Production Engineering

Casting Processes

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First class-2020

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METAL CASTING PROCESSES

2. OTHER EXPENDABLE-MOLD CASTING PROCESSES

There are other casting processes that have been developed to meet special needs. The differences between these methods are in the composition of the mold material, or the manner in which the mold is made, or in the way the pattern is made.

2.1 SHELL MOLDING

2.2 VACUUM MOLDING , (V-process)

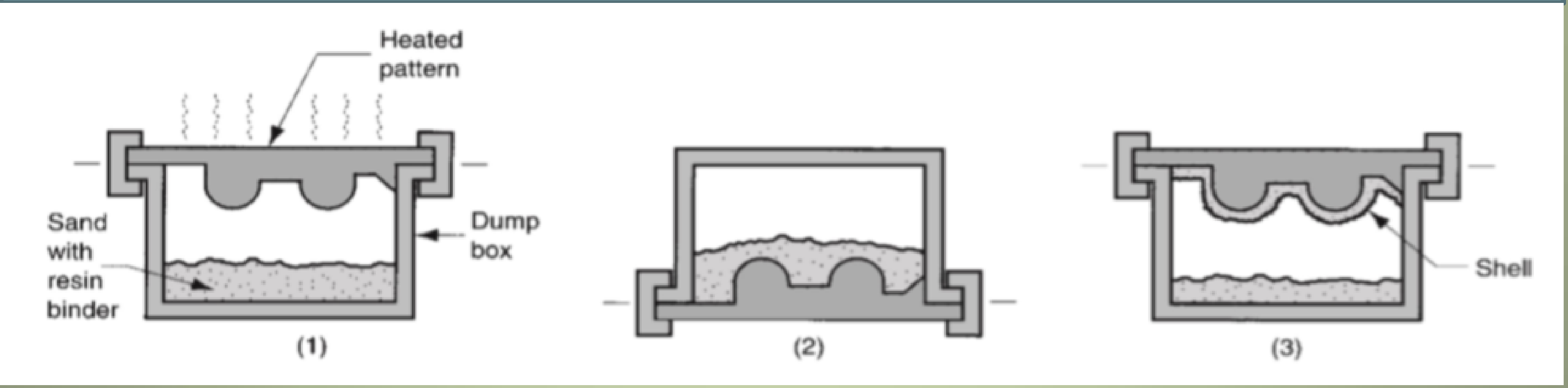
2.3 EXPANDED POLYSTYRENE PROCESS

2.4 INVESTMENT CASTING, (lost-wax process)

2.1 SHELL MOLDING

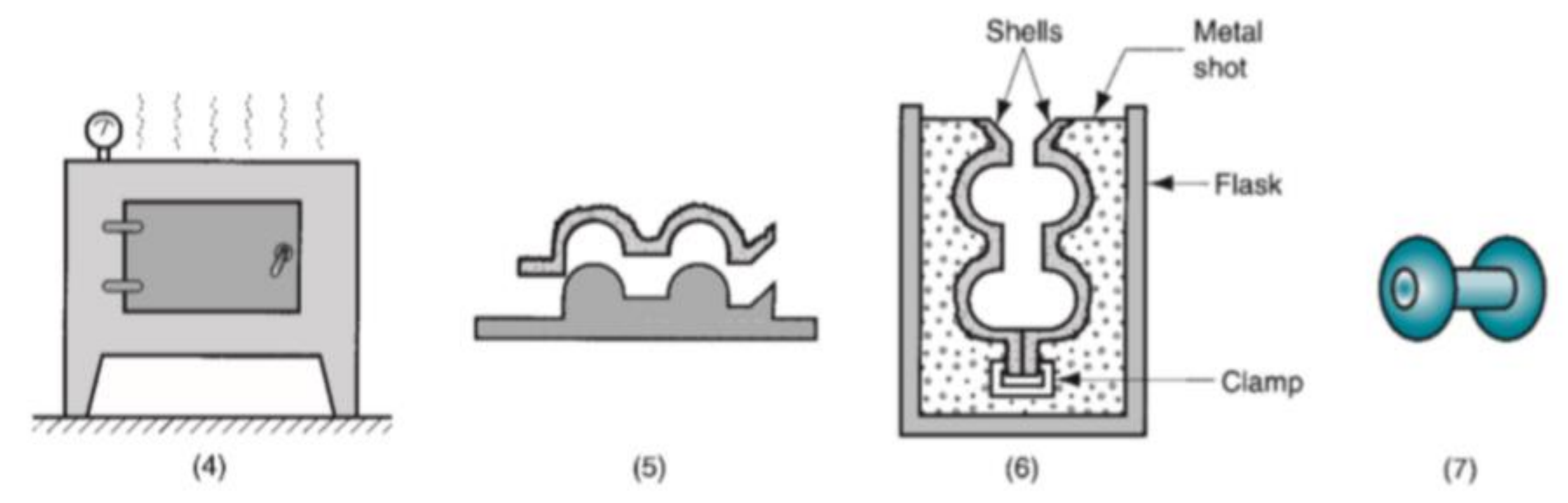
Shell molding is a casting process in which the mold is a thin shell (typically 9 mm) made of sand held together by a thermos setting resin binder. Developed in Germany during the early 1940s,

1) a match-plate or cope-and-drag metal pattern is heated and placed over a box containing sand mixed with thermosetting resin;
2) box is inverted so that sand and resin fall onto the hot pattern, causing a layer of the mixture to partially cure on the surface to form a hard shell;
3) box is repositioned so that loose, uncured particles drop away;



4) sand shell is heated in oven for several minutes to complete curing;
5) shell mold is stripped from the pattern;
6) two halves of the shell mold are assembled, supported by sand or metal shot in a box, and pouring is accomplished.

The finished casting with sprue removed is shown in Figure.



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The advantages to the shell-molding process

- The surface of the shell mold cavity is smoother than a conventional green-sand mold, and this smoothness permits easier flow of molten metal during pouring and better surface finish on the final casting. Finishes of 2.5 mm can be obtained.
- Good dimensional accuracy is also achieved, with tolerances of 0.25 mm possible on small-to-medium-sized parts.
- The good finish and accuracy often precludes the need for further machining.
- Collapsibility of the mold is generally sufficient to avoid tearing and cracking of the casting.

Disadvantages of shell molding include

- A more expensive metal pattern than the corresponding pattern for green-sand molding. This makes shell molding difficult to justify for small quantities of parts.
- Shell molding can be mechanized for mass production and is very economical for large quantities.
- particularly suited to steel castings of less than 20 Ib.

- **Examples of parts** made using shell molding include gears, valve bodies, bushings, and camshafts.

2.2 VACUUM MOLDING , (V-process)

VACUUM MOLDING was developed in Japan around 1970 It uses a sand mold held together by vacuum pressure rather than by a chemical binder.

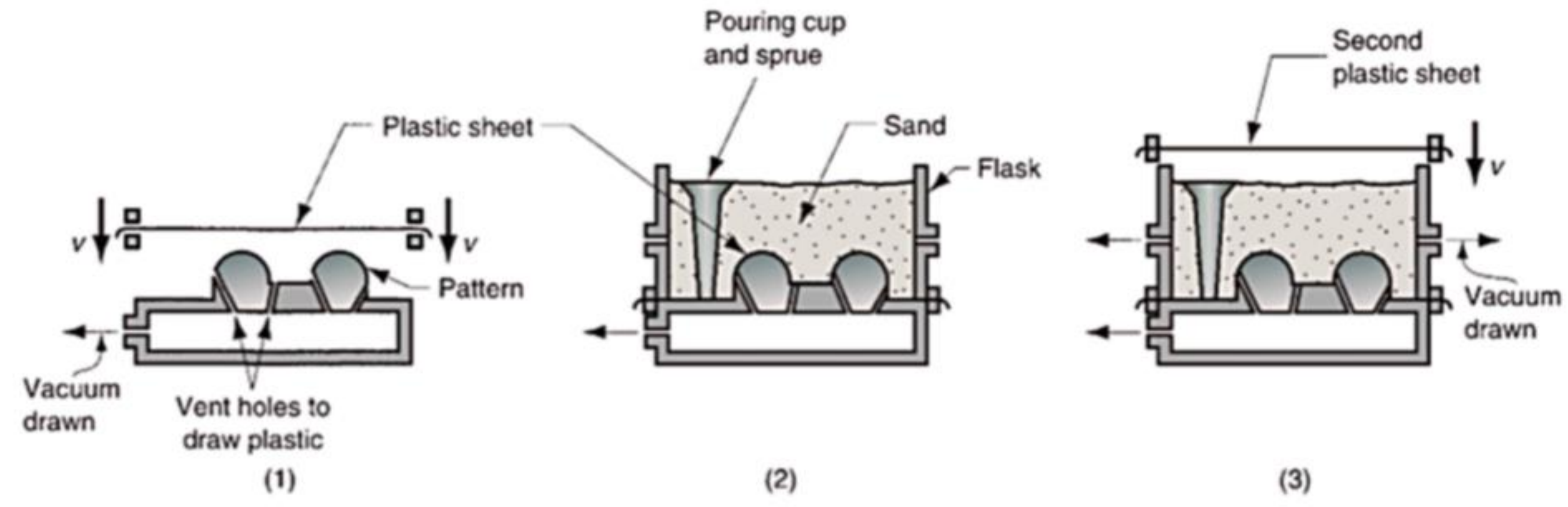
- ✓ Because no binders are used, the sand is readily recovered in vacuum molding. Also, the sand does not require extensive mechanical reconditioning normally done when binders are used in the molding sand.
- ✓ Since no water is mixed with the sand, moisture related defects are absent from the product.

Disadvantages of the V-process are that it is relatively slow and not readily adaptable to mechanization.

Accordingly, the term vacuum in this process refers to the making of the mold rather than the casting operation itself.

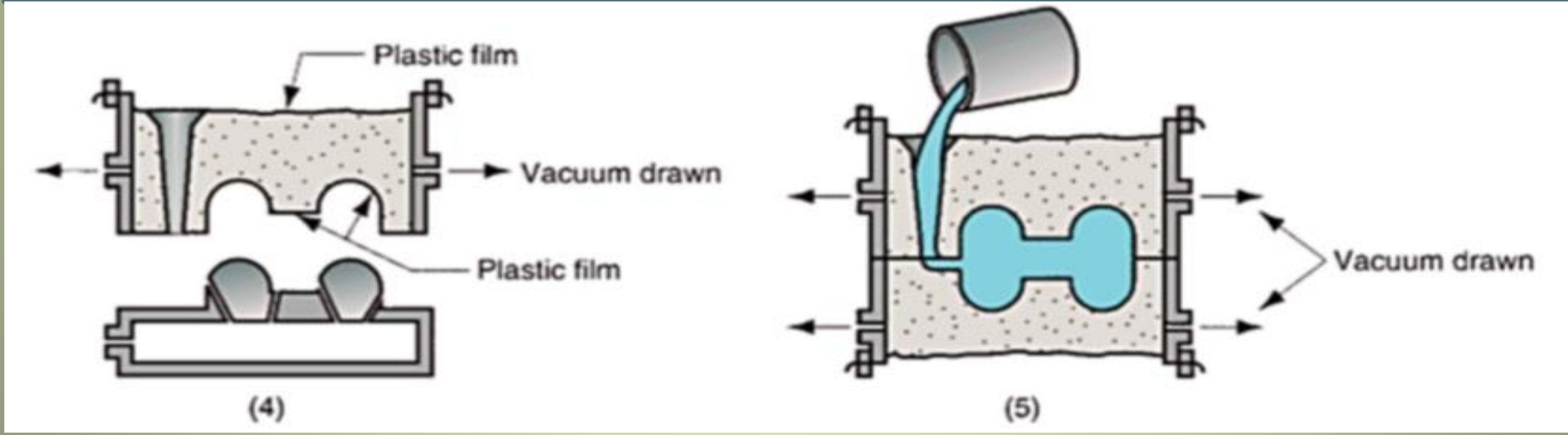
Steps in vacuum molding

1) A thin sheet of preheated plastic is drawn over a match-plate or cope-and-drag pattern by vacuum—the pattern has small vent holes to facilitate vacuum forming;
2) A specially designed flask is placed over the pattern plate and filled with sand, and a sprue and pouring cup are formed in the sand;
3) Another thin plastic sheet is placed over the flask, and a vacuum is drawn that causes the sand grains to be held together, forming a rigid mold;



Steps in vacuum molding

4) The vacuum on the mold pattern is released to permit the pattern to be stripped from the mold;
5) This mold is assembled with its matching half to form the cope and drag, and with vacuum maintained on both halves, pouring is accomplished. The plastic sheet quickly burns away on contacting the molten metal. After solidification, nearly all of the sand can be recovered for reuse.



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2.3 EXPANDED POLYSTYRENE PROCESS

The expanded polystyrene casting process uses a mold of sand packed around a polystyrene foam pattern that vaporizes when the molten metal is poured into the mold.

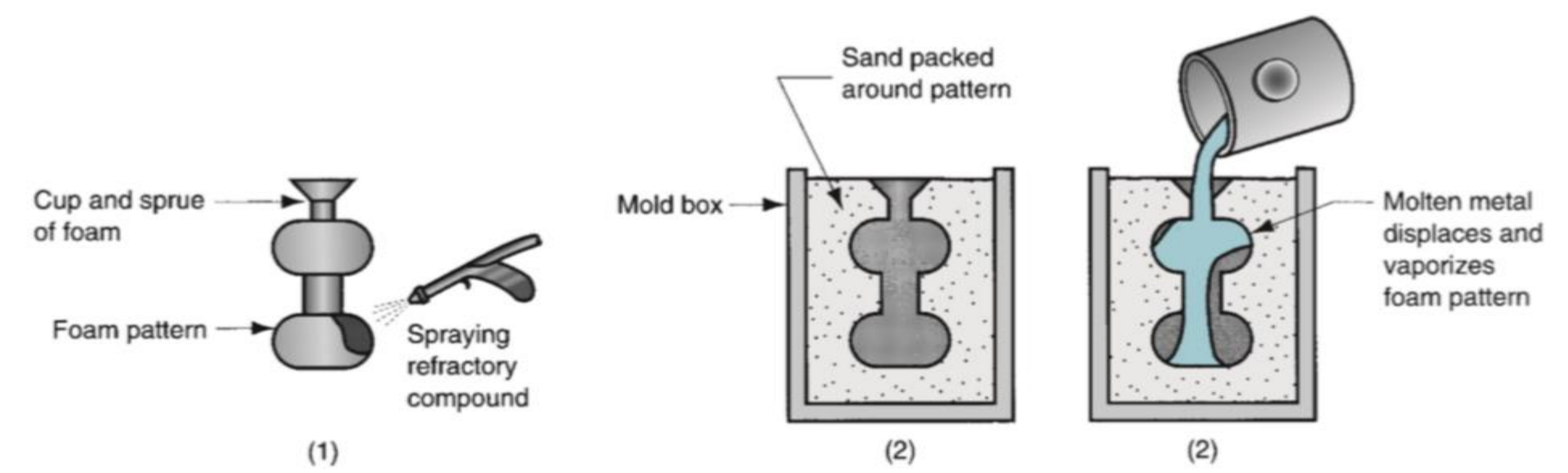
The process and variations of it are known by other names, including lost-foam process, lost pattern process, evaporative-foam process, and **full-mold process** (the last being a trade name).

The foam pattern includes the sprue, risers, and gating system, and it may also contain internal cores (if needed), thus eliminating the need for a separate core in the mold. Also, since the foam pattern itself becomes the cavity in the mold, considerations of draft and parting lines can be ignored.

Various methods for making the pattern can be used, depending on the quantities of castings to be produced.
For one-of-a-kind castings, the foam is manually cut from large strips and assembled to form the pattern.

Expanded polystyrene casting process steps:

1) pattern of polystyrene is coated with refractory compound;
2) foam pattern is placed in mold box, and sand is compacted around the pattern; and
3) molten metal is poured into the portion of the pattern that forms the pouring cup and sprue. As the metal enters the mold, the polystyrene foam is vaporized ahead of the advancing liquid, thus allowing the resulting mold cavity to be filled.



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Automated molding operation can be setup to mold the patterns prior to making the molds for casting. The pattern is normally coated with a refractory compound to provide a smoother surface on the pattern and to improve its high temperature resistance. Molding sands usually include bonding agents .However, dry sand is used in certain processes in this group, which aids recovering and reuse .

A significant advantage for this process is:

1) the pattern need not be removed from the mold.
2) this simplifies and expedites mold making.
3) the parts (cope and drag with proper parting line, cores, gating and riser system) are built into the pattern itself.

A new pattern is needed for every casting, so the economics of the expanded polystyrene casting process depend largely on the cost of producing the patterns. The process has been applied to mass produce castings for automobiles engines. Automated production systems are installed to mold the polystyrene foam patterns for these applications.

2.4 INVESTMENT CASTING, (lost-wax process)

In **investment casting**, a pattern made of wax is coated with a refractory material to make the mold, after which the wax is melted away prior to pouring the molten metal.
It is a precision casting process, because it is capable of making castings of high accuracy and intricate detail. The process is also known as the **lost-wax process**, because the wax pattern is lost from the mold prior to casting.

The term investment comes from one of the less familiar definitions of the word invest, which is "to cover completely," this referring to the coating of the refractory material around the wax pattern.

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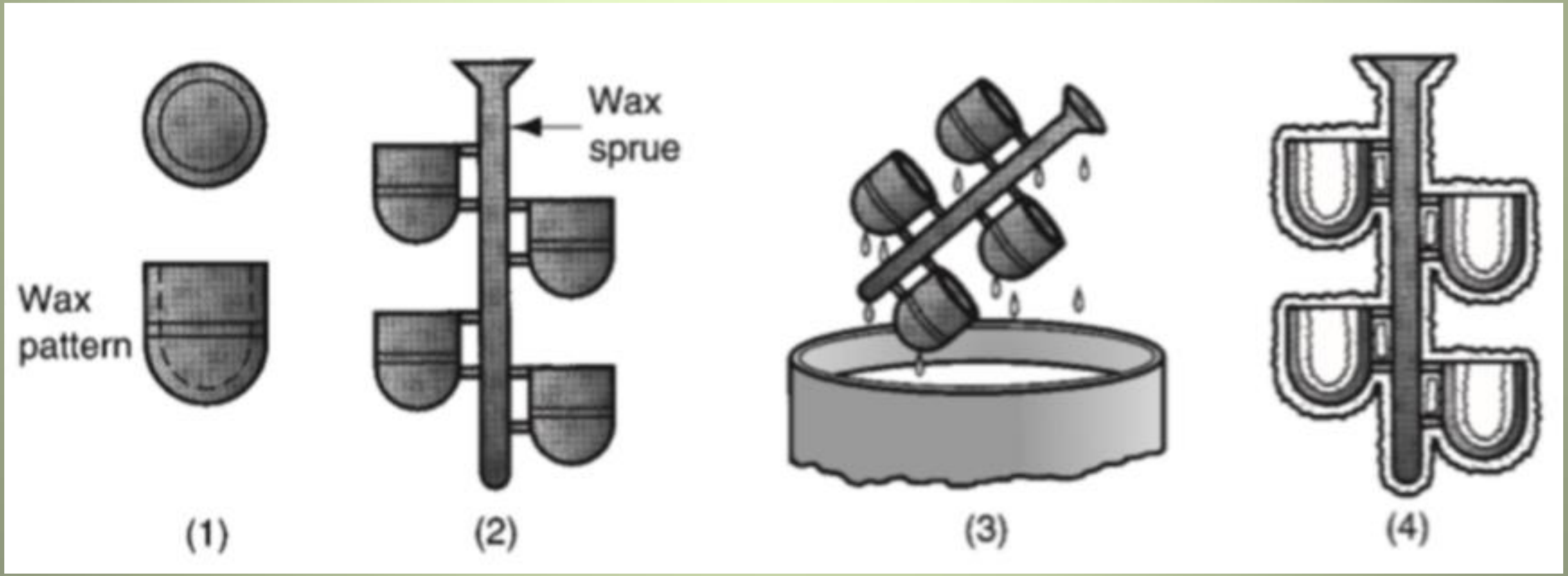
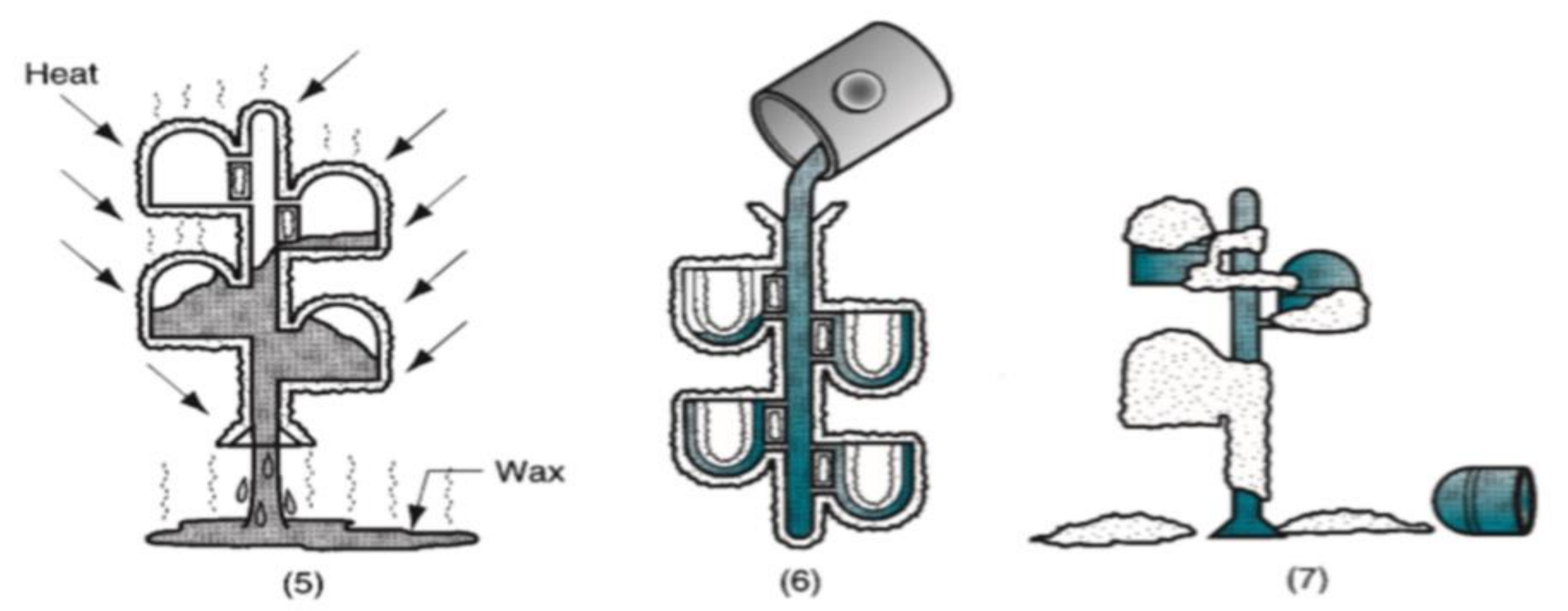
Steps in investment casting:

1) wax patterns are produced;
2) several patterns are attached to a sprue to form a pattern tree;
3) the pattern tree is coated with a thin layer of refractory material;
4) the full mold is formed by covering the coated tree with sufficient refractory material to make it rigid;



The mold is allowed to air dry for about 8 hours to harden the binder.

5) the mold is held in an inverted position and heated to melt the wax and permit it to drip out of the cavity;
6) the mold is preheated to a high temperature, which ensures that all contaminants are eliminated from the mold; it also permits the liquid metal to flow more easily into the detailed cavity; the molten metal is poured; it solidifies; and
7) the mold is broken away from the finished casting. Parts are separated from the sprue.



Coating with refractory (step 3) is usually accomplished by dipping the tree into a slurry of very fine grained silica or other refractory (powder form) mixed with plaster to bond the mold into shape.
The small grain size of the refractory material provides a smooth surface and capture the intricate details of the wax pattern.
The final mold (step 4) is accomplished by repeatedly dipping the tree into the refractory slurry or by gently packing the refractory around the tree in a container.

- ✓ Since the wax pattern is melted off after the refractory mold is made, a separate pattern must be made for every casting.
- ✓ Pattern production is usually accomplished by a molding operation-pouring or injecting the hot wax into a master die that has been designed with proper allowances for shrinkage of both wax and subsequent metal casting.
- ✓ In cases where the part geometry is complicated, several separate wax pieces must be joined to make the pattern.
- ✓ In high production operations, several patterns are attached to a sprue, also made of wax, to form a pattern tree; this is the geometry that will be cast out of metal.

Advantages of investment casting include:

1. parts of great complexity and intricacy can be cast;
2. close dimensional control-tolerances of 0.075 mm are possible;
3. good surface finish is possible;
4. the wax can usually be recovered for reuse; and
5. additional machining is not normally required-this is a net shape process.

Because many steps are involved in this casting operation, it is a relatively expensive process. Investment castings are normally small in size, although parts with complex geometries have been successfully cast.

All types of metals, including steels, stainless steels, and other high temperature alloys, can be investment cast. Examples of parts include complex machinery parts, blades, and other components for turbine engines, jewelry, and dental fixtures.

References

- B.H. Amstead, Phillip F. Ostwald, Myron L. Begeman, Manufacturing Processes, Seventh Edition, SI Version (1979, 1987).
- Mikell P. Groover, Fundamentals of Modern Manufacturing, Materials, Processes and Systems, 4th Edition (2010).

Thanks you

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