Brief Descriptions of Manufacturing Processes

CASTING PROCESSES TABLE

Advantages and Disadvantages of the Common Casting Processes

Form	The Process	Advantages	Limitations
Sand castings	Green sand. Moist, bonded sand is packed around a wood or metal patterns, the pattern removed, and molten metal poured into the cavity; when metal solidifies, mold is broken and casting removed	Almost any metal can be used; almost no limit on size and shape of part; extreme complexity possible; low tool cost; most direct route from pattern to casting	Some machining always necessary; large castings have rough surface finish; close tolerances difficult to achieve; long, thin projections not practical; some alloys develop defects
	Dry sand. Same as above except; core boxes used instead of patterns, sand bonded with a setting binder, and core baked in an oven	Same as above plus ability to handle long, thin projections	Usually limited to smaller parts than possible with green sand
Shell-mold castings	Sand coated with a thermosetting plastic resin is dropped onto a heated metal pattern (which cures resin); shell halves are stripped off and assembled. When poured metal solidifies, shell is broken away from finished casting	Rapid production rate; high dimensional accuracy; smooth surfaces; uniform grain structure; minimized finishing operations	Some metals cannot be cast; requires expensive patterns; equipment, and resin binder; size of part limited
Full-mold castings	Sand casting process using foamed plastic such as polystyrene for pattern and one-piece mold. Pattern is vaporized during casting. One-piece or multipiece patterns can be used depending on complexity	Most metals can be cast; almost no limit on shape, size; useful for complex shapes. Plastic patterns easily handled; no draft required; no flash	Pattern costs can be high for low quantities; some limitations imposed by low strength of pattern material
Permanent-mold castings	Mold cavities are machined into metal die blocks designated for repetitive use; molten metal is gravity-fed to cavity (pressure sometimes applied after pouring). Mold consists of two or more parts and is hinged and clamped for easy removal of castings	Good surface finish and grain structure; high dimensional accuracy; repeated use of molds (up to 25,000); rapid production rate; low scrap loss; low porosity	High initial mold costs; shape, size and intricacy limited; high-melting metals such as steel unsuitable
Die castings	Molten metal is poured into closed steel die under pressures varying from 1500 to 25,000 psi; when the metal solidifies, the die is opened and the casting ejected	Extremely smooth surfaces; excellent dimensional accuracy; rapid production rate	High initial die costs; limited to nonferrous metals; size of part limited

Casting Processes Table (continued)

Plaster-mold castings	Slurry of special gypsum plaster, water, and other ingredients is poured over pattern and allowed to set; pattern is removed and the mold baked. When poured metal cools, mold is broken for removal of casting	High dimensional accuracy; smooth surfaces; almost unlimited intricacy; low porosity	Limited to nonferrous metals; limited to relatively small parts; mold-making time is relatively long
Ceramic-mold castings	Precision technique using stable ceramic powders, binder, and gelling agent for mold. Mold can be ceramic or ceramic facing with sand backup	Intricate, close tolerance parts with smooth finishes can be cast	Some limit to maximum size
Investment castings	Refractory slurry is cast around (or dipped on) a pattern formed from wax or plastic; when slurry hardens, pattern is melted out and mold is baked. When poured metal solidifies, mold is broken away from casting	High dimensional accuracy; excellent surface finish; almost unlimited intricacy; almost any metal can be used; no flash to remove; no parting line tolerances	Size of part limited; requires expensive patterns and molds; high labor costs
Centrifugal castings	Sand, metal, or graphite mold is rotated in a horizontal or vertical plane (true centrifugal method); molten metal introduced into the revolving mold is thrown to mold wall, where it is held by centrifugal force until solidified	Good dimensional accuracy; rapid production rate; good soundness and cleanliness of castings; ability to produce extremely large cylindrical parts	Shape of part limited; spinning equipment expensive

From “Materials Selector.” *Materials Engineering Magazine*. Penton/IPC. Cleveland, OH.

FORGING PROCESSES TABLE

Advantages and Disadvantages of the Common Forging Processes

Form	The Process	Advantages	Limitations
Open-die forgings	Compressive forces (produced by hand tools or mechanical hammers) are applied locally to heated metal stock; little or no lateral confinement is involved. Desired shape is achieved by turning and manipulating workpiece between blows	Simple, inexpensive tools; useful for small quantities; wide range of sizes available; good strength characteristics	Limited to simple shapes; difficult to hold close tolerances; machining to final shape necessary; slow production rate; relatively poor utilization of material; high degree of skill required
Closed-die forgings	Compressive forces (produced by a mechanical hammer in a mechanical or hydraulic press) are applied over the entire surface of heated metal stock, forcing metal into a die cavity of desired shape. There are several types of closed-die forgings	Relatively good utilization of material; generally better properties than open-die forgings; good dimensional accuracy; rapid production rate; good reproducibility	High tool cost for small quantities; machining often necessary
	Blocker type. Uses single-impression dies and produces parts with somewhat generalized contours	Low tool costs; high production rates	Machining to final shape necessary; thick webs and large fillets necessary
	Conventional type. Uses preblocked workpiece and multiple-impression dies	Requires much less machining than blocker type; rapid production rates; good utilization of material	Somewhat higher tool cost than blocker type
	Precision type. Uses minimum draft (often 0°)	Close tolerances; machining often unnecessary; excellent material utilization; very thin webs and flanges possible	Requires intricate tooling and elaborate provision for removing forging from tools
Upset forgings	Heated metal stock is gripped by dies (which also form the impression) and pressed into desired shape	Fair amount of intricacy possible; good dimensional accuracy; rapid production rate	Limited to cylindrical shapes; finish not as good as with other forgings; size of part limited; high die costs
Cold-headed parts	Similar to upset forging except metal is cold. Wire up to about 1 mm diam. is fed to die in punch press and positioned with one end protruding; this end mushrooms out under force of punch and is formed between die and punch face	Good surface strength; alloys used are generally tough, ductile and crack resistant; excellent surface finish; no scrap loss; rapid production rate	Head volume and shape limited; internal stresses may be left at critical points; size of part limited

From "Materials Selector," *Materials Engineering Magazine*. Penton/IPC, Cleveland, OH.