test**. A test when a relatively short

cylinder is compressed parallel to its axis. This test is used for the evaluation of the ductility of a material rather than its resistance to deformation.

697. **Plane-strain tension test.** A test when a plane-strain tensile specimen with deep grooves designed to restrict the deformation to the grooved region is subjected to tension.

698. **Planishing.** A finishing operation to remove the trim line of a forging or to obtain closer tolerances. Usually done by hot or cold rolling, pressing, or hammering.

699. **Plastic deformation.** The permanent (inelastic) distortion (change) of metals under applied stresses (forces) that strain the material beyond its elastic limit. The ability of metals to flow in a plastic manner without fracture is the fundamental basis for all metal-forming processes.

700. **Plastic flow.** The phenomenon that takes place when metals or other substances are stretched or compressed permanently without rupture.

701. **Plastic strain.** The amount of inelastic strain that remains after a material is unloaded.

702. **Plasticity.** The ability of a metal to undergo permanent deformation without rupture.

703. **Plastic-strain ratio** (***r***-value). The ratio of the true width strain to the true thickness strain in a sheet tensile test. A formability parameter that relates to drawing, it is also known as the anisotropy factor. A high ***r***-value indicates a material with good drawing properties.

704. **Platen.** The sliding member, slide, or ram of a press.

705. **Platter.** The entire mass of metal (workpiece) upon which the forging equipment (hammer) performs work, including the flash, sprue, tonghold, and as many forgings as are made at a time.

706. **Plug**. (1) A rod or mandrel over which a pierced tube is forced. (2) A rod or mandrel that fills a tube as it is drawn through a die. (3) A punch or mandrel over which a cup is drawn. (4) A protruding portion of a die impression for forming a corresponding recess in the forging. (5) A false bottom in a die.

707. **Plyer**. A carriage, which pulls the rod through al the zones of the die hole of a drawbench where it undergoes deformation.

708. **Pointing**. Swaging operation to tapering the tip of a cylindrical part.

709. **Poisson's ratio.** The ratio of lateral unit deformation to longitudinal unit deformation within the elastic limit during a uniaxial tension or compression test. Also called the "factor of lateral contraction"; a body that is stretched lengthwise becomes thinner crosswise. Poisson established by experiment that, within the elastic limit, the ratio of the length of stretch or squeeze to the length by which a body of given material is decreased or increased in crosswise thickness is a

constant; for aluminum, Poisson's ratio is an average of approximately 0.33.

710. **Polish (stock preparation).** Grind or polish surfaces to remove scratches, scars, and marks left by cutting equipment; operation usually performed by a flexible shaft machine with an abrasive disk.

711. **Polishing.** A mechanical finishing operation to apply a gloss or luster to the surface of a product.

712. **Porthole dies**. Special dies for extrusion of intricate hollow shapes, in which metal divides and flows around the supports for the internal mandrel into strands. These strands are then rewelded under the high pressures in the welding chamber before exiting through the die.

713. **Positive stress (strain).** Tensile stress (strain) caused by extension

714. **Pouring reel**. Type of the reel for receiving finished rod during rod drawing when the reel revolves and is synchronized to the finishing speed of the rod mill.

715. **Powder forging.** The plastic deformation of a powder metallurgy compact or preform into a fully dense finished shape by using compressive force; usually done hot and within closed dies.

716. **Powder metals.** Metals and alloys in the form of fine particles (usually in the range of 1 to 1000 (Jim). Shaped objects can be produced from powders by compaction and bonding of the particles under high pressures and temperatures

717. **Power-driven hammer.** A forging hammer with a steam or air cylinder for raising the ram and augmenting its downward blow.

718. **Precipitation hardening.** A heat treatment that develops an increase in strength and hardness by precipitation of a constituent from a supersaturated solid solution. This is a common form of heat treatment for aluminum alloys.

719. **Precision forging.** A forging produced to closer tolerances than normally considered standard by the industry.

720. **Preform.** (1) The forging operation in which stock is preformed or shaped to a predetermined size and contour prior to subsequent die forging operations; the operation may involve drawing, bending, flattening, edging, fullering, rolling, or upsetting. The preform operation is not considered to be a scheduled operation unless a separate heat is required; when a preform operation is required, it will precede a forging operation and will be performed in conjunction with the forging operation and in the same heat. In ring rolling, a term generally applied to ring blanks of a specific shape to be used for profile (contour) ring rolling. (2) The initially pressed powder metallurgy com-pact to be subjected to repressing. (3) The original shape of the material before manufacturing begins.

721. **Preheating.** A high-temperature soaking treatment used to

change the metallurgical structure in preparation for a subsequent operation, usually applied to the ingot.

722. **Preparation charge.** A one-time charge covering the cost of sinking dies and preparing required auxiliary tooling for producing forgings to a particular design. In usual practice, this charge conveys to the customer the exclusive right to purchase forgings produced on this tooling. The dies themselves are the property of the forger, who also has the responsibility for maintaining and replacing the dies as required for satisfactory production of forgings.

723. **Prepierce.** In ring rolling, a vertically mounted piercing (punching) tool used for preparation of ring blanks on the ring blank press, a tapered tool of various diameters and lengths.

724. **Press brake.** An open-frame single-action press used to bend, blank, corrugate, curl, notch, perforate, pierce, or punch sheet metal or plate.

725. **Press capacity.** The rated force a press is designed to exert at a predetermined distance above the bottom of the stroke of the slide.

726. **Press data.** The characteristics of the forging machine such that the die stroke versus angle may be determined.

727. **Press direction.** Direction in which the die moves.

728. **Press forging.** Shaping of metal between dies by mechanical or hydraulic presses. Usually this is accomplished with a single work stroke of the press at each die station

729. **Press forming.** Any sheet metal forming operation performed with tooling by means of a mechanical or hydraulic press.

730. **Press load.** The amount of force exerted in a given forging or forming operation.

731. **Press slide.** See slide.

732. **Press.** A machine tool with a stationary bed and a slide or ram that has reciprocating motion at right angles to the bed surface; the slide is guided in the frame of the machine.

733. **Pressure plate.** A plate located beneath the bolster that acts against the resistance of a group of cylinders mounted to the pressure plate to provide uniform pressure throughout the press stroke when the press is symmetrically loaded.

734. **Pre-stage Cooling.** Time period while moving workpiece to table during which convective cooling occurs.

735. **Primary processes.** The function of such processes is to provide the semifinished shapes that have the necessary configuration, dimensions, and properties that will be suitable for the subsequent, secondary processing whether by additional forming, welding, machining, heat treating, or whatever

736. **Principal axis.** The direction in which a principal stress acts.

737. **Principal plane.** A plane normal to a principal axis.

738. **Principal stresses**. Stresses which remains when the axes are

rotated so that the shear stresses on each face of the elemental cube are all zero.

739. **Principal Values.** The eigenvalues of the stress or strain tensor. The values are often used to determine if or when fracture would occur.

740. **Process annealing.** Heating iron-base alloys to a temperature at, or close to, the lower limit of the critical range and then cooling as desired, usually for stress relief.

741. **Profile (contour) rolling.** In ring rolling a process to produce seamless rolled rings with a predesigned shape either on the outside or the inside diameter, requiring less volume of material and less machining to produce finished parts.

742. **Progression.** The constant dimension between adjacent stations in a progressive die.

743. **Progressive die.** A die with two or more stations arranged in line for performing two or more operations on a part; one operation is usually performed at each station.

744. **Progressive forming.** Sequential forming at consecutive stations with a single die or separate dies.

745. **Proof load.** A predetermined load, generally some multiple of the service load, at which a product will just begin to permanently deform or load, to which a specimen or structure is submitted before acceptance for use. Rated working loads of a part are commonly based on a percentage of the proof load. Since proof-load tests are nondestructive, they can be used to establish product integrity.

746. **Proof stress.** (1) The stress that will cause a specified small permanent set in a material. (2) A specified stress to be applied to a member or structure to indicate its ability to withstand service loads.

747. **Proof.** Any reproduction of a die impression in any material, frequently a lead or plaster cast. See also Die proof.

748. **Proportional limit.** The greatest stress a material is capable of developing without a deviation from straight-line proportionality between stress and strain. See also elastic limit and Hooke's law.

749. **Puckering**. A wrinkling of the drawn cup wall.

750. **Pull-through slitting equipment**. When the strip is pulled through idling blades.

751. **Punch.** (1) The male part of a die—as distinguished from the female part, which is called the die. The punch is usually the upper member of the complete die assembly and is mounted on the slide or in a die set for alignment (except in the inverted die). (2) In double-action draw dies, the punch is the inner portion of the upper die, which is mounted on the plunger (inner slide) and does the drawing. (3) The movable die in a press or forging machine. (4) The act of piercing or punching a hole. Punch is a shearing operation to remove a section of metal as outlined by the inner parting line in a

blocked or finished forging; the operation is generally performed on a trim press using a punch die. Also referred to as punching. (5) A tool used in punching holes in metal.

752. **Punching.** (1) The die shearing of a closed contour in which the sheared out sheet metal part is scrap. (2) Open die forging operation when the surface of a workpiece is broken through with a punch.

753. **Punchout rigging.** The parts required to fasten the punch and plates to the press.

754. **Punchout.** A pierced hole in a forging.

755. **Pure or tensor shear strain**. Strain defined as the change in angle between two line segments within or scribed on the surface of a body, which were mutually perpendicular or at right angles in the undeformed state.

756. **Pusher furnace.** A continuous-type furnace where stock to be heated is charged at one end, carried through one or more heating zones, and discharged at the opposite end.

757. **Quantity tolerance.** Allowable variation of quantity to be shipped on a purchase order, agreed on by the forging producer and purchaser when the order is placed. (A schedule of suggested standard quantity tolerances for various order quantities is available from the Forging Industry Association.)

758. **Quasi-static stress-strain curve.** Curve obtained at a rather low strain rate such as about 10^{-3}/s which is typical of a slow speed testing machine.

759. **Quenching.** Rapid cooling from a high temperature by contact with liquids, gases, or solids. The cooling rate during quenching is important in heat treatment because it controls the degree of hardening of most alloys

760. **Radial draw forming.** The forming of sheet metals by the simultaneous application of tangential stretch and radial compression forces. The operation is done gradually by tangential contact with the die member. This type of forming is characterized by very close dimensional control.

761. **Radial forging (rotary swaging).** A process using two or more moving anvils or dies for producing shafts with constant or varying diameters along their length or tubes with internal or external variations in diameter. Often incorrectly referred to as rotary forging.

762. **Radial roll (main roll, king roll).** The primary driven roll of the rolling mill for rolling rings in the radial pass. The roll is supported at both ends.

763. **Radial rolling force.** The action produced by the horizontal pressing force of the rolling mandrel acting against the ring and the main roll. Usually expressed in metric tons.

764. **Radial-axial ring rolling mill (RAW or RW).** A type of ring forging equipment for producing seamless rolled rings by controlling the

outside diameter, the inside diameter, and the ring height (axial height).

765. **Radius.** To remove sharp edges or corners of forging stock by means of a radius or form tool (radius ***OE***: radius one end; radius ***BE***: radius both ends).

766. **Ram.** The moving or falling part (The dropping weight) of a drop hammer or the power-actuated platen of a press to which one of the dies (the moving die) is attached; sometimes applied to the upper flat die of a steam hammer. Also referred to as the slide.

767. **Ram-force capacity**. Capacity which delivered by the ram.

768. **Recoil line.** See impact line.

769. **Recovery.** Removal of residual stresses in strain-hardened metals without substantial change in grain structure

770. **Recrystallization.** The formation of a new grain structure either by annealing a cold-worked metal or by heating a metal above its transformation temperature

771. **Redrawing.** The second and successive deep-drawing operations in which cuplike shells are deepened and reduced in cross-sectional dimensions. In reverse redrawing the cup is subjected to bending in the direction opposite to its original bending configuration.

772. **Reducing.** Forging operation when a bar or a rod is pushed through the matrix for the purpose of reduction of a cross section.

773. **Reducing atmosphere.** Combustion in a furnace where there is no excess oxygen or a deficiency of oxygen; also termed "wet fire."

774. **Reduction of area (contraction of area).** A tensile ductility parameter that measures the ability of a material to deform plastically in a localized fashion. It is **t**he difference, in a tension specimen, between the size of the original sectional area and that of the area at the point of rupture. It is generally stated as the percentage of decrease of cross-sectional area of a tension specimen after rupture.

775. **Reduction of the metal in extrusion**. The ratio of the difference between the cross-sectional areas of the container and die opening to the cross-sectional area of the container.

776. **Reduction.** (1) In cupping and deep drawing, a measure of the percentage of decrease from blank diameter to cup diameter, or of the diameter reduction in redrawing. (2) In forging, extrusion, rolling, and drawing, either the ratio of the original to the final cross-sectional area or the percentage of decrease in cross-sectional area.

777. **Redundancy factor.** Factor which relates the ideal or lossless deformation to the actual.

778. **Redundant work.** An unnecessary work or energy loss resulting due to internal macroshearing or internal friction losses. An element during the process of deformation may shear forward, then backward again producing such losses. The redundant work consists of friction component which causes macroscopic shearing of the outer layers of

the material relative to the inner layers but does not include surface sliding, and the geometric component which causes shearing and unshearing (bending and unbending), because of the difference in the velocities of metal flow from one section to another.

779. **Refining temperature or heat.** A temperature employed in heat treating to refine grain structure – in particular, grain size.

780. **Reflectoscope.** A nondestructive inspection instrument in which internal quality of forgings or stock is evaluated through the utilization of high-frequency sound.

781. **Refractory metals.** The group of metals with melting points above 3400 °F that offer the highest elevated-temperature engineering properties of commercially available metals; most commonly, columbium, tantalum, molybdenum, tungsten, and their alloys.

782. **Refractory.** Heat-resistant material, usually nonmetallic, used for furnace linings.

783. **Reheating.** A thermal operation designed solely to heat stock for hot working; in general, no metallurgical changes are intended.

784. **Relaxation.** The type of creep deformation when a spontaneous alteration of stresses occur under a constant strain.

785. **Release.** The process by which two bodies are allowed to separate from one another. Upon separation, the forces which resisted the other body/surface are redistributed within the body.

786. **Repressing.** The application of pressure to a sintered compact; usually done to improve a physical or mechanical property or for dimensional accuracy.

787. **Rerolling quality.** Rolled billets from which the surface defects have not been removed or completely removed.

788. **Reset.** Realign or adjust dies or tools during a production run; not to be confused with "setup," an operation performed prior to a production run.

789. **Residual alloys.** Elements present in a metal in minute quantities but not added intentionally

790. **Residual Forces.** The out of equilibrium forces in the body due to the linearized solution of the nonlinear equilibrium equations.

791. **Residual stress.** Stresses that are present in a free metal body, usually as a result of nonuniform plastic deformation or severe temperature gradients during quenching (heating and cooling) after all loads have been removed. These stresses often may be removed through annealing.

792. **Resink designation.** Identification of a duplicate set of dies made to supplement or replace a die set.

793. **Restrike on draw.** Restriking a forging on the tempering heat of a heat treatment to produce closer alignment of sections.

794. **Restrike.** A salvage operation following a primary forging operation in which the parts involved are rehit in the same forging die in

which the pieces were last forged.

795. **Restriking.** (1) The striking of a trimmed but slightly misaligned or otherwise faulty forging with one or more blows to improve alignment, improve surface condition, maintain close tolerances, increase hardness, or effect other improvements. (2) A sizing operation in which coining or stretching is used to correct or alter profiles and to counteract distortion. (3) A salvage operation following a primary forging operation in which the parts involved are rehit in the same forging die in which the pieces were last forged.

796. **Reverse drawing.** Redrawing of a sheet metal part in a direction opposite to that of the original drawing.

797. **Reverse flange.** A sheet metal flange made by shrinking, as opposed to one formed by stretching.

798. **Reversing mill.** Rolls which can be reversed after each pass.

799. **Rib.** (1) A forged wall or brace projecting generally in a direction parallel to the ram stroke. (2) A long V-shaped or radiused indentation used to strengthen large sheet metal panels. (3) A long, usually thin protuberance used to provide flexural strength to a forging (as in a rib-web forging). See also Web.

800. **Rigid tool.** The tools which are used to shape the workpiece. No deformation of the tools exist, so while the user obtains the force on the surface, the user does not obtain the stresses in the tool. A rigid tool is composed of curves.

801. **Ring compression test.** Test when the changes are produced in the inner and outer diameters of a short, hollow cylinder during axial compression between flat, rigid parallel platens. This test can be used for two purposes: to evaluate the flow stress of a given material, and to evaluate the Coulomb coefficient of friction.

802. **Ring rolling.** The process of shaping preform, usually weldless rings from pierced disks or thick-walled, ring-shaped blanks between rolls that control wall thickness, ring diameter, height, and contour. This forging process reduces the ring wall section while increasing the diameter.

803. **Robert lines.** See Luders lines.

804. **Rockwell hardness testing.** A method of determining the relative hardness value of a material by measuring the depth of residual penetration by a steel ball or diamond point under controlled loading.

805. **Rod.** A solid round section 9.5 mm or greater in diameter, whose length is great in relation to its diameter.

806. **Roll bending**. Bending operation when plates, sheets, bars, and sections are bent (curved) by adjustable and driven rolls.

807. **Roll flattening.** The flattening of sheets that have been rolled in packs by passing them separately through a two-high cold mill with virtually no deformation. Not to be confused with roller leveling.

808. **Roll (die) forging.** The process of shaping stock between power

driven rolls bearing contoured dies (roll die). The workpiece is introduced from the delivery side of the rolls, and is reinserted for each succeeding pass. Usually used for preforming, roll forging is often employed to reduce thickness and increase length of stock.

809. **Roll forming.** Metal forming through the use of power-driven rolls whose contour determines the shape of the product; sometimes used to denote power spinning.

810. **Roll straightening.** The straightening of metal stock of various shapes by passing it through a series of staggered rolls (the rolls usually being in horizontal and vertical planes) or by reeling in two-roll straightening machines.

811. **Roll threading.** The production of threads by rolling the piece between two grooved die plates, one of which is in motion, or between rotating grooved circular rolls.

812. **Roller (rolling impression).** The portion of a forging die where cross sections are altered by hammering or pressing while the workpiece is being rotated.

813. **Roller leveler breaks.** Obvious transverse breaks on sheet metal usually about 3 to 6 mm apart that are caused by the sheet fluting during roller leveling. These will not be removed by stretching.

814. **Roller leveling.** Leveling by passing flat sheet metal stock through a machine having a series of small-diameter staggered rolls that are adjusted to produce repeated reverse bending.

815. **Rolling edger.** A combined edger and roller, employed for the distribution of metal in preparation for the finishing operation.

816. **Rolling mandrel.** In ring rolling, a vertical roll of sufficient diameter to accept various sizes of ring blanks and to exert rolling force on an axis parallel to the main roll.

817. **Rolling mills.** Machines used to decrease the cross-sectional area of metal stock and to produce certain desired shapes as the metal passes between rotating rolls mounted in a framework comprising a basic unit called a stand. Cylindrical rolls produce flat shapes; grooved rolls produce rounds, squares, and structural shapes. See also four-high mill, Sendzymir mill, and two-high mill.

818. **Rolling table.** Serves to carry the ring during the rolling process of the ring rolling mill. The table is horizontally displaceable with the rolling mandrel.

819. **Rolling.** (1) The forging operation of working a bar between contoured dies while turning it between blows to produce a varying circular cross section. (2) The reduction of the cross-sectional area of metal stock, or the general shaping of metal products by compressive forces, through the use of a set of rotating rolls similar to rolling dough with a rolling pin to reduce its thickness.

820. **Rope hammer.** A gravity-powered forging hammer with ropes for raising the ram and upper die.

821. **Rotary forging.** A process in which the workpiece is pressed between a flat anvil and a swiveling (rocking) die with a conical working face; the upper die moves along an orbital path and the platens move toward each other during forging; the part is formed incrementally. Also called orbital forging. Compare with radial forging.
822. **Rotary furnace.** A circular furnace constructed so that the hearth and work-pieces rotate around the axis of the furnace during heating.
823. **Rotary shear.** A sheet metal cutting machine with two rotating-disk cutters mounted on parallel shafts driven in unison.
824. **Rotary swager.** (1) A swaging machine consisting of a power-driven ring that revolves at high speed, causing rollers to engage cam surfaces and force the dies to deliver hammerlike blows on the work at high frequency. Both straight and tapered sections can be produced. (2) A bulk forming process for reducing the cross-sectional area or otherwise changing the shape of bars, tubes, or wires by repeated radial blows with one or more pairs of opposed dies.
825. **Rotary tube piercing (Mannesmann process**). A hot-working process for making long, thick-walled seamless tubing and pipe based on the subjecting of a round bar to radial compressive forces by means of arrangement of rotating rolls and by expanding the hole by means of mandrel.
826. **Rotation**. Motion (usually of pure rigid body) causing angular displacement.
827. **Rough blank.** A blank for a forming or drawing operation, usually of irregular outline, with necessary stock allowance for process metal, which is trimmed after forming or drawing to the desired size.
828. **Rough machine.** Remove excess or undesired metal from forgings or from forging stock in process by means of machine tools such as lathes and boring mills. The term includes most machining operations other than scalping.
829. **Roughing stand.** The first stand (or several stands) of rolls through which a reheated billet passes in front of the finishing stands. See also rolling mills and stand.
830. **Rub mark.** A minor form of scratching consisting of areas made up of large numbers of very fine scratches or abrasions.
831. **Rubber-pad forming (rubber forming)**. A sheet metal forming operation for shallow parts in which a confined, pliable rubber pad attached to the press slide (ram) is forced by hydraulic pressure to become a mating die for a punch or group of punches placed on the press bed or baseplate. Developed in the aircraft industry for the limited production of a large number of diversified parts, the process is limited to the forming of relatively shallow parts, normally not exceeding 40 mm (1.5 in.) deep. Also known as the Guerin process. Variations of the Guerin process include the Marforming process, the fluid-cell process, and fluid forming.

832. **Ruptured metal.** Forging stock, particularly on very thin sections, that has been hammered so severely as to cause broken fibers in the metal.
833. **Saddling (mandrel forging).** The process of rolling and forging a pierced disk of stock over a mandrel to produce a weld-less ring.
834. **Sand blasting.** The process of cleaning forgings by propelling sand against them at high velocity. See also Blast cleaning.
835. **Saw trim.** The operation of removing flash from blocker or finished forgings by means of handsaw equipment.
836. **Scale pit.** A surface depression formed on a forging due to scale in the dies during the forging operation.
837. **Scale.** The oxide film (surface layer) that is formed on forgings, or other heated metal, by chemical action between the surface metal and oxygen in the air. Steel forging scale is loosely adherent and easily removed.
838. **Scalping.** Machining operation in which the outside surface of rolled, pressed, or cast stock is removed to eliminate surface defects.
839. **Scarfing**. Conditioning of the surface of the material of the hot rolling blooms, billets and slabs for a subsequent operation prior to rolling.
840. **Scleroscope hardness testing.** A method of measuring hardness of metal by the drop and rebound of a diamond-tipped hammer.
841. **Scoring**. (1) The marring or scratching of any formed part by metal pickup on the punch or die. (2) The reduction in thickness of a material along a line to weaken it intentionally along that line.
842. **Scratch.** A visible linear indentation caused by a sharp object passing over the surface.
843. **Screw dislocation**. A defect of a crystal structure the end of the crystal is partially sheared one atomic dimension sidewise.
844. **Screw press.** A high-speed press in which the ram is activated by a large screw assembly that is powered by various types of drive mechanisms. Usually screw presses derive their energy from a flywheel; hence they are energy limited.
845. **Seam.** A longitudinal surface defect in the form of a seam that appears on a forging when opened by the forging action; a crack or inclusion on the surface of a forging. If very fine, termed a hair seam or hair crack.
846. **Seaming**. Bending operation in a press brake for sheet metal assembling.
847. **Seams**. Type of defect in drawing which are longitudinal scratches or folds in the material.
848. **Secant modulus.** The slope of the secant drawn from the origin to any specified point on the stress-strain curve. See also modulus of elasticity.
849. **Secondary metalworking processes.** Subsequent to primary

processes that will produce the final configuration of the desired part.

850. **Segment die.** Same as split die.

851. **Segregation.** A nonuniform distribution of alloying elements in a metal that occurs during solidification of an ingot or shape casting.

852. **Sejournet process**. Process of lubrication during extrusion when a circular glass pad is placed at the die entrance. This pad acts as a reservoir of molten glass and supplies it as a lubricant.

853. **Semifinisher (semifinishing impression).** An impression in the forging die that only approximates the finish dimensions of the forging. Semifinishers are often used to extend die life of the finishing impression, to ensure proper control of grain flow during forging, and to assist in obtaining desired tolerances.

854. **Seminotching.** Sheetmetal operations involving restricted or partial cutting where a piece of scrap metal is removed from the central portion of a strip to facilitate subsequent bending or for providing part attachment along the edges of a skeleton for progressive forming.

855. **Sendzimir mill.** A type of cluster mill with small-diameter work rolls and larger-diameter backup rolls, backed up by bearings on a shaft mounted eccentrically so that it can be rotated to increase the pressure between the bearing and the backup rolls. Used to roll precision and very thin sheet and strip.

856. **Separation force.** The force at which two bodies separate. In theory, two bodies would separate for any tensile force, neglecting cohesive forces. Too small of a force results in a chattering process as the bodies separate and recontact.

857. **Set hammer.** Forming tool used to make smooth, flat surfaces, especially in small areas. See also Flatter.

858. **Setting**. (1) A twisting deformation of a solid or tubular body about an axis for the purpose of exact positioning of elements of the part relative to axis. (2) See bottoming.

859. **Setup.** Preparing equipment or unit for operation; includes miscellaneous rearrangement of auxiliary facilities such as conveyors, skids, and hand tools.

860. **Shank.** The portion of the die or tool by which it is held in position in the forging unit or press.

861. **Shape factor**. A factor describing the complexity of an extrusion whish is a function of the ratio of the perimeter of the extruded product to its cross-sectional area.

862. **Shape fixability**. Workability limit criterion which confines ability of a ready part to maintain the desirable shape.

863. **Shaping**. A process of a changing the shape usually of nonsolid body which involves molding or casting. The resulting product is usually at or near the final desired shape, and may require little or no further finishing operations.

864. **Shaving**. Sheetmetal operations/or size control involving the cut-

ting off of metal in a chiplike fashion to remove the rough fractured edge of the sheet and to obtain accurate dimensions.

865. **Shear** (**defect**). An indirect result of mismatch, a shearing action can occur: (1) by restriking mismatched forgings, or (2) by restriking in misaligned dies. The first way is more common, as it is generally employed as a remedial action for mismatched parts. The severity of the shear depends on the amount of mismatch on the parts; the acceptance or rejection of parts so treated depends on the resulting effect on forging dimensions. Because forging dies may wander "off match," restriking in misaligned dies can occur at die setup or at any time during the operation.

866. **Shear die**. (1) dies used in shearing operation such as blanking and punching (2) Square dies usually used in extrusion of nonferrous metals, especially aluminium.

867. **Shear Friction.** A friction model for the resisting shear friction that is proportional to the flow stress of the material.

868. **Shear modulus (modulus of rigidity) *G*.** A ratio of shear stress to shear strain.

869. **Shear spinning (power spinning, flow turning, hydrospinning or spin forging).** Process of plastic working of metal producing parts to a predetermined geometrical shape by displacing metal in advance of a roller that is fed along a mandrel machined to the desired inside diameter of the part. Usually, hydraulic pressure is used to force the roller against the part and for clamping the blank to the tailstock. In this process, the metal is displaced in the direction of the feed of the roller along the length of the mandrel.

870. **Shear strength.** The maximum shear stress a material can sustain. Shear strength is calculated from the maximum load during a shear or torsion test and is based on the original dimensions of the cross section of the specimen.

871. **Shear stress.** (1) A stress that exists when parallel planes in metal crystals slide across each other. (2) The stress component tangential to the plane (surface) on which the forces act.

872. **Shear.** (1) A machine or tool for cutting metal and other material by the closing motion of two sharp, closely adjoining edges; for example, squaring shear and circular shear. (2) An inclination between two cutting edges, such as between two straight knife blades or between the punch cutting edge and the die cutting edge, so that a reduced area will be cut each time. This lessens the necessary force and distributes the load over a greater portion of the stroke, but increases the required length of the working stroke. This method is referred to as angular shear. (3) The act of cutting by shearing dies or blades, as in a squaring shear. (4) The type of force that causes or tends to cause two contiguous parts of the same body to slide relative to each other in a direction parallel to their plane of contact.

873. **Shearing.** (1) A process of mechanically cutting metal bars when one blade forces the material past an opposing blade to the proper stock length necessary for forging the desired product. See also cropping. (2) Shearing is a sheet-metal operations for producing blanks where the shear cutting action is along a straight line as opposed to cut-off.

874. **Sheet forming.** The plastic deformation of a piece of sheet metal by tensile loads into a three-dimensional shape, often without significant changes in sheet thickness or surface characteristics. Compare with bulk forming.

875. **Sheet.** Any material or piece of uniform thickness and of considerable length and width as compared to its thickness. With regard to metal, such pieces under 6.5 mm (1/4 in.) thick are called sheets, and those 6.5 mm thick and over are called plates. Occasionally, the limiting thickness for steel to be designated as sheet steel is No. 10 Manufacturer's Standard Gage for sheet steel, which is 3.42 mm (0.1345 in.) thick.

876. **Shim.** A thin piece of material used between two surfaces to obtain a proper fit, adjustment, or alignment.

877. **Shipping tolerance.** See Quantity tolerance.

878. **Shoe.** A holder used as a support for the stationary portions of forging and trimming dies.

879. **Short transverse (ST) specimen**. The specimen taken parallel to the edge and perpendicular to the rolled surfaces.

880. **Shotblasting.** A process of cleaning forgings by propelling metal shot at high velocity by air pressure or centrifugal force at the surface of the forgings. See also Blast cleaning.

881. **Shrink flanging**. Process of bending the edges of sheet metals when the flange is subjected to compressive hoop stresses which cause the flange edges to wrinkle.

882. **Shrink scale.** A measuring scale or rule, used in die layout, on which graduations are expanded to compensate for thermal contraction (shrinkage) of the forging during cooling.

883. **Shrinkage.** The contraction of metal during cooling after hot forging. Die impressions are made oversize according to precise shrinkage scales to allow the forgings to shrink to design dimensions and tolerances.

884. **Shut height.** For a press, the distance from the top of the bed to the bottom of the slide with the stroke down and adjustment up. In general, it is the maximum die height that can be accommodated for normal operation, taking the bolster plate into consideration.

885. **Side thrust.** Lateral force exerted between the dies by reaction of the forged piece on the die impressions.

886. **Single-stand mill.** A rolling mill designed such that the product contacts only two rolls at a given moment. Contrast with tandem mill.

887. **Sink Temp.** The environmental temperature associated with convective thermal boundary conditions.
888. **Sinking.** The operation of machining the impression of the desired forging into the forging dies.
889. **Sintering.** The densification and bonding of adjacent particles in a powder mass or compact by heating to a temperature below the melting point of the main constituent.
890. **Sizing (coining).** The operation in a coining press performed in order to obtain closer tolerances on portions of a forging. (1) Secondary forming or squeezing operations needed to square up, set down, flatten, or otherwise correct surfaces to produce specified dimensions and tolerances. See restriking. (2) Some burnishing, broaching, drawing, and shaving operations are also called sizing. (3) A finishing operation for correcting quality in tubing or a process employed to control precisely a diameter of rings or tubular components. (4) Final pressing of a sintered powder metallurgy part.
891. **Sizing pass**. A light reduction which is taken on rod to improve surface finish and dimensional accuracy.
892. **Skeleton (scrap, scrap skeleton)**. The waste metal, sometimes called offal, which is scrapped after being removed from the slag or sheet blank or strip. See also offal.
893. **Skew rolling**. A process similar to roll forging typically used for making ball bearings when round wire or rod stock is fed into the roll gap, and roughly spherical blanks are formed continuously by the rotating rolls.
894. **Slab method**. The method when the equilibrium of a slab of the deformed body is considered, in which a simplified stress distribution such as plane strain is assumed for the slab. The governing equilibrium equations in the direction of the principal stresses are solved, and an approximate solution for the forming forces and stresses is obtained.
895. **Slab.** A flat-shaped semifinished rolled metal ingot with a width not less than 250 mm (10 in.) and a cross-sectional area not less than 105 cm^2 (16 $in.^2$).
896. **Slabbing.** The hot working of an ingot to a flat rectangular shape.
897. **Slide adjustment.** The distance that a press slide position can be altered to change the shut height of the die space. The adjustment can be made by hand or by power mechanism.
898. **Slide.** The main reciprocating member of a press, guided in the press frame, to which the punch or upper die is fastened; sometimes called the ram. The inner slide of a double-action press is called the plunger or punch-holder slide; the outer slide is called the blank-holder slide. The third slide of a triple-action press is called the lower slide, and the slide of a hydraulic press is often called the platen.
899. **Slip.** The ultimate shear displacement of discrete sections of a

crystal relative to other adjacent sections. It usually takes place on the densest or closest-packed atomic planes and in the densest atomic direction.

900. **Slip-line**. Orthogonal net of theoretical lines in deformed material which follow maximum shear stress directions.

901. **Slitting.** (1) Cutting or shearing along single lines to cut strips from a sheet or to cut along lines of a given length or contour in a sheet or workpiece. (2) Sheet metal operations/or size control where the cutting of a wide coil into several narrow coils in a rotary shear called a slitter.

902. **Sliver.** A slender fragment or splinter that is a part of the material, but that is incompletely attached. A torn fiber of metal forced into the surface of a forging.

903. **Slot furnace.** A common batch-type forge furnace where stock is charged and removed through a slot or opening.

904. **Slotting**. Sheet metal operations/or shear cutting holes where the cutting or shearing action forms elongated or square holes.

905. **Slug.** (1) The metal removed when punching a hole in a forging; also termed punchout. (2) The forging stock for one workpiece cut to length. See also blank.

906. **Smith forging.** See Flat or hand forge (smith forge).

907. **Smith hammer.** Any power hammer where impression dies are not used for the reproduction of commercially exact forgings.

908. **Snag grinding (snagging).** The process of removing portions of forgings not desired in the finished product, by grinding.

909. **Snip vents.** An operation to remove metal projections resulting from vents in the die cavity and where such an operation is an independently scheduled operation and not performed in conjunction with the forging operation.

910. **Soaking.** A heating process during which metal is held at an elevated temperature for the length of time sufficient for the attainment of uniform temperature throughout the material, or for homogenization of elements.

911. **Solution heat treatment.** A process in which an alloy is heated to a suitable temperature, held at this temperature long enough to allow a certain constituent to enter into solid solution, and then cooled rapidly to hold the constituent in solution. The metal is left in a supersaturated, unstable state and may subsequently exhibit age hardening.

912. **Sonic testing.** See also Ultrasonic testing.

913. **Sow block.** Metal die holder – a block of heat-treated steel placed between the anvil of the hammer and the forging die to prevent undue wear and shock to the anvil. Sow blocks are occasionally used to hold insert dies. Also called anvil cap.

914. **Space lattice.** A regular or periodic array of points in space over large intervals as compared to the distance between the points, and

each point is so arranged that it has identical surroundings.

915. **Spall.** The cracking off or flaking of small particles of metal from the surface.

916. **Special tolerance.** Any tolerance that is closer or wider than "standard."

917. **Spheroidizing.** A form of annealing consisting of prolonged heating of iron-base alloys at a temperature in the neighborhood of, but generally slightly below, the critical range, usually followed by a relatively slow cooling. Spheroidizing causes the graphite to assume a spheroidal shape, hence the name.

918. **Spider dies**. Special dies for extrusion of intricate hollow shapes in which metal divides and flows around the supports for the internal mandrel into strands. These strands are then rewelded under the high pressures in the welding chamber before exiting through the die.

919. **Spinning.** The forming of a seamless hollow metal part by forcing a rotating blank to conform to a shaped mandrel that rotates concentrically with the blank. In the typical application, a flat-rolled metal blank is forced against the mandrel by a blunt, rounded tool; however, other stock (notably, welded or seamless tubing) can be formed. A roller is sometimes used as the working end of the tool.

920. **Split die.** A die made of parts that can be separated for ready removal of the workpiece. Also known as segment die.

921. **Splitting.** The process by which an increment of load or time is divided such that the contact conditions are satisfied. During the first part of the increment, no constraint is applied, while in the second part, the contact constraint is applied.

922. **Spreading.** The increase in width of rolling plates and sheet usually with small width-to-thickness ratios. The increase occurs in the roll gap. It may be prevented by the use of vertical rolls in contact with the edges of the rolled product.

923. **Spring.** A one-dimensional device that transmits a force. Often the force is considered to be linearly dependent on the relative displacement of the endpoints.

924. **Springback.** (1) The elastic recovery of metal after stressing. (2) The extent to which metal tends to return to its original shape or contour after undergoing a forming operation. This is compensated for by overbending or by a secondary operation of restriking.

925. **Sprue** (**gate**). A small impression at one end of the finisher for forming a small projection that can be used to handle those forgings cut off from the forging stock before completion of the forging operations; permits connection between multiple impressions or the forging bar and impression.

926. **Squeezing.** Forming under pressure in closed dies.

927. **Stable deformation**. Deformation with a continuously rising load.

928. **Stage.** A full cycle of a forging machine during which set-up, de-

formation, and release

929. **Stains (black smut).** A product of caustic action on aluminum; sometimes results from inefficient etching operations, hindering the visual inspection of parts. The condition is easily remedied by repeating the etching operations, taking care that the method of stacking and agitation is sufficient to result in complete removal of the etching products.
930. **Stamp (marking).** An operation performed to identify the particular forgings as specified or requested by the customer.
931. **Stamping.** (1) The general term used to denote all sheet metal pressworking. (2) Sheetmetal formed parts, especially shallow parts that are blanked out of sheetmetal with only minor forming operations done on them.
932. **Stand.** (1) A piece of rolling mill equipment containing one set of work rolls. In the usual sense, any pass of a cold- or hot-rolling mill. See also rolling mills. (2) Equipment for rolling, which consists of a set of rolls with its own housing and controls.
933. **Standard tolerance.** An established tolerance for a certain class of product; this term is preferred to "commercial" or "published" tolerance.
934. **State of stress at the point**. A set of stresses occurring on all planes passing through the point in question.
935. **States.** The state variable in the analysis, generally the temperature in a stress analysis.
936. **Static.** A loadcase type which does not include any inertia terms.
937. **Steady state.** A loadcase type which performs steady-state heat transfer analysis; no specific heat is considered.
938. **Steam hammer.** A type of drop hammer in which the ram is raised for each stroke by a double-action steam cylinder and the energy delivered to the workpiece is supplied by the velocity and weight of the ram and attached upper die driven downward by steam pressure. The energy delivered during each stroke can be varied.
939. **Steel rule die**. Consists of a thin strip of hardened steel bent to the shape to be sheared and held on its edge on a flat wooden base.
940. **Step.** A particular step, or iteration, in a loadcase.
941. **Stepped extrusion**. An extrusion operation when it is produced by extruding the billet partially in one die, then in one or more larger dies.
942. **Sticking friction**. The condition at which no relative motion of the interfaces of the die and workpiece, even though no sticking or actual adhesion of the surfaces occurs.
943. **Stiffness. (1)** The element stiffness matrix, or the elastic foundation stiffness. (2) Resistance to bending.
944. **STL - Stereo Lithography.** A Geometric representation of a solid that is comprised of a tessellated surface.

945. **Stock marks.** In cutting forging stock to specified length for a die-forged part, the ends of the bar always contain surface imperfections caused by the cutting tool; these are often retained on the surface of the finished part. If pronounced, such marks are removed by light grinding. On parts where repeated indications of stock marks are encountered, efforts are usually made to eliminate them by conditioning the stock ends prior to forging by polishing the cut ends and beveling the edge of the cut.
946. **Stock.** A general term used to refer to a supply of metal in any form or shape and also to an individual piece of metal used to produce a single forging.
947. **Stocks.** Stocks are tong-like forging instruments that permit the operator to obtain a good hold on the hot metal and manipulate forgings at the hammer.
948. **Stop.** A device for positioning stock or parts in a die.
949. **Straighten, coin.** A combination coining and straightening operation performed in special cavity dies designed to impart a specific amount of working in specified areas of the forging to relieve stresses set up during heat treatment.
950. **Straighten, die.** A straightening operation performed in either a hammer or a press using flat or cavity dies to remove undesired deformation and bring the forging within straightness tolerance.
951. **Straighten, hand.** A straightening operation performed on a surface plate to bring a forging within straightness tolerance. Frequently, a bottom die from a set of finish dies is used instead of a surface plate; hand tools used include mallets, sledges, blocks, jacks, and oil gear presses, in addition to regular inspection tools.
952. **Straightening (straighten).** A finishing operation for correcting (decreasing) misalignment in a forging or between various sections of a forging. Straightening may be done by hand, with simple tools, or in a die in forging equipment.
953. **Strain aging.** The changes in ductility, hardness, yield point, and tensile strength that occur when a metal or alloy that has been cold worked is stored for some time. In steel, strain aging is characterized by a loss of ductility and a corresponding increase in hardness, yield point, and tensile strength.
954. **Strain at failure initiation**. The strain at which the stress begins to fall off sharply.
955. **Strain hardening.** An increase in hardness and strength caused by plastic deformation at temperatures below the recrystallization range. Also known as work hardening.
956. **Strain rate.** The rate of deformation, the percent elongation per second
957. **Strain.** Deformation expression (dimensionless) number— the change in length/original length (The unit of change in the size or

shape of a body due to force, in reference to its original size or shape)

958. **Strain-hardening coefficient.** See strain-hardening exponent.

959. **Strain-hardening exponent.** The value ***n*** in the relationship $\sigma = Ke^n$, where σ is the true stress; ***e*** is the true strain; and ***K***, which is called the strength coefficient, is equal to the true stress at a true strain of 1.0. The strain-hardening exponent, also called ***n***-value, is equal to the slope of the true stress/true strain curve up to maximum load, when plotted on log-log coordinates. The ***n***-value relates to the ability of a sheet material to be stretched in metalworking operations. The higher the ***n***-value, the better the formability (stretch-ability).

960. **Strain-rate sensitivity** (***m*** value). The increase in stress (or) needed to cause a certain increase in plastic strain rate (***e***) at a given level of plastic strain (***e***) and a given temperature (***T***). Strain-rate sensitivity = ***m***

961. **Streamline.** A line that represents the motion of a material particle.

962. **Stress raisers.** Design features (such as sharp corners) or mechanical defects (such as notches) that act to intensify the stress at these locations.

963. **Stress relieving.** A process of reducing residual stresses in a metal object by heating the object to a suitable temperature and holding for a sufficient time. This treatment may be applied to relieve stresses induced by quenching, normalizing, machining, cold working, or welding.

964. **Stress**. The intensity of the internally distributed forces or components of forces that resist a change in the volume or shape of a material that is or has been subjected to external forces. Stress is expressed in force per unit area. Stress can be normal (tension or compression) or shear.

965. **Stress-strain curve.** See stress-strain diagram

966. **Stress-strain diagram.** A graph in which corresponding values of stress and strain from a tension, compression, or torsion test are plotted against each other. Values of stress are usually plotted vertically (ordinates or y-axis) and values of strain horizontally (abscissas or x-axis). Also known as deformation curve and stress-strain curve.

967. **Stretch bending**. Method of bending to avoid the springback when the part is subjected to tension while being bent.

968. **Stretch flanging**. Process of bending the edges of sheet metals when the flange edges are subjected to tensile stresses.

969. **Stretch former.** (1) A machine used to perform stretch forming operations. (2) A device adaptable to a conventional press for accomplishing stretch forming.

970. **Stretch forming (stretch-wrap forming).** The shaping of a sheet or part, usually of uniform cross section, by first clamping around its edges and applying suitable tension or stretch and then wrapping it

around a die of the desired shape.

971. **Stretcher leveling.** The leveling of a piece of sheet metal (that is, removing warp and distortion) by gripping it at both ends and subjecting it to a stress higher than its yield strength.

972. **Stretcher straightening.** A process for straightening rod, tubing, and shapes by the application of tension at the ends of the stock. The products are elongated a definite amount to remove warpage.

973. **Stretcher strains (Lueder's band, worm**). Surface irregularities of a mild steel during sheet-forming operation which occure due to yield-point elongation. These markings lie approximately parallel to the direction of maximum shear stress and are the result of localized yielding. See also Luders lines.

974. **Stretching.** The extension of the surface of a sheet in all directions. In stretching, the flange of the flat blank is securely clamped. Deformation is restricted to the area initially within the die. The stretching limit is the onset of metal failure.

975. **Striking surface.** Those areas on the faces of a set of dies that are designed to meet when the upper die and lower die are brought together. Striking surface helps protect impressions from impact shock and aids in maintaining longer die life. Also termed "beating area."

976. **Strip.** A flat-rolled metal product of some maximum thickness and width arbitrarily dependent on the type of metal; narrower than sheet.

977. **Stripper punch.** A punch that serves as the top or bottom of the die cavity and later moves farther into the die to eject the part or compact. See also ejector rod and knockout.

978. **Stripper**. (1) A lug or ring on the forging or an impression in the dies for a mechanical upsetter to ensure clamping the piece firmly in the gripper dies. (2) A plate designed to remove, or strip, sheet metal stock from the punching members during the withdrawal cycle. Strippers are also used to guide small precision punches in close-tolerance dies, to guide scrap away from dies, and to assist in the cutting action. Strippers are made in two types: fixed and movable.

979. **Stroke (up or down).** (1) The vertical movement of a ram during half of the cycle, from the full open to the full closed position or vice versa. (2) The distance traveled of the punch in a kinematic press during a cycle.

980. **Structural (plate) punch presses**. Presses for punching, blanking, and stamping work of rough, hot-rolled bars, structural members, and thick plates.

981. **Structure.** The size and arrangement of the metal grains in metal.

982. **Stuffing box**. Box filled with the lubricant (such as soap) which is passed on the surface of the rod to be drawn.

983. **Sub-sow block (die holder).** A block used as an adapter in order

to permit the use of forging dies that otherwise would not have sufficient height to be used in the particular unit or to permit the use of dies in a unit where the shank sizes are different.

984. **Substage.** A part of a forging stage.

985. **Suck-in.** A defect caused by the "sucking in" of one face of a forging to fill a projection on the opposite side.

986. **Superalloys.** A term broadly applied to iron-base, nickel-base, and cobalt-base alloys, often quite complex, that exhibit high elevated-temperature mechanical properties and oxidation resistance

987. **Superplasticity.** The ability of certain metals to develop extremely high tensile elongations at elevated temperatures and under controlled rates of deformation.

988. **Support plate.** A plate that supports a draw ring or draw plate. It also serves as a spacer.

989. **Surface peening.** Shotblasting to increase the fatigue life of forgings.

990. **Swage (Swaging).** (1) The operation of reducing or changing the cross-section area of stock by the fast impact of revolving longitudinal, semicircular or semicontoured dies. (2) The tapering of bar, rod, wire, or tubing by forging, hammering, or squeezing; reducing a section by progressively tapering lengthwise until the entire section attains the smaller dimension of the taper. Finishing tool with concave working surface, useful for rounding out work after its preliminary drawing to size.

991. **Swift cup test.** A simulative test in which circular blanks of various diameter are clamped in a die ring and deep drawn into a cup by a flat-bottomed cylindrical punch. The ratio of the largest blank diameter that can be drawn successfully to the cup diameter is known as the limiting drawing ratio (***LDR***) or deformation limit.

992. **T Shape.** Forgings generally in the approximate form of a "T."

993. **Table mill.** In ring rolling, a type of ring forging equipment employing multiple mandrels with a common main roll. Usually used in high volume production of small-diameter rolled rings.

994. **Tailpipe (fishtailing or pipe defect)**. A defect of extruded pattern, when it tends to draw surface oxides and impurities toward the center of the billet.

995. **Tandem die.** Same as follow die.

996. **Tandem mill.** A rolling mill consisting of two or more stands arranged so that the metal being processed travels in a straight line from stand to stand. In continuous rolling, the various stands are synchronized so that the strip can be rolled in all stands simultaneously. Contrast with single-stand mill.

997. **Tangent bending.** The forming of one or more identical bends having parallel axes by wiping sheet metal around one or more radius dies in a single operation. The sheet, which may have side

flanges, is clamped against the radius die and then made to conform to the radius die by pressure from a rocker-plate die that moves along the periphery of the radius die. See also wiper forming (wiping).

998. **Tangent modulus.** The slope of the stress-strain curve at any specified stress or strain. See also modulus of elasticity.

999. **Tap**. Fluteless forming tool for internal thread rolling.

1000. **Temper rolling**. Sheet-forming operation when the sheet metal is subjected to a light pass of 0.5–1.5 percent reduction to avoid surface irregularities (stretcher strains).

1001. **Temper.** The degree of hardening produced in a metal by heat treatment or cold working.

1002. **Temperature Dependent Properties.** The change in mechanical or thermal properties due to a change in temperature.

1003. **Tempering.** Reheating a quench-hardened or normalized steel to a subcritical temperature to develop desired mechanical properties. See Drawing

1004. **Template (templet).** A gage or pattern made in a die department, usually from sheet steel; used to check dimensions on forgings and as an aid in sinking die impressions in order to correct dimensions.

1005. **Tensile (or ultimate) strength.** The maximum stress a metal will withstand in tension. Calculated as the maximum load divided by the original cross-sectional area obtained before rupture of a specimen pulled to failure in a tensile test.

1006. **Tensile properties.** Mechanical properties of a metal when loaded in tension, including tensile strength, yield strength, proportional limit, elongation, and reduction of area

1007. **Tensile stress.** A stress that causes two parts of an elastic body, on either side of a typical stress plane, to pull apart. Contrast with compressive stress.

1008. **Tension.** The force or load that produces elongation.

1009. **Tension-Squeeze test**. Test which combines axial tension and lateral pressure to counteract the undesirable effects of necking in the uniaxial tension.

1010. **Tensor.** All components of the stress or strain. A tensor is identified by the post index of one of its components.

1011. **Terminate.** The stopping of the workpiece deformation stage because the maximum force on the dies has been reached.

1012. **Theory of elasticity.** The mathematical discipline that deals with the elastic behavior of materials subjected to external loads

1013. **Thermal Strain.** The amount of strain caused by a change in temperature, because of the elongation or contraction of the crystal structure.

1014. **Thermal.** The heat transfer properties of the material.

1015. **Thermomechanical working (treatment).** A general term cover-

ing a variety of processes combining controlled thermal and deformation treatments to obtain synergistic effects, such as improvement in strength without loss of toughness. Same as thermal-mechanical treatment.

1016. **Thickness.** Either the layer or total thickness of a planar element.

1017. **Three-point bending.** The bending of a piece of metal or a structural member in which the object is placed across two supports and force is applied between and in opposition to them. See V-hend die.

1018. **Through flow process**. Corresponding to mass-conservation processes such as forging and extrusion

1019. **Throw.** The distance from the centerline of the crankshaft or main shaft to the centerline of the crankpin or eccentric in crank or eccentric presses. Equal to one-half of the stroke. See also crank press and eccentric press.

1020. **Toggle press**. A mechanical press in which the slide is actuated by one or more toggle links or mechanisms.

1021. **Tolerance.** Allowable deviation from a nominal or specified dimension; the permissible deviation from the exact dimensions given on the drawing or model, or from a specification for any characteristic.

1022. **Tong hold.** The portion of a forging billet (a small portion of metal projecting), usually on one end, that is gripped by the operator's tongs. It is removed from the part at the end of the forging operation. Common to drop hammer and press-type forging.

1023. **Tongs.** Metal holder used to handle metal pieces.

1024. **Tool steel.** A superior grade of steel made primarily for use in tools and dies.

1025. **Tooling marks.** Dies containing surface imperfections and dies on which some repair work has been done will impart indications on the surface of the forged part; these tooling marks are usually slight rises or depressions in the metal. Light grinding or polishing is used to remove the marks if they seriously affect the appearance of the product.

1026. **Tooling pad.** See Chucking lug.

1027. **Torsion.** A twisting deformation of a solid or tubular body about an axis in which lines that were initially parallel to the axis become helices.

1028. **Torsional stress**. The shear stress on a transverse cross section resulting from a twisting action.

1029. **Total elongation.** The total amount of permanent extension of a test piece broken in a tensile test usually expressed as a percentage over a fixed gage length. See also elongation, percent.

1030. **Tote box.** Metal container used to convey forgings to the various processing operations.

1031. **Toughness.** Ability of a metal to absorb energy without failure

when a load is applied.

1032. **Traffic marks.** Abrasions that result from metal-to-metal contact and vibration during transit. These abrasions are usually dark in appearance because of the presence of a dark powder consisting of aluminum and aluminum oxide fines produced by the abrasive action of surfaces rubbing together.

1033. **Train**. Group of stands.

1034. **Transfer dies**. In a transfer die setup, the sheet metal undergoes different operations at different stations, which are arranged along a straight line or a circular path. After each operation, the part is transferred to the next station for additional operations

1035. **Transfer medium**. The material or agent through which energy and or information are transmitted to the work-piece.

1036. **Transformation.** A phase change that occurs in pure metals at a specific temperature and in alloys over a range of temperatures.

1037. **Translation**. Motion (usually of pure rigid body) causing linear displacement.

1038. **Transverse.** The direction in a wrought metal product perpendicular to the principal direction of working. See Directional properties.

1039. **Trim and punch.** A shearing operation to remove both an inner and an outer section of metal from a blocked or finished forging. A combination of two operations whereby flash and punchout are removed simultaneously. The operation is generally performed on a trim press using a combination trim and punch die.

1040. **Trimmer blade.** The portion of the trimmers through which the forging is pushed to shear off the flash. The shearing edge may be in more than one plane in-order to fit the parting line of the forging.

1041. **Trimmer die.** The punch-press die used for trimming flash from a forging,

1042. **Trimmer punch.** The upper portion of the trimmer that comes in contact with the forging and pushes it through the trimmer blades; the lower end of the trimmer punch is generally shaped to fit the surface of the forging against which it pushes.

1043. **Trimmers.** The combination of trimmer punch, trimmer blades, and perhaps trimmer shoe used to remove flash from a forging.

1044. **Trimming press.** A power press suitable for trimming flash from forgings.

1045. **Trimming.** (1) The mechanical shearing (removing) of flash or excess material from a forging by use of a trimmer in a trim press. This can be done either hot or cold. (2) Sheetmetal operations/or size control involving the cutting off of excess or damaged metal after a forming operation such as deep drawing

1046. **Trip hammer.** A small power hammer that delivers blows in rapid succession.

1047. **Triple-action press.** A mechanical or hydraulic press having

three slides with three motions properly synchronized for triple-action drawing, redrawing, and forming. Usually, two slides—the blank-holder slide and the plunger—are located above and a lower slide is located within the bed of the press. See also hydraulic press, mechanical press, and slide.

1048. **True stress**. Stress defined as the ratio of the load to the current or instantaneous area of deformed specimen.

1049. **Tryout.** Preparatory run to check or test equipment, lubricant, stock, tools, or methods prior to a production run. Production tryout is run with tools previously approved; new dies tryout is run with new tools not previously approved.

1050. **Tube spinning.** Sheet metal working process when the thickness of cylindrical parts is reduced by spinning them on a cylindrical mandrel using rollers.

1051. **Tube stock.** A semifinished tube suitable for subsequent reduction and finishing.

1052. **Tumbling.** The process for removing scale from forgings in a rotating container by means of impact with each other and abrasive particles and small bits of metal. A process for removing scale and roughness from forgings by impact with each other, together with abrasive material in a rotating container.

1053. **Turk's head**. A set of idling rolls used in drawing rods or bars of various shapes.

1054. **Twist.** See Bend.

1055. **Two-high mill.** A type of rolling mill in which only two rolls, the working rolls, are contained in a single housing. Compare with four-high mill and cluster mill.

1056. **Type.** A small, hardened block machined to the shape of a small portion of the impression and driven into this portion of the impression to determine the shape and dimensions accurately.

1057. **U Shape.** Forgings generally in the approximate form of a "U."

1058. **U-bend die.** A die, commonly used in press-brake forming, that is machined horizontally with a square or rectangular cross-sectional opening that provides two edges over which metal is drawn into a channel shape.

1059. **Ultimate strength.** The maximum stress (tensile, compressive, or shear) a material can sustain without fracture; determined by dividing maximum load by the original cross-sectional area of the specimen. Also known as nominal strength or maximum strength.

1060. **Ultrasonic testing.** A nondestructive test applied to sound-conductive materials having elastic properties for the purpose of locating inhomogeneities or structural discontinuities within a material by means of an ultrasonic beam (sound waves).

1061. **Undercuts.** Sections of a forging which, if driven into the impression while the metal is hot, would lock themselves into a die impres-

sion and prevent removal of the forging without distortion.

1062. **Underfill.** A portion of a forging that has insufficient metal to give it the true shape of the impression.

1063. **Uniaxial tension (compression**). State of stress when only one stress is the nonzero stress.

1064. **Unit cell.** The basic unit of the space lattice. The unit cell must be selected so that the entire lattice can be built up by translation of the cell without rotation.

1065. **Upend forging.** A forging in which the metal is so placed in the die that the direction of the fiber structure is at right angles to the faces of the die.

1066. **Upper bound**. A load which is too large to cause plastic deformation to begin.

1067. **Upset forging.** A forging obtained by upset of a suitable length of bar, billet, or bloom; formed by heading or gathering the material by pressure upon hot or cold metal between dies operated in a horizontal plane.

1068. **Upset.** (1) The localized increase in cross-sectional area of a workpiece or weldment resulting from the application of pressure during mechanical fabrication or welding. (2) Working metal in such a manner that the cross-sectional area of a portion or all of the stock is increased, and length is decreased

1069. **Upsetter (forging machine).** A horizontal forging machine (mechanical press) where the workpiece is gripped between two grooved dies and deformed by a punch that exerts force on the end of the stock. Upsetter used to make parts from bar stock or tubing by upset forging, piercing, bending, or otherwise forming in dies. Also known as a header.

1070. **Vacuum refining.** Melting and/or casting in vacuum to remove gaseous contaminants from a metal.

1071. **V-bend die.** A die commonly used in press-brake forming, usually machined with a triangular cross-sectional opening to provide two edges as fulcrums for accomplishing three-point bending.

1072. **Vent mark.** A small protrusion resulting from the entrance of metal into die vent holes.

1073. **Vent.** A small hole in a punch or die for admitting air to avoid suction holding or for relieving pockets of trapped air that would prevent die closure or action.

1074. **Virtual displacement (forces).** Imaginary displacement (forces).

1075. **Viscoplastic deformation**. Time-dependent permanent deformation.

1076. **Warm working.** Deformation at elevated temperatures below the recrystatlization temperature. The flow stress and rate of strain hardening are reduced with increasing temperature; therefore, lower forces are required than in cold working. See also cold working and

hot working.

1077. **Warpage.** Term generally applied to distortion that results during quenching from the heat-treating temperature; hand straightening, press straightening, or cold restriking is employed, depending on the configuration of the part and the amount of warpage involved. The condition is governed by applicable straightness tolerances; beyond tolerances, warpage is a defect and cause for rejection. The term is not to be confused with "bend" or "twist."

1078. **Water stain.** A superficial etching of the surface from prolonged contact with moisture in a restricted air space such as between layers of the product. The stain is generally white.

1079. **Ways.** The fitted V-shaped grooves in the ram and columns of a hammer or press that guide the descent and ascent of the ram.

1080. **Web fire.** See Reducing atmosphere.

1081. **Web**. A relatively flat, thin portion of a forging that effects an interconnection between ribs and bosses; a panel or wall that is generally parallel to the forging plane. See also Rib.

1082. **Wet drawing**. Drawing in which the dies and the rod are completely immersed in the lubricant, typically oils and emulsions containing fatty or chlorinated additives and various chemical compounds.

1083. **Wide tolerance.** Any special tolerance that is wider than "standard."

1084. **Wiper forming (wiping).** Method of curving sheet metal sections or tubing over a form block or die in which this form block is rotated relative to a wiper block or slide block.

1085. **Wire drawing.** Reducing the cross section of wire by pulling it through a die.

1086. **Wire rod.** Hot-rolled coiled stock that is to be cold drawn into wire.

1087. **Wire.** A thin, flexible, continuous length of metal, usually of circular cross section and usually produced by drawing through a die.

1088. **Work hardening.** See strain hardening.

1089. **Work rolls.** The rolls in contact with the deformed metal.

1090. **Workability (formability).** (1) The general term concerning to the degree of deformation that can be achieved in a particular metalworking process without creating an undesirable condition. (2) The maximum amount of plastic deformation as determined by the maximum true or logarithmic strain that a material can withstand, without the initiation of fracture.

1091. **Workpiece.** The body which is to be deformed.

1092. **Wrap forming.** See stretch forming.

1093. **Wrinkling.** A wavy condition obtained in deep drawing of sheet metal, in the area of the metal between the edge of the flange and the draw radius. Wrinkling may also occur in other forming operations

when unbalanced compressive forces are set up.

1094. **Y shape.** A forging, such as a connecting rod or banjo-shaped parts, that is widened at each end. Abbreviation is "DY." Piece where one end requires spreading into a U, V, disk, or similar shape, or a combination of one or more of the these.

1095. **Yield criterion**. Any mathematical expression that attempts to predict the state of stress that will induce yielding, or the onset of plastic deformation.

1096. **Yield point.** The load per unit of original cross section at which a marked increase in the deformation of the specimen occurs without increase of load. It is usually calculated from the load determined by the drop of the beam of the testing machine or by the use of dividers. If there is a decrease in stress after yielding, a distinction can be made between upper and lower yield points. The load at which a sudden drop in the flow curve occurs is called the upper yield point. The constant load shown on the flow curve is the lower yield point. Only certain metals—those which exhibit a localized, heterogeneous type of transition from elastic to plastic deformation—produce a yield point (low- and medium-carbon steels).

1097. **Yield strength.** The stress at which a material exhibits a specific amount of permanent deformation. In tensile tests, usually measured as the stress at 0.2% elongation (0.1 or 0.2% offset from the modulus slope).

1098. **Yield stress**. The stress level of highly ductile materials, such as structural steels, at which large strains take place without further increase in stress.

1099. **Yield.** Evidence of plastic deformation in structural materials. Also known as plastic flow or creep.

1100. **Young's modulus.** A term used synonymously with modulus of elasticity. The ratio of tensile or compressive stresses to the resulting strain.

1101. **Zipper cracks**. Defects in the center of the rolled plates and sheet caused by poor material ductility at the rolling temperature.

1102. **Zyglo.** A method for nondestructive surface inspection of primarily nonmagnetic materials using fluorescent penetrants. Trade name of Magnaflux Corp.

Список русских терминов

1. Последействие – деформация при постоянных напряжениях
2. Старение. (1) Второй этап термической операции для упрочнения; (2) изменение свойств при сравнительно низкой температуре
3. Гибка (свободная)
4. Качество, необходимое для ответственных деталей самолетов
5. Пневматический молот
6. Сетка трещин
7. Сплав
8. Угол захвата при прокатке
9. Искажение углов поперечного сечения
10. Отжиг, полный цикл
11. Штамповочная плита
12. Головка наковальни
13. Зона деформирования (вторая входная зона волочильного отверстия)
14. Аустенит
15. Автоматический останов пресса (сигнал)
16. Автоматический пресс
17. Вспомогательные операции
18. Ковочные вальцы с оправкой
19. Обратный угол выхода зоны волочильного отверстия
20. Напряжение при нагрузке обратного знака (эффект Баушингера)
21. Устройство для поддержки оправки при прокатке колец
22. Валки, поддерживающие рабочие валки
23. Обратное выдавливание
24. Искажение продольного сечения при выдавливании
25. Полосчатая структура
26. Пруток, профиль
27. Технологический отход при обрезке прутка
28. Гибочная машина
29. Бочкообразование
30. Барьерный эффект (при перемещении дислокаций)
31. Наковальня
32. Периодическая печь
33. Эффект Баушингера
34. Кромка, элемент жесткости
35. Отбортованный фланец
36. Отбортовка для придания жесткости
37. (1) Станина; (2) неподвижная режущая кромка при резке металла сдвигом
38. Входной конус (зона) в фильере для волочения
39. Угол гиба
40. Дефект искривления продольной оси или поперечного сечения
41. Радиус изгиба

42. Операция гибки (предварительная в многоручьевой штамповке)
43. Гибочный ручей
44. Гибочный пресс с открытой рамой простого действия с длинной гибочной кромкой
45. Гибочный штамп
46. Гибочные вальцы
47. Напряжение при изгибе
48. Гибка
49. Заготовка
50. (1) Заготовка, получаемая вырубкой из листового материала; (2) заготовка для ковки или штамповки
51. Фиксатор фланца
52. (1) Заготовительная операция разделения; (2) вырубка
53. Песко- и дробеструйная очистка
54. Раковина, плена
55. Операция объемной штамповки, при которой операции предварительной и окончательной обработки выполняются одновременно в одном штампе
56. Многоручьевая штамповка
57. Заготовительная операция штамповки (формовочная или подкатная)
58. Заготовительный формовочный ручей
59. Заготовительный формовочный штамп
60. Блюм
61. Блюминг
62. Удар
63. Падающий молот с доской
64. Подштамповая плита
65. Прилив; выпуклость
66. Нижняя мертвая точка
67. Штамповочные уклоны низа ручья
68. Изгиб с прижимом (чеканкой)
69. Смазочные материалы, обеспечивающие смешанный тип трения
70. Саблевидность
71. Отжиг в ящиках для предотвращения окисления
72. Пространственные решетки Браве
73. (1) Первичная операция прокатки или протяжки для уменьшения слитка; (2) уков
74. Штампы для выдавливания (мостиковые) полых деталей с оправкой
75. Испытание на твердость по Бринеллю
76. Хрупкость
77. Сетка поверхностных трещин
78. Коэффициент потери устойчивости
79. Потеря устойчивости, коробление при сжимающих напряжениях

80. Метод определения напряжения текучести с поправкой на бочкообразование
81. Раздача
82. Объемная штамповка
83. Вращающийся волочильный барабан
84. Стан однократного волочения с вращающимся барабаном
85. Горизонтальный пресс для гибки
86. Вектор Бюргера
87. Пережог
88. Задир, заусенец
89. Комбинированный формовочный и подкатной заготовительный ручей
90. Технологический остаток выдавливаемой заготовки в матрице
91. Вычисление вариаций
92. Кулачковая испытательная машина, в которой образец сжимается при постоянной скорости деформации
93. Вертикально-ковочная машина
94. (1) Изгиб полосы при разделении; (2) конусность вальцов
95. (1) Дефект листового материала; (2) нанесение защитного покрытия на заготовку
96. Блок для волочения
97. Углеродистая сталь
98. Упрочнение насыщением азотом и углеродом
99. Науглероживание
100. Фестонообразование при вытяжке
101. Науглероживание, цементация, цианирование (поверхностное)
102. Упрочненный поверхностный слой (металла)
103. Контроль ручья
104. Ручей штампа
105. Наружный валик для прокатки колец, задающий внешний диаметр кольца
106. Керамика для термоизоляции печей
107. Фаска; скос
108. Многоугловая гибка
109. Испытание на ударную вязкость по Шарпи
110. Вибрации вследствие автоколебаний
111. (1) Трещины в углу ручья из-за концентрации напряжений; (2) трещины из-за термических напряжений
112. Шевронное растрескивание (центральной части заготовки) при выдавливании
113. Промежуточный контроль и удаление поверхностных дефектов пневмозубилом
114. Удаление поверхностных дефектов (окалины) перед ОМД с помощью зубила и т. п.

115. Зубило
116. Зажим (дефект при штамповке)
117. Модуль упругости
118. Технологический выступ
119. Сетка окружностей на листовой заготовке для измерения деформаций
120. Анализ деформаций листовой заготовки с помощью сетки окружностей
121. Диаметр окружности, описывающей форму выдавливаемой заготовки
122. Коаксиальное выдавливание двух заготовок одновременно
123. Очистка от окалины, смазки и т. п.
124. Штамп с ручьем
125. Закрытый ручей прокатного валка
126. Открытая (с облоем) объемная штамповка
127. Точная объемная штамповка
128. Величина, характеризующая среднее отклонение по толщине поковки (штамповки)
129. Прокатный стан Сендзимира
130. Модель разрушаемого материала Кокрофта – Латама
131. Коэффициент удлинения при прокатке (обжатии)
132. Коэффициент уширения при прокатке (обжатии)
133. Коэффициенты (индексы) анизотропии
134. Обжатие
135. Калибровка
136. Комбинация калибровки и правки
137. Калибровочный штамп
138. (1) Калибровка – операция объемной штамповки; (2) правка – изменение радиусов или профиля
139. Холодная калибровка
140. Холодная штамповка
141. Холодная высадка
142. Конечный контроль (неразрушающий)
143. Холодный закат (дефект проката); плена; морщина (дефект стального слитка)
144. Холодная обрезка (облоя)
145. Холодная ОМД
146. Холоднокатаный лист
147. Штамп совмещенного действия
148. Калибровочный, правочный штамп
149. Брикет, прессованная порошковая заготовка
150. Прессовать из порошка
151. Условие совместности (деформаций)
152. Штамп совмещенного действия
153. Изгиб при сжатии (при гибке труб)

154. Предел прочности при сжатии
155. Испытания на сжатие
156. Предел прочности при сжатии
157. Сжимающее напряжение
158. Вогнутость
159. Концентричность
160. Уравнения состояния
161. Допуск на контакт (тел)
162. Контакт (тел)
163. Стан непрерывного действия с несколькими клетями
164. Сплошная среда
165. Контурная формовка
166. Стандартные испытания на сжатие
167. Условный предел текучести
168. Стандартная поковка
169. Проверка сходимости
170. Технологические процессы с увеличением массы (сварка, сборка)
171. (1) Сердцевина (заготовки); (2) выдра
172. (1) Центральная каверна в выдавленной заготовке; (2) различие свойств в центре и на периферии единицы микроструктуры из-за неравновесной солидификации
173. (1) Гофрирование (операция листовой ОМД); (2) гофрирование (дефект)
174. Модель трения по закону Кулона
175. Бесшаботное кузнечное оборудование
176. Бесшаботный молот
177. Замок штампа
178. Модель пластически деформируемого материала Купера – Симондса
179. Длина кривошипа – длина прута между кривошипом и пуансоном в кривошипно-кулачковых прессах
180. Кривошипный пресс
181. Кривошип
182. Ползучесть
183. (1) Гофрирование; (2) обжатие, опрессовка
184. Критический (температурный) диапазон
185. Критическая точка
186. Критическое расчетное касательное напряжение, требуемое для сдвига по плоскости скольжения
187. Отходы на конец заготовки
188. Обрезка или обрубка в холодном состоянии; холодная разделка (кратной заготовки)
189. Проковка (для изменения свойств)
190. Растрескивание (поверхности)

191. Крестообразная поковка
192. Крестообразная форма
193. (1) Верхняя часть рамы пресса; (2) операция выравнивания; (3) дефект прокатки
194. Кристаллическая структура
195. Текстура
196. Комбинированная трещина в виде стакана и усеченного конуса при растяжении образца, когда в центре – плоское деформированное, а на периферии – напряженное состояния
197. (1) Стакан (листовая заготовка после глубокой вытяжки); (2) любая цилиндрическая деталь или заготовка, закрытая с одной стороны
198. Испытание на максимальную глубокую вытяжку пуансоном с круглым концом
199. (1) Первый этап глубокой вытяжки; (2) растрескивание образца, когда один конец выглядит как стакан, а другой – как конус
200. (1) Место для отрезки на штампе; (2) отрезная операция
201. Топоры (кузнечный инструмент)
202. Отрезка (заготовки)
203. Цианирование
204. Максимальная высота межштампового пространства
205. Мертвая зона, зона торможения
206. Обезуглероживание
207. Процедура анализа, при котором инструмент сначала рассматривают как жесткое тело, а затем (для определения н. д. с.) – как деформируемое
208. Глубокая вытяжка
209. Отклонение (от прямой, плоскости)
210. Деформируемый инструмент
211. Предельный коэффициент вытяжки
212. Теория деформаций
213. Деформированный
214. Процесс Демареста – формовка эластичными средами оболочечных и цилиндрических листовых заготовок
215. Дендриты
216. Удаление окалины
217. Готовая заготовка (не нуждающаяся в обрезке)
218. Штамповочный уклон
219. Часть штампа или пресса, на которой устанавливается матрица
220. Штамп; матрица; подушка матрицы
221. Ручей
222. Сетка трещин в штампе
223. Зазор между пуансоном и матрицей
224. Среднее отклонение по толщине штамповки

225. Подвижная подушка (прокладка) под штампом, обеспечивающая дополнительное движение или давление
226. Объемная штамповка
227. Формовка в матрице
228. Закрытая высота штампа
229. Матрицедержатель
230. Ручей штампа
231. Штамповая вставка
232. Отверстие, задающее поперечное сечение выдавливаемой детали
233. Перенос чертежа штампа на трафарет или поверхность ручья
234. Срок службы штампа
235. Царапины на штампе
236. Замок штампа – максимальное отклонение размера в линии разъема параллельно ходу пресса
237. Смазочный материал в штампе
238. Совпадение половинок штампа
239. Идентификационный номер штампа
240. Буфер штампа, выталкиватель
241. Заливка, получение отпечатка ручья для проверки его точности
242. Штамповочный радиус
243. (1) Штамподержатель; (2) штамповочный пакет
244. Смещение половинок штампа
245. Штамповочный блок (плиты)
246. Фрезерование ручья
247. Максимальная закрытая высота пресса
248. Отштампованная листовая деталь
249. Правка
250. Штамп, матрица
251. Обжимная ковочная машина
252. Объемная штамповка
253. Клещи
254. Распределенная шейка
255. Диффузия
256. Размерный (пространственный) фактор неоднородности – отношение исходной площади сечения шейки к исходной площади равномерно деформируемой части
257. (1) Выдавливание лунки в листовом металле; (2) то же под заклепку с потайной головкой
258. Прямое выдавливание
259. Анизотропия
260. Разрывы непрерывности
261. Дискретные задачи
262. Диск (заготовка-поковка для шестерен, ступица, втулка)
263. Дислокация

264. Распределенная нагрузка
265. Процессы обработки с удалением материала
266. Число степеней свободы
267. Сдвоенная поковка (одновременно выкованные две поковки, в дальнейшем разделяемые и используемые отдельно)
268. Механический пресс двойного действия
269. Шпонка (вставка) между хвостовиком и держателем штампа, обеспечивающая продольное совпадение половинок штампа
270. Штамповочный угол
271. Штамповочный уклон
272. Поковка без штамповочного уклона
273. Вставка (или выступ) на прижимном кольце для глубокой вытяжки, контролирующая скорость течения металла
274. Формовка вытяжкой прутков или труб с помощью вращающегося формблока с одновременным изгибом заготовки в зажиме формблока
275. След (на поверхности детали) при глубокой вытяжке
276. Матрица для глубокой вытяжки
277. Радиус перетяжного ребра при глубокой вытяжке
278. Кольцо для глубокой вытяжки (или часть матрицы)
279. Протяжка-вытяжка
280. Предельная способность к глубокой вытяжке
281. Волочильный стан (цепной) для прутков
282. Отпуск стали, закалка с последующим отпуском, искусственное старение
283. Смазка для глубокой вытяжки
284. Вытяжка (протяжка)
285. (1) Глубокая вытяжка, повторная вытяжка, волочение; (2) вытяжка листового материала; (3) вытяжка-ковка; (4) волочение прутка
286. Оборудование для резки с приводом ножей
287. Объемная штамповка на молотах
288. Листовая штамповка на падающих молотах
289. Падающий молот
290. Волочение прутка со смазкой
291. Ковкость, пластичность
292. Прокладка между пуансоном и нагретой заготовкой при выдавливании
293. Остановка (выстой) пресса (часть хода)
294. Неразрушающий контроль штампа проникающими красителями
295. Фестонообразование (при глубокой вытяжке)
296. Эксцентриковый механизм
297. Эксцентриковый пресс
298. Эксцентрик

299. Краевая дислокация
300. Формуемость на ребре – способность материала сопротивляться образованию шейки или трещины на краю материала (отверстия)
301. Наборной и подкатной ручьи
302. (1) Загиб кромки, уменьшение радиуса фланца при листовой штамповке; (2) боковое обжатие, ребровый проход (при прокатке); (3) пережимная и подкатная операция (объемная штамповка)
303. Эффективное напряжение (интенсивность напряжений)
304. Предельный коэффициент вытяжки
305. Коэффициент полезного действия (оборудования)
306. Выталкиватель
307. Упругая деформация
308. Предел упругости
309. Упругость
310. Удельная электропроводность
311. Магнитоимпульсная штамповка
312. Электрошлаковый переплав
313. Удлинение
314. Штамп для гофрирования (получения выштамповок)
315. Выдавливание рельефа, гофрирование
316. Хрупкость
317. Потери материала при обрезке кратной заготовки
318. Срок службы, предел усталости
319. Ковочное оборудование с контролируемым объемом энергии, передаваемым заготовке
320. Энергетический к. п. д. ковочного оборудования
321. Условное напряжение
322. Относительная (условная) деформация сдвига
323. Деформирующая (вторая) зона в фильере для волочения
324. Равноосная структура зерна
325. Интенсивность пластической деформации
326. Интенсивность пластических напряжений
327. Испытание Эрихсена – вдавливание конического или сферического инструмента и измерение глубины при образовании трещин
328. Взрывная штамповка
329. Противозадирные смазки (выдерживающие высокие давления)
330. Заготовка для выдавливания
331. Дефекты выдавливания
332. (1) Операция выдавливания; (2) профиль, полученный выдавливанием
333. Полость, дефект в середине выдавливаемого профиля на конечной стадии прессования
334. Коэффициент выдавливания – отношение площади заготовки

к площади получаемого профиля
335. Заготовка для выдавливания
336. Выдавливание, прессование
337. Отбортовка
338. Назначение припуска на механическую обработку
339. Процесс развития трещины
340. Усталость
341. Выступ, заусенец
342. Феррит
343. Локальное напряжение в волокнах (элемента конструкции), причина изгибающих нагрузок
344. Волокно
345. (1) Сопряжение поверхностей (внутренних); (2) внутренний радиус сопряжения
346. Коэффициент тепловой конвекции
347. Граничное условие при тепловой конвекции
348. Точная вырубка
349. Припуск на механическую обработку
350. Окончательная ковка
351. Удаление облоя
352. (1) Шероховатость поверхности; (2) шероховатость после механической обработки; (3) окончательная штамповка; (4) поверхность проката, не требующая дополнительной обработки; (5) удаляемый с поковки материал
353. Окончательный ручей
354. Штамп для окончательной штамповки
355. Температура окончания обработки
356. Последовательная обработка поковки в трех инструментах, установленных на одной машине при однократном нагреве
357. Трещины, дефект прессования
358. «Рыбий хвост», удаляемый излишек материала при ковке
359. Критерий легкости сборки данной детали
360. Процесс задания (ограничения) числа степеней свободы
361. Трещины от внутренних напряжений при остывании
362. Поверхностное упрочнение ферритных сплавов при нагревании
363. Правка локальным нагревом
364. Фланец
365. Получение кромки, фланца листового материала
366. Развальцовка; раскатывание
367. Остаток облоя
368. Мостик в штампе
369. Линия разъема штампа, след от облоя
370. Облойная канавка
371. Облой

372. Плоская прокатка
373. Ковка
374. Штамп для выравнивая, правки кромки листового материала
375. Выравнивание, рихтовка, правка
376. Плоский инструмент для правки
377. Подвижный ролик в роликовой правильной машине
378. Правка на роликовой машине
379. Плавающий штамп (подвижно закрепленный или на демпфирующей подушке)
380. Оправка для выдавливания труб
381. Площадь, занимаемая оборудованием
382. Штамповка в штампе с симметричными половинками, позволяющими кантовать поковку
383. Кривая напряжения – деформации
384. (1) Линии текстуры; (2) линии течения металла
385. Чертеж линий течения
386. Соотношения напряжения – деформации
387. Напряжение текучести
388. Трещина, дефект штамповки
389. Гидроштамповка
390. Гидроштамповка
391. Гидропрессование
392. Оправка прокатного стана
393. Машина для продольной резки
394. Фольга
395. Закат (дефект)
396. Штамп последовательного действия
397. Площадка контакта инструмента и заготовки
398. Ковкость
399. Кованная заготовка
400. Ковочные штампы
401. Допуск на окончательную (чистовую) обработку
402. Горизонтально-ковочная машина, высадочный пресс
403. Зеркало матрицы
404. Качество поковки
405. Ковочные вальцы
406. Заготовка для ковки
407. Деформации ковки (остаточные)
408. Напряжения ковки (остаточные)
409. (1) Процесс ковки, штамповки; (2) продукт ковки, штамповки
410. Формблок
411. Штамп для формовки листового материала
412. Формовка прокаткой
413. Ковкость
414. Мастер-штамп, шаблон, копир

415. Фасонный штамп, штамп для выдавливания рельефа, подкладной штамп
416. (1) Диаграмма предельных возможностей обработки; (2) тест на предельные возможности вытяжки
417. (1) Формовка; (2) формоизменение без изменения поперечного сечения
418. Прямое выдавливание
419. Фундамент, основание кузнечно-штамповочного оборудования
420. Четырехвалковый прокатный стан
421. Предел прочности при растяжении
422. Напряжение при разрушении
423. Испытания на разрушение
424. Рама (пресса)
425. Ковка
426. Хорошая обрабатываемость резанием
427. Метод верхней оценки
428. Распределение нормального давления по контактной площадке
429. Коэффициент трения
430. Трение
431. Метод верхней оценки
432. Протяжной ручей
433. Протяжка при ковке
434. (1) Калибр, сортамент; толщина (листового металла), диаметр (проволоки или винта); (2) средства измерений, контрольно-измерительный прибор
435. Пресс с консольной рамой
436. Литник, углубление, соединяющее ручьи
437. Подкатная (наборная) операция
438. Подкладной штамп
439. Клиновые шпонки, клин, прижимной клин
440. Полукруглое долото
441. Ориентированная макроструктура, ориентация зерна
442. Межзеренное растрескивание
443. Размер зерна
444. Зерно
445. Падающий молот
446. Неспеченная прессовка, сырец
447. (1) Способность прессовки поддерживать свою форму и размеры до спечения; (2) прочность прессовки
448. Неспеченный
449. Шлифование
450. Зажимной штамп
451. Штамповка эластичной средой
452. Направляющие втулки для штифтов, служащих для установ-

ки пуансона относительно матрицы
453. Штифты в штамповом блоке для закрепления пуансона относительно матрицы
454. Направляющая
455. Облойная канавка
456. Ковка на молотах
457. Пресс с контролируемой энергией (как у молота)
458. Молот
459. Листовая штамповка на молотах
460. Ручная ковка
461. Ручная правка
462. Такелажные отверстия
463. Забоины, вмятины, царапины
464. Закаливаемость
465. Упрочнение
466. Отрубной топор
467. Определение твердости
468. Твердость
469. Линии Хартниана, линии Людерса
470. Высадочная машина
471. Высадка
472. Загрузка периодической печи
473. Температурное растрескивание штампа
474. Плавка – количество металла, полученное за одну выплавку
475. Термообработка
476. Пятна побежалости от нагрева
477. Нижний блок, плита, вкладыш пяты
478. Ручной молот
479. Гибка на 180 градусов
480. Высокоэнергетическая ковка-штамповка
481. Высокоскоростная ковка-штамповка
482. Высокоскоростные молоты, прессы
483. Продукт, полученный операцией ковки
484. Удерживающая пластина (лентопротяжный механизм)
485. Отбортовка отверстия
486. Однородный
487. Гомогенизирование
488. Гомологичная температура
489. Изотропный эластичный материал
490. Закон Гука
491. Горячая ОМД
492. Оперативный неразрушающий контроль горячей ковки
493. Изостатическая горячая ОМД
494. Красноломкость
495. Горячая ковка

496. Горячая обрезка (облоя)
497. Горячая осадка
498. Горячая ОМД
499. Испытание на ковкость кручением круглого образца при различных температурах
500. Режим «песочных часов» – способ интегрирования по времени матрицы жесткости
501. Ковка двутавров
502. Ступица
503. Выпрессовывание неглубоких выштамповок в матрице
504. Молот с гидравлическим приводом подъема падающей массы
505. Тормоз гидравлического пресса
506. Гидропресс
507. Гидравлические ножницы
508. Гидравлический тормоз механического пресса
509. Пресс с гидроформовкой
510. Прессование жидкостью
511. Гидростатическое давление (напряжение)
512. Гидростатическое выдавливание
513. Идеализированная кривая напряжения – деформации
514. Ударное прессование
515. Дефекты изменения толщины в листовом материале после глубокой вытяжки
516. Ударная прочность
517. Испытание на ударную вязкость
518. Объемная штамповка в ручье
519. Ручей штампа
520. Неметаллические включения
521. Приращение интенсивности деформаций – корень квадратный из второго инварианта девиатора деформаций
522. Обратное выдавливание
523. Индукционное закаливание
524. Слиток, чушка
525. Начальное напряжение
526. Начальная температура
527. Штамповая вставка (штамп)
528. Штамповая вставка
529. Операция контроля
530. Пластичность материала
531. Инварианты напряженного состояния
532. (1) Выглаживание; (2) выглаживание трубчатых заготовок
533. Изостатическая ОМД
534. Изотермический отжиг
535. Изотермическая ковка
536. Изотермический

537. Изотропный
538. Испытание на ударную вязкость
539. Герметизация активных металлов в металлических оболочках (для горячей обработки)
540. Многоугловая гибка
541. Испытание на упрочняемость
542. Клин крепления штампа
543. Раскисленная сталь
544. Кинематический метод (основанный на методе верхней оценки)
545. Кинематически допустимое перемещение
546. Обжим (ротационная ковка)
547. Выталкиватель
548. Отметка от выталкивателя на поковке
549. Выталкиватель
550. Шарнирно-коленчатый пресс
551. Уголок
552. Профиль с углом в сечении, отличным от 90°
553. Надрезка
554. Закат, плена, складка
555. Лазерный раскрой
556. Боковое выдавливание
557. Стационарный барабан волочильного стана
558. Контрольный образец металла штампа
559. (1) Чертеж лекала для изготовления гравюры штампа; (2) операция контроля определяющих размеров поковки (штампа)
560. Свинцовый контроль – копирование ручья заливкой расплавленным металлом
561. Линии на листовом металле поперек направления роликовой правки
562. Правка, рихтовка
563. Выталкиватель
564. Анализ с использованием экстремального принципа виртуальных перемещений
565. Предельный коэффициент вытяжки
566. Линейно-упругий материал
567. Вкладыши
568. Нагрузка
569. (1) Процессор, задающий нагрузку (в ***CAE***-приложениях); (2) набор параметров, задающих нагружение
570. Распределенные механические нагрузки
571. Локализованное шейкообразование
572. Замок штампа
573. Штампы, в которых поверхность соприкосновения половинок не лежит в одной плоскости

574. Образец для испытаний из прокатанного листового материала
575. Направление, параллельное направлению обработки поковки
576. Потери материала
577. Нагрузки, вызывающие упругую деформацию
578. Нижняя половинка штампа
579. Остатки перегоревшего смазочного материала
580. Смазка
581. Линии Людерса
582. Чувствительность к скорости деформации
583. Горизонтально-высадочная машина
584. Припуск на механическую обработку
585. Контроль качества горячекованной заготовки
586. Макроструктура
587. Метод магнитной дефектоскопии
588. Метод магнитной дефектоскопии
589. Ковкость
590. Ковкий
591. Раскатка на оправке
592. Оправка
593. Манипулятор
594. Прокатка бесшовных труб на оправке
595. Вытяжка эластичными средами
596. Закалка на мартенсит
597. Мартенсит
598. Массовая плотность
599. Штамповый блок
600. Контрольный калибр; эталонный калибр; мастер-модель
601. Совпадение половинок штампа
602. Совпадающие грани половинок штампа
603. Назначение штамповочных углов с обеспечением совпадения половинок штампа
604. Математическая модель материала
605. Прессовый тормоз
606. Механический пресс
607. Механические свойства
608. Деформация кристалла по методу двойникования
609. Механический высадочный пресс
610. Механическая обработка
611. Разрыв, нарушение непрерывности металла
612. Обработка металлов давлением
613. Микроструктура
614. Прокат
615. Окалина после горячей ОМД
616. (1) Металлургический комбинат; (2) прокатный стан; (3) прокатный стан; (4) фреза; (5) мельница

617. Министан
618. Минимальный радиус гиба
619. Несовпадение половинок штампа
620. Копир, шаблон
621. Модуль упругости, ***E***
622. Монотонная кривая зависимости деформаций от напряжения
623. Подвижная оправка для волочения труб
624. Кратная заготовка
625. Штамп для получения нескольких деталей одновременно
626. Многопозиционный пресс
627. Естественный уклон, конусность поковки
628. Точная штамповка
629. (1) Шейкообразование; (2) сужение части цилиндрической или трубчатой заготовки
630. Отрицательное напряжение (деформация)
631. Высечная операция
632. Азотирование
633. Поковка без штамповочных уклонов
634. Железо со свободным графитом в форме шаров
635. Неферритные металлы
636. Незаполнение ручья
637. Пластичная анизотропия
638. Нормальное напряжение
639. Нормализация
640. Оковка
641. Чувствительность к надрезу
642. Ударная вязкость
643. Процесс нанесения на листовой материал надсечек, пазов
644. Кромка без заусенцев, получаемая при прокатке
645. Показатель деформационного упрочнения
646. Выход за заданную размерную точность
647. Отходы материала
648. Операция гибки
649. Условный предел текучести
650. Деформация, которой соответствует условный предел текучести
651. Нанесение защитных покрытий
652. Пятно от неполно сгоревшей смазки
653. Испытание на пластичность при глубокой вытяжке
654. Одномерное формирование
655. Ковочные бойки
656. Ковка
657. Оптический пирометр
658. Апельсиновая корка (дефект листового материала)
659. Орбитальная ковка

660. Формозадающий процесс
661. Гибка с компенсацией угла пружинения
662. Перетравка
663. Перегретый металл
664. Перегрев
665. Прокатка пакетами
666. Прокладка (передающая удерживающее давление на заготовку) опора; опорная площадка, нажимная подушка; нажимной сухарь
667. Ковка с получением грубой формы (шлаковая лепешка)
668. Частично упругое тело
669. (1) Плоскость разъема штампа; (2) линия разъема штампа
670. плоскость разъема штампа
671. (1) Отрезка, отделение (операция листовой штамповки) (2) линия разъема штампа
672. (1) Проход; (2) калибр, ручей (прокатного валка)
673. Патентирование (закалка в свинцовой ванне)
674. Перлит
675. Процесс листовой штамповки обдувкой шариками
676. Перфорация
677. Остаточный прогиб
678. Фаза
679. Физические свойства
680. Протравливание, травление, декапирование
681. Частицы оксидированного металла, прилипшие к прокату
682. Пробивка в раскатке колец
683. (1) Пробивка в листовой штамповке; (2) прошивка
684. Пилигримовый прокатный стан
685. Пилигримовый прокатный процесс
686. Ловитель
687. Обрезка оболочковой детали по кромке пуансона
688. Усадочная раковина
689. Поверхностная раковина, выемка
690. Вид поковки сверху
691. Плоский
692. Плоская деформация
693. Плоское напряжение
694. Плоскость разъема
695. Испытание на сжатие листового материала при плоском деформированном состоянии
696. Испытание цилиндрического образца на сжатие параллельно оси при плоском деформированном состоянии
697. Испытание листового материала при плоском деформированном состоянии на растяжение
698. Выглаживание, рихтовка

699. Пластическая деформирование
700. Пластическое течение
701. Пластическая деформация
702. Пластичность
703. Коэффициент анизотропии листового материала
704. Плита, пластина, ползун пресса
705. Полная масса одновременно обрабатываемого давлением металла
706. (1, 2, 3) Оправка; (4) наметка под прошивку; (5) низ штампа
707. Захват, клещи
708. Обжим конца цилиндрической заготовки
709. Коэффициент Пуассона
710. Подготовительная операция удаления поверхностных дефектов
711. Полировка
712. Матрица для выдавливания изделий с отверстием
713. Положительное напряжение (деформация)
714. Вращающийся барабан волочильного стана
715. Порошковая ковка
716. Порошковые металлы
717. Молот двойного действия
718. Дисперсионное твердение
719. Точная штамповка
720. (1) Предварительная операция объемной штамповки; (2) брикет; (3) заготовка
721. Предварительный нагрев с выдержкой в печи
722. Расходы ТПП
723. Пуансон для раскатки колец
724. Листоштамповочный пресс, кромкогибочный пресс
725. Номинальное усилие пресса
726. Характеристики пресса
727. Направление движения штампа
728. ОМД на прессах
729. Листовая штамповка-формовка
730. Усилие пресса
731. Ползун пресса
732. Пресс
733. Твердая прокладка в штамповом блоке
734. Охлаждение заготовки во время перемещения от печи в рабочую зону
735. Первичные процессы
736. Главная ось
737. Главная плоскость
738. Главные напряжения
739. Значения тензора напряжений

740. Отжиг
741. Профильный прокат колец
742. Шаг штамповки
743. Штамп последовательного действия
744. Последовательная штамповка
745. Пробная нагрузка
746. Напряжение при испытании образца на предельные нагрузки
747. Копия, шаблон рабочего ручья
748. Предел пропорциональности
749. Образование гофра (при вытяжке)
750. Оборудование для резки листового металла с неподвижными лезвиями
751. (1) Пуансон; (2) операция пробивки
752. (1) Пробивка в листовой штамповке; (2) операция ковки пробивка
753. Система крепления штампа в прессе
754. Прошитое отверстие
755. Деформация сдвига
756. Толкательная печь непрерывного действия
757. Допустимые отклонения параметров, согласованные с заказчиком
758. Квазистатическая кривая зависимости деформаций от напряжения
759. Закалка; закаливание
760. Вытяжка с поддавливанием торца
761. Радиальная ковка (ротационный обжим)
762. Главный валок в прокатном стане
763. Сила, прикладываемая к оправке во время прокатки колец
764. Металлопрокатный стан для прокатки бесшовных колец
765. Радиус закругления
766. Ползун пресса, падающая часть молота
767. Мощность, передаваемая ползуном пресса или падающей частью молота
768. Дефекты изменения толщины в листовом материале после глубокой вытяжки
769. Восстановление
770. Рекристаллизация
771. Повторная вытяжка
772. Редуцирование
773. Восстановительная атмосфера
774. Относительное сужение
775. Коэффициент деформации при прессовании
776. (1) Коэффициент вытяжки; (2) коэффициент укова
777. Коэффициент потерь пластической деформации
778. Избыточная работа

779. Температура рекристаллизации
780. Ультразвуковой дефектоскоп
781. Жаропрочные сплавы
782. Огнеупорный материал
783. Нагрев перед ОМД
784. Релаксация – изменение напряжений при постоянной деформации
785. Размыкание, разъединение (тел)
786. Допрессовывание брикета
787. Прокат с наличием поверхностных дефектов
788. Адьюстирование половинок штампа во время рабочего хода
789. Примеси в сплавах
790. Неисключенные погрешности расчета сил при линеаризации нелинейного уравнения равновесия
791. Остаточное напряжение
792. Маркировка штампа
793. Температурный режим нагрева при протяжке
794. Нагрев поковки в оснастке
795. (1) Правка; (2) чеканка; (3) нагрев поковки в оснастке
796. Обратная вытяжка
797. Отбортовка, фланцеобразование сжатием
798. Реверсивный прокатный стан
799. Жесткость, ребро жесткости
800. Жесткий инструмент (модель)
801. Испытания на сжатие кольца
802. Раскатка колец
803. Линии Робертса (Людерса)
804. Испытание твердости по Роквеллу
805. Пруток
806. Гибка роликами
807. Выравнивание прокаткой
808. Вальцовка
809. (1) Силовое выдавливание (с утонением) (2) профилирование листового металла роликами; профилировка листового металла на роликовой листогибочной машине
810. Выравнивание роликами
811. Накатка резьбы
812. Открытый протяжной ручей штампа
813. Разрывы проката
814. Правка (проката) в роликовых правильных машинах
815. Подкатный-наборный ручей
816. Оправка для раскатки колец
817. Металлопрокатные станы
818. Опора кольца при раскатке колец
819. (1) Операция подкатки, набора; (2) прокатка

820. Молот с канатной тягой
821. Ротационная (орбитальная) ковка
822. Карусельная печь
823. Машина для резки роликами
824. Ротационный обжим
825. Ротационная ковка на оправке бесшовных колец, труб
826. Вращение
827. Заготовка для протяжки, вытяжки
828. Обрезка облоя, клещевин и т. п.
829. Черновая клеть прокатного стана
830. Незначительные поверхностные царапины
831. Штамповка эластичной средой
832. Укованный до разрыва волокон металл
833. Прокатка (раскатка) бесшовных труб на оправке
834. Пескоструйная очистка
835. Опиловка облоя
836. Раковина от окалины
837. Окалина
838. Удаление поверхностного слоя (со слитка)
839. Зачистка поверхностных дефектов для последующей обработки
840. Определение твердости ударом алмазным наконечником
841. (1) Образование задиров, задирание; (2) уменьшение толщины материала вдоль заданной линии
842. Царапина
843. Винтовая дислокация
844. Винтовой пресс
845. Царапина, шов, волосовина
846. Фальцовка, закатка
847. Швы
848. Наклон линии, проведенной из центра к любой точке кривой напряжения – деформации
849. Вторичные процессы обработки металлов
850. Разъемный штамп
851. Сегрегация, ликвация
852. Смазка жидким стеклом при выдавливании
853. Предварительный ручей
854. Надрез, облегчающий последующие операции гибки, пробивки
855. Стан Сендзимира
856. Сила, необходимая для расцепления двух тел
857. Рихтовальный, выколоточный, правильный молот
858. Скручивание или гибка с калибровкой
859. Подготовка оборудования
860. Хвостовик
861. Коэффициент сложности прессованного изделия

862. Жесткость изделия
863. Формовка
864. Обрезка (заусенцев, облоя), зачистка
865. Сдвиг (дефект)
866. (1) Вырубной штамп; (2) штамп для прессования цветных металлов
867. Модель сдвигового трения, пропорционального пределу текучести
868. Модуль сдвига ***G***
869. Силовое выдавливание, выдавливание с утонением
870. Предел прочности при сдвиге
871. Касательное напряжение
872. (1) Оборудование для разделения материала; (2) резка ножницами; (3) резка в штампах; (4) сдвиг, срез
873. (1) Резка на мерные заготовки ножницами или ломка на хладноломах; (2) резка (операция листовой штамповки)
874. Листовая штамповка
875. Лист
876. Регулировочная прокладка, прослойка, шайба, клин
877. Допустимые отклонения параметров, согласованные с заказчиком
878. Башмак, колодка, опорная подушка, фундаментная плита, станина (рабочей клети)
879. Короткий образец, вырезанный поперек направления проката
880. Песко- и дробеструйная очистка
881. Отбортовка, гибка со сжатием (гофрообразованием)
882. Учет усадки нагретого металла при проектировании ручья штампа
883. Усадка
884. Минимальная закрытая высота пресса
885. Боковое усилие, распор
886. Одноклетевой прокатный стан
887. Температура окружающей среды, теплоотвод
888. Изготовление гравюры штампов; обработка ручьев штампов
889. Спекание
890. Калибровка
891. Калибровочный проход, калибр, ручей (прокатного валка)
892. Отход, остающийся
893. Косая прокатка
894. Метод верхней оценки
895. Сляб
896. Уковка сляба
897. Регулировка расстояния между ползуном и столом пресса
898. Ползун пресса
899. Скольжение

900. Линии скольжения
901. Надрез, надрезание
902. Заусенец, плены, "жуки" (дефект листового проката)
903. Щелевая печь
904. Просечка (выштамповывание) отверстий
905. (1) Выдра; (2) заготовка для ОМД
906. Ручная ковка
907. Молот с плоскими бойками, кузнечный молот
908. Обдирка поковок
909. Удаление дефектов со штамповки
910. Выдержка (в нагревательной печи для термообработки)
911. Гомогенизация
912. Ульразвуковой неразрушающий контроль
913. Верхняя плита наковальни
914. Ячейка кристаллической решетки
915. Отслаивание, скалывание поверхностных частиц металла
916. Нестандартный допуск
917. Сфероидизирующий отжиг стали
918. Штамп для выдавливания с разделением на оправке и последующей сваркой полос металла давлением
919. Выдавливание на токарно-давильных станках
920. Разъемная матрица
921. Прием приложения нагрузки при анализе поэтапно
922. Расширение, уширение (при прокатке)
923. Пружина
924. Упругое последействие
925. Порог ручья, выемка под клещевину
926. Сжатие, сдавливание, нажатие (в отличие от удара)
927. Деформация при активной нагрузке
928. Цикл производственного процесса
929. Протрава
930. Маркировка
931. (1) Листовая шамповка; (2) продукты рельефной штамповки
932. Клеть
933. Стандартный допуск
934. Напряженное состояние в точке
935. Состояние (термодинамическое)
936. Статический
937. Установившееся состояние
938. Паровой молот
939. Деревянный вырубной штамп с металлическим покрытием
940. Шаг (нагружения)
941. Поэтапное прессование
942. Трение прилипания
943. (1) Матрица жесткости; (2) жесткость

944. Стереолитография
945. Отпечаток, следы обработки заготовки
946. Заготовка
947. Кузнечные клещи
948. Упор в штампе
949. Правка с чеканкой, калибровкой
950. Правочный штамп
951. Ручная правка
952. Правка
953. Деформационное старение; механическое старение, старение от наклепа
954. Деформация разрушения
955. Деформационное упрочнение
956. Скорость деформации
957. Деформация
958. Показатель упрочнения
959. Показатель степени упрочнения
960. Показатель чувствительности к скорости деформации
961. Линия течения
962. Концентраторы напряжений
963. Снятие напряжений, отдых
964. Напряжение
965. Кривая зависимости деформаций от напряжения
966. Диаграмма зависимости деформаций от напряжения
967. Гибка с растяжением
968. Отбортовка с растяжением
969. Оборудование, оснастка для формообразования с растяжением
970. Обтяжка, формообразование методом растяжения
971. Правка (проката) в растяжной правильной машине
972. Правка растяжением
973. Линии Чернова-Людерса
974. Растяжение
975. Ударная поверхность контакта половинок штампа
976. Полоса
977. Выталкиватель
978. (1) Клещевина; (2) съемник
979. Ход, величина хода
980. Штамповочный пресс
981. Макроструктура зерна
982. Смазочный состав, нанесенный на пруток при волочении
983. Штамподержатель, адаптер, подкладная плита
984. Переход
985. Дефект поковки
986. Высоколегированные сплавы

987. Сверхпластичность
988. Опорная плита
989. Поверхностная нагартовка
990. Обжим
991. Ускоренный тест на предельный коэффициент вытяжки
992. Тавр
993. Стан с оправками для проката бесшовных труб
994. «Рыбий хвост» – дефект средних слоев прессованных изделий
995. Штамп последовательного действия
996. Прокатный стан-тандем (с последовательным расположением клетей)
997. Многоугловая гибка по параллельным кромкам
998. Модуль упругости
999. Метчик для накатки внутренней резьбы
1000. Дрессировка (полосы или листов) – прокатка с небольшим коэффициентом вытяжки
1001. Степень упрочнения после термообработки или холодной деформации
1002. Температурозависимые свойства
1003. Закалка, отпуск
1004. Калибр
1005. Временное сопротивление разрыву, предел прочности
1006. Свойства материала, измеряемые при растяжении
1007. Растягивающее напряжение
1008. Растяжение
1009. Испытание на растяжение с радиальным давлением
1010. Тензор
1011. Прерывание рабочего хода
1012. Теория упругости
1013. Термические деформации
1014. Теплообменные свойства материала
1015. Термомеханическая обработка
1016. Толщина
1017. Одноугловая гибка
1018. Процессы объемной обработки давлением
1019. Расстояние от оси коленчатого вала до оси его шейки
1020. Кривошипно-коленный пресс
1021. Допуск
1022. Клещевина
1023. Клещи
1024. Инструментальная сталь
1025. Легкие следы износа штампов
1026. Технологический выступ
1027. Кручение
1028. Напряжение при кручении

1029. Общее удлинение
1030. Лоток для деталей
1031. Прочность, ударовязкость
1032. Следы контакта на алюминиевых заготовках
1033. Группа прокатных клетей или валков
1034. Штамп последовательного действия
1035. Передающая среда
1036. Фазовое превращение
1037. Поступательное перемещение
1038. Направление, перпендикулярное направлению обработки
1039. Одновременная обрезка-пробивка
1040. Режущая кромка обрезного штампа
1041. Обрезной штамп
1042. Пуансон обрезного штампа
1043. Обрезные штампы
1044. Обрезной пресс
1045. Обрезка (излишка материала)
1046. Высокопроизводительный пневмомолоток
1047. Пресс для вытяжки, повторной вытяжки и формообразования
1048. Действительное напряжение
1049. Подготовительный этап производства
1050. Выдавливание труб на токарно-давильном оборудовании
1051. Трубчатая заготовка
1052. Галтовка
1053. Группа неподвижных роликов в прокатном стане
1054. Кручение
1055. Двухвалковая клеть прокатного стана
1056. Модель, оттиск ручья штампа
1057. Изогнутая форма поковки
1058. Штамп для многоугловой гибки
1059. Предел прочности
1060. Ультразвуковая дефектоскопия
1061. Подрезы
1062. Незаполнение ручья
1063. Одноосное растяжение (сжатие)
1064. Элементарная ячейка кристаллической решетки
1065. Штамповка осадкой в торец
1066. Верхний предел
1067. Штамповка осадкой, высадкой
1068. Осадка
1069. Высадочный пресс
1070. Рафинирование (переплав) в вакууме
1071. Штамп для одноугловой гибки
1072. Следы-отпечатки на штамповке от отверстий в штампе
1073. Вентиляционные отверстия в штампе

1074. Виртуальное перемещение (сила)
1075. Вязкопластичная деформация
1076. Теплая ОМД
1077. Температурное коробление
1078. Водяная протрава
1079. Направляющие
1080. Восстановительная атмосфера
1081. Перемычка
1082. Волочение в условиях гидродинамического трения
1083. Широкий допуск
1084. Формовка обкаткой (с выглаживанием)
1085. Волочение проволоки
1086. Заготовка для волочения
1087. Проволока
1088. Деформационное упрочнение
1089. Рабочие вальцы
1090. Обрабатываемость
1091. Заготовка
1092. Обтяжка
1093. Образование складок, местная потеря устойчивости
1094. Y форма поковки
1095. Условие пластичности
1096. Предел текучести
1097. Условный предел текучести
1098. Напряжение текучести
1099. Течение
1100. Модуль Юнга
1101. Дефект центральной части проката
1102. Контроль флуоресцентными пенетрантами

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