Lost Foam Process

The Future of Metal Casting

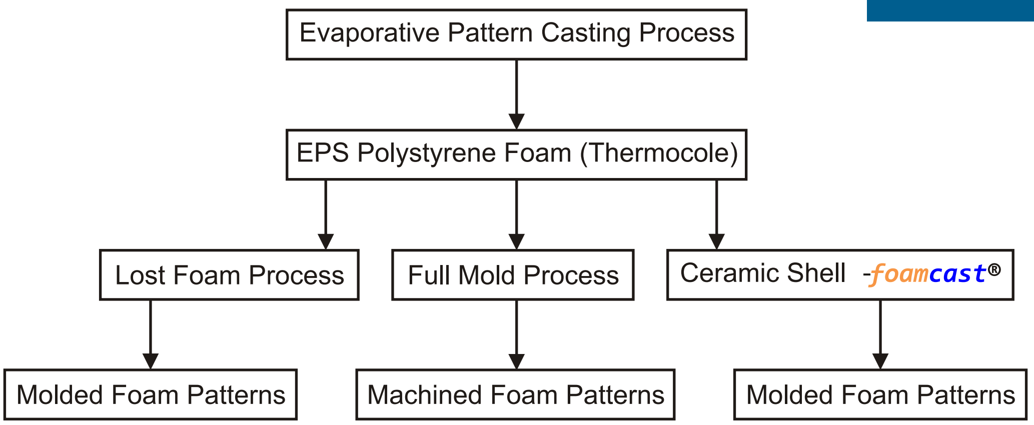
Evaporative Pattern Casting Process is a class of casting processes that use pattern materials that evaporate during the pour, which means there is no need to remove the pattern material from the mold before casting.

The first patent for an evaporative-pattern casting process was filed in April 1956, by H.F. Shroyer. He patented the use of foam patterns embedded in traditional green sand for metal casting. In his patent, a pattern was machined from a block of expanded polystyrene (EPS), and supported by bonded sand during pouring.

In 1964, M.C. Flemmings used un-bonded sand for the process. The first North American foundry to use evaporative-pattern casting was the Robinson Foundry at Alexander City, Alabama. General motors first product using these processes was the 4.3L, V-6 diesel cylinder head, which were made in 1981 at Massena, New York.

Lost foam casting (LFC) is a type of metal casting process that uses expendable foam patterns to produce castings. Lost foam casting utilises a foam pattern which remains in the mould during metal pouring. The foam pattern is replaced by molten metal, producing the casting. With LFC, the foam pattern is moulded from polystyrene beads. LFC is differentiated from the full mould method by the use of unbonded sand as opposed to bonded sand.

Types of Evaporative Pattern Casting Process



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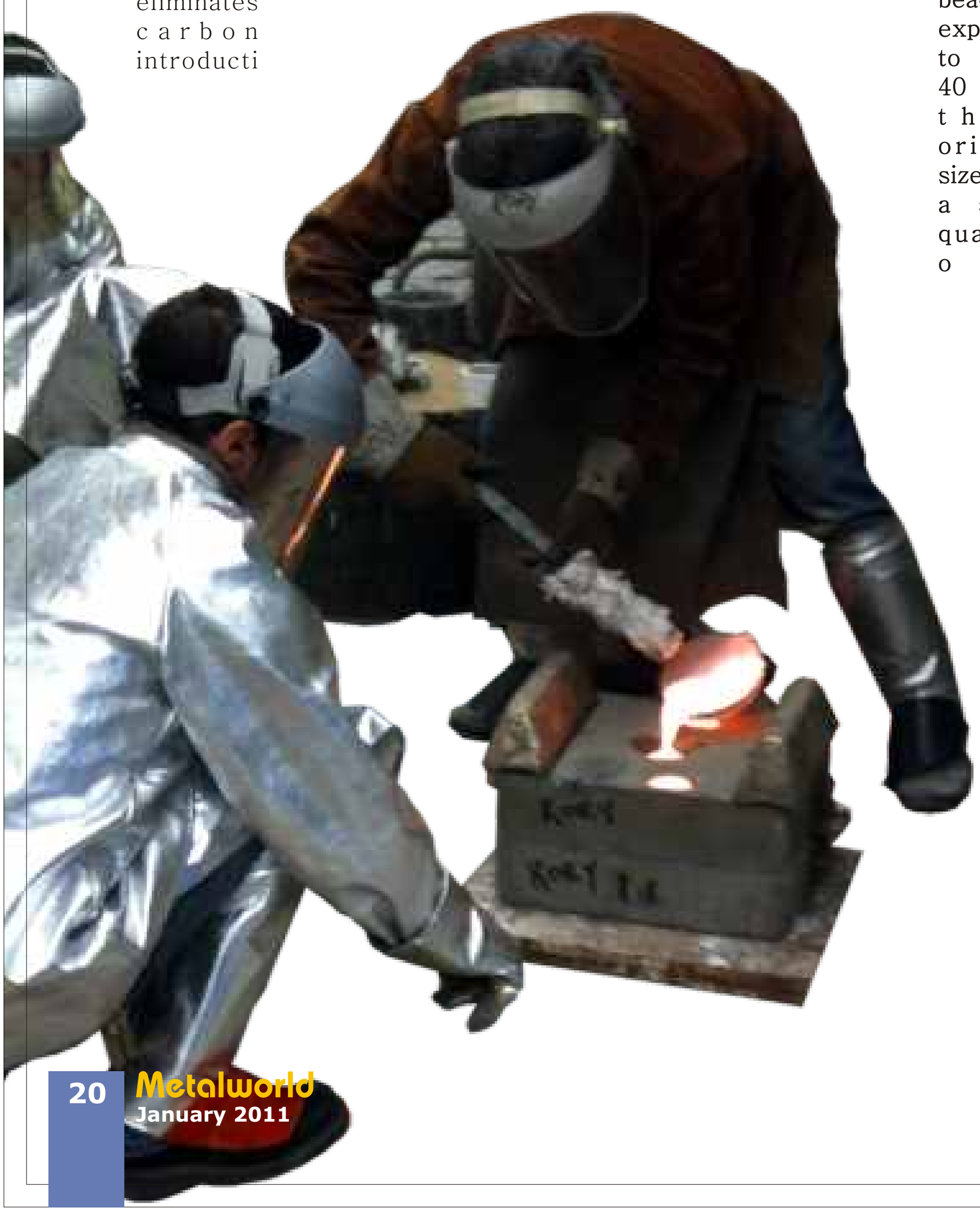
Lost foam casting, Full-Mold casting & ceramic shell process

Lost-foam casting (LFC) is a type of evaporative-pattern casting process that is similar to investment casting except foam is used for the pattern instead of wax. This process takes advantage of the low boiling point of foam to simplify the investment casting process by removing the need to melt the wax out of the mold.

Full-mold casting is an evaporative-pattern casting process which is a combination of sand casting and lost-foam casting. It uses a expanded polystyrene foam pattern which is then surrounded by sand, much like sand casting. The metal is then poured directly into the mold, which vaporizes the foam upon contact.

Ceramic Shell Casting – ***foamcast®*** is a hybrid method between lost-foam and investment or lost-wax castings. The expendable pattern is made from Expandable Polystyrene (Thermocole), but unlike lost foam, the pattern is removed from the mold cavity during firing of the ceramic that surrounds the pattern. ***foamcast®*** is more like the investment casting process, where the disposable pattern material is removed from the mold shape before the introduction of the molten metal. The process is developed for steel castings, especially low-carbon steels as pattern removal before pouring eliminates carbon introduction in the metal as Expanded Polystyrene (Thermocole) is mainly comprised of carbon. The process is valuable for large parts.



Processing of Polystyrene Pattern – White Side

Polystyrene Pattern Molding

Unlike other thermoplastic processes, the production of Polystyrene Foam (Thermocole) Patterns requires that the raw materials be pre-conditioned prior to their final "tooled" moulding process. The raw material (also known as "expandable polystyrene" or "bead") has a spherical shape and is similar to sugar in appearance.

The conversion process is carried out in three stages:

Pre-expansion

The tiny spherical polystyrene beads are expanded to about 40 times their original size using a small quantity of pentane (typically 5% by weight) as a blowing agent. This process involves the heating of beads, using a flow of steam, which causes the blowing agent to boil and thus a honeycomb of closed cells is formed.

Maturing

As the material cools the pentane liquefies and a partial vacuum is formed inside the bead. The beads are returned to a holding tank for approximately twelve hours to allow the pressure differential to equalize, giving a stabilised granule.

Final Molding

In this final stage the pre-expanded stabilized beads are reheated with steam in a mould that molds a pattern that essentially is identical to the casting. The final expansion takes place and the beads fuse to give a shaped pattern. In this final form the Polystyrene Foam (Thermocole) Pattern is made up of 98% air.

The Machines and Tools

The patterns are formed in aluminium mould tools. These are generally of male and female form, with the shape between the two halves of the mould being the shape, of the casting.

The mould tool is fitted into a molding machine, which has the facility to introduce steam from behind each half of the tool. The steam is introduced through small slotted vents, which have been machined into the mould tool when it was manufactured.

Polystyrene Pattern Assembly

After the patterns are dried they are ready for assembly. In this process the pattern is assembled by gluing Polystyrene foam runners and risers in case of a single large pattern. In case of smaller patterns, multiple patterns are a assembled by gluing Polystyrene foam runners and risers in a "tree" or a "cluster" connecting to the patterns to the main polystyrene foam “sprue” which is the central column.

Polystyrene Pattern Coating

Ceramic shell molds are made from a mixture of graded refractory fillers that are blended to a slurry consistency. A ceramic shell builds around the polystyrene foam pattern assembly as it is repeatedly dipped in the slurry.

Ceramic Shell

This mold is heated to a high temperature in a heat treatment furnace until the polystyrene foam evaporates. Simultaneously during this process the ceramic shell is sintered and becomes rigid.

Metal Casting–Black Side Sand Filling

One of the important tricks in making consistently reliable "lost foam," or evaporative pattern castings, is engineering the filling of the flask with sand. The foam cluster must be totally surrounded and structurally supported by sand without being distorted or causing dimensional changes. Sand fill around the foam can be accomplished in several ways, two of which, fill tubes and rain fill.

Compaction

Proper compaction of the dry sand is an essential element of a successful lost foam system. The sand must be totally compacted in all areas of the flask to correctly position and support the foam cluster for dimensionally stable castings to be produced consistently. Vibration is now utilized to compact the sand. Compaction tables for foam pattern castings having horizontal or vertical–axis movement.

Sand fill and compaction are important keys to success of the process and must not be taken lightly.

Pouring

Once the compaction of the sand is complete the flask is ready for pouring. The pouring can be done either manually or by automatic pouring using a bottom pouring ladle.

Cleaning and Finishing

After the casting has solidified, it is transferred to the shakeout area and proceeds through cleaning and finishing operations like other casting processes. The shakeout process is easy with un–bonded sand.

Evaporative Pattern Casting V/s. Traditional Casting Processes

- Evaporative Pattern Casting Process V/s Green Sand Process
- Evaporative Pattern Casting Process V/s No Bake Process
- Evaporative Pattern Casting Process V/s Lost Wax Process

Evaporative Pattern Casting Process V/s Green Sand Process:

Property	Green Sand Casting	Evaporative Pattern Casting
Complex Internal Features and Part Consolidation.	Complexity determined by sand core limitations, geometry, strength, and cost.	Extensive and complex internal features (as thin as 3mm), based on detail duplication and pattern assembly in foam.
Dimensional Tolerances	+ / - 0.030" is typical depending on part size, complexity, and geometry	+ / - 0.005" - 0.010" is typical depending on part size, complexity, and geometry.
Surface Finish Capabilities	Depends on grain fineness of sand.	Depends on bead size and ceramic coating grain fineness.
Feature Accuracy	Core movement and shift between mold halves across the parting line limit feature accuracy.	No cores or mold halves to shift and degrade feature accuracy.
Parting Line and Draft Angles	Parting lines and draft angles are necessary for molding.	No parting lines in the mold and minimal draft on tools.
Environmental Costs	Sand recovery requires binder removal	Sand is binder free, so it can be easily and rapidly recovered at low cost.
Tool Life	Wear on wood & metal tools from sand abrasion	Low wear and long life with aluminium tool

Evaporative Pattern Casting Process V/s No Bake Process

Property	No Bake	Evaporative Pattern Casting
Molding Process	Mix moulding sand Mould cope and drag Mix core sand Mould cores	Pre-formed EPS bead a pneumatically injected in Pattern Mold.
Assembly time	Approx. 15 mins. Assembly of EPS Patterns	Approx. 25 mins. Hardening of cores and molds
Process Time	Short process as the pattern is molded in one piece.	Involves setting up of the mold, cores , etc.
Knock-out & finishing	Thin shell requires short vibratory knockout & shot-blasting	Is labour intensive as grinding, welding, etc. is required

Evaporative Pattern Casting Process V/s Lost Wax Process

Property	Lost Wax	Evaporative Pattern Casting
Composition of Pattern	Microcrystalline Wax	Expanded Polystyrene Foam
Density of Material used for pattern	Density of Microcrystalline Wax Patterns - 795 kgs./m³, resulting in heavy delicate patterns.	Density of Expanded Polystyrene Patterns - 42 kgs./m³ sufficient for strong, sturdy, dimensionally accurate and light patterns.
Maximum Weight of Cast Part	Well Below 125 kgs.	No limitation of weight of cast part.
Pre-Heating of Ceramic Shell	Required	No required, pouring is possible at room temperature of ceramic shell.
Rejection of Shell during process	The ceramic shell has a tendency to crack during the autoclave process due to the expansion of Wax	The ceramic shell does not crack during the burn-off process as EPS does not expand but evaporates/melts.
Methoding	Difficult and has limitations in addition to the problem of riser backfilling.	Flexible, risers are simply glued on the pattern to suit the methoding. The feeding ability of riser is improved with the use of exothermic sleeves.
Ceramic Shell Thickness	Approx. 10-15mm	Approx. 5-10mm depending on the size of component.

Evaporative Pattern Casting Process capability:

Casting Alloy

Cast Iron	Grey Iron, Ferrite/Pearlite Ductile Iron, High-Nickel Ductile Iron, Hi-Chrome White Iron
Cast Steel	Aluminum alloy, Bronze, Brass
Non-ferrous	Carbon Steel, Tool Steel, Hi-Manganese Steel, Heat-resistant Steel

Process Capability

Weight	Size	Liner Tolerance	Thickness	Sharpness	Surface Finish
15~2500kgs.	≦1200mm	ISO8062, CT6~9	≧3mm	R0.5	Non-Ferrous, Ra3.2~6.3μm;
					Ferrous, Ra6.3~12.5μm;

Summary of the Evaporative Pattern Casting Process

Evaporative Pattern Casting Process and the Environment

The most important environmental impacts during foundry are the large use of energy and all kinds of emissions and dust.

The process has tremendous advantages for the production of castings which require complex cored passageways, uniform wall thickness and limited or no draft angles. As the casting is a virtual reproduction of the molded foam pattern, dimensional control is improved over castings produced by the green-sand route and for many features such as gasket surfaces and drilled holes. Furthermore, the improved dimensional control means a significant reduction in, or even the elimination of, machining. And this means a reduction in the use of coolants and lubricants, the largest environmental impacts in the metal industry!

The process differs from other techniques primarily in the following areas:

- There are no cores and no parting lines,
- Dry un-bonded sand is used,
- There is no mold wall movement and
- The tooling is not subjected to foundry wear.

These differences result in the following advantages to foamcast® over conventional foundry processes:

- There is less energy needed;
- There are lower emissions, the waste is solid and relatively clean, and the sand is easily recycled;
- Complex shapes are possible and the surface is almost finished. This means that there is less or no machining, less or no finishing and less or no assembly needed;
- The financial advantages are that there is less labour needed & the lifetime of tools is extremely long.
- Concerning the core: there are no related defects, shifts or fins, there is no core removal and there is no core equipment necessary, so no handling of hazardous core materials;
- Due to the close dimensional tolerances and the possibility of complex shapes, the design freedom is larger;
- The employees'/workers working conditions are improved. ❍❍❍