Shaping the future with the Lost Foam casting process

The principles of the Lost Foam casting process are now generally well known and many foundrymen will be familiar with the technique (1,2,3). What is perhaps not so well known, is the amount of progress that has been made since the process was first developed. With a conservative minimum 65000 tonnes of aluminium and 75000 tonnes of iron now being poured annually using the Lost Foam casting process, many designers, buyers and foundries now see this casting method as the way forward for truck, pipe and automotive component production. Recent forecasts (4,5) suggest that, by the year 2007, 29% of aluminium castings and 14% of grey and ductile iron castings poured in North America will be made by Lost Foam casting.

The Lost Foam casting process is illustrated schematically in figure 1. Raw polymer or copolymer bead is first pre-expanded to the required density and then moulded to make patterns and running systems, with close attention paid to pattern density and dimensions. The pieces are then accurately bonded together, using "nests" to align and support the parts in the automatic gluing machinery. The components are assembled into clusters ready for the application of a refractory coating, specially designed for Lost Foam casting. The coating is dried and the cluster transferred to the moulding line where unbonded sand is vibrated around the pattern. Following pouring, the castings are cooled, shaken out, fettled, cleaned and machined. Meanwhile the sand is conditioned ready for reuse.

It has always been recognised that the key to success with the process is component selection. In particular, manifolds, heat exchangers, cylinder heads and engine blocks are now widely recognised as being ideally suited to the process. These and other similar components are now being designed specifically for manufacture using the Lost Foam process.

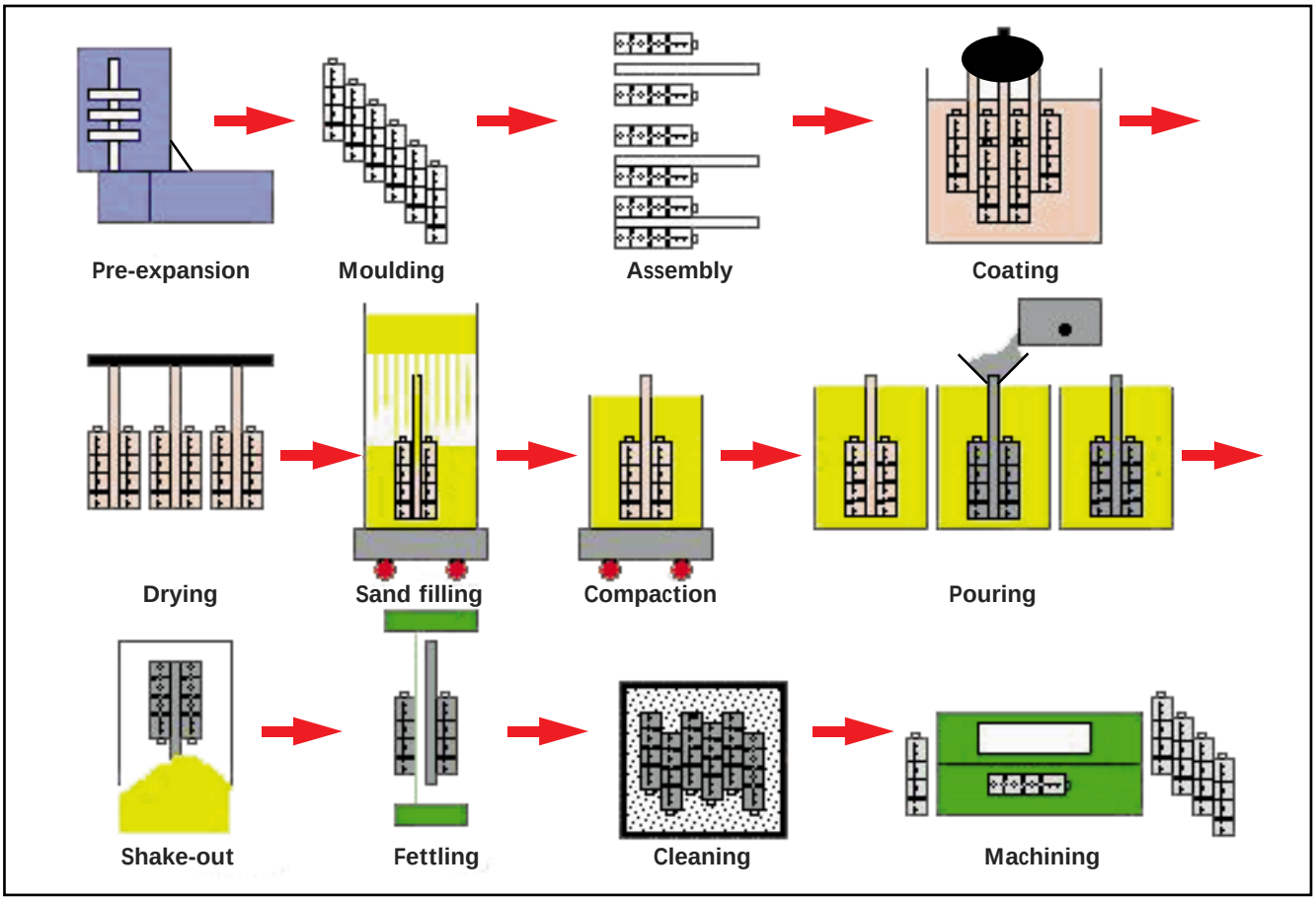

Figure 1: The Lost Foam casting process, illustrated schematically.

Adding value with the Lost Foam casting process

Foundry	Casting	Benefits of using the lost foam casting process.
Diversa Cast Technologies, Canada.	Aluminium railway valve body.	Three different versions combined into one casting.
Cagiva Group Italy. (4)	Aluminium cylinder head.	Elimination of cubing. Weight reduced by 15% compared to semi-permanent mould version.
Cagiva Group Italy. (4)	Aluminium three cylinder intake manifold, 5000 pieces per day.	Weight reduced by 15% and cost reduced by 30% compared to the sand cast version.
Citation foam, USA	Ductile iron marine engine parts.	Six castings combined into just two parts.
General Motors, USA. (4,5)	Aluminium 2.2L cylinder head, 5 million pieces produced to date. Aluminium engine block.	High dimensional repeatability. Near net shape. No draft angles. Integral design and manufacturing process.
Lovink, Netherlands. (6)	Grey and ductile iron castings, including butterfly valves, cam housings, cylinder heads, compressor casings and shaft hubs.	Reduced casting weight. Lower unit cost for machined casting. Almost unlimited design freedom. Improved enamelling.
Pont à Mousson, Stanton plc. UK.	Ductile iron pipe fittings.	Improved productivity and dimensional control of cast components with reduced costs.

The proven production benefits that have driven the development of this process allow Lost Foam foundries to add value to their castings, particularly by reducing weight, casting in complex features and reducing or eliminating machining operations. With these benefits now recognised by automotive component designers, castings are being developed that take full advantage of the Lost Foam casting process benefits through, for example:

- significantly reducing draft angles.
- incorporating complex, narrow water jackets.
- reducing cast and machined component weights by using:-
  - cast in bolt holes and channels.
  - reduced wall thicknesses.
  - reduced machining allowances.

The foundry can also benefit from improved productivity and lower costs through :-

- Reductions in tool wear.
- Higher casting production rates.
- Fewer finished casting machining operations.

Figure 2: This aluminium intake manifold for a three cylinder engine with its thin 3mm walls, cast in holes and narrow 4mm diameter air channel gave the foundry a 15% weight reduction and 30% cost reduction. (Courtesy of Alluminio Dongo SpA, CAGIVA Group).

Some foundrymen will recall the problems that hindered the development of the lost foam casting process in the early, pioneering, days. By working closely together, designers, foundries, equipment engineers, polymer manufacturers and coating suppliers have now removed these barriers, making the process a cost effective way to manufacture quality castings. The casting of iron components was initially very difficult due to the formation of lustrous carbon defects on the surface and subsurface carbonaceous inclusions, which were only revealed on machining. Essential to the advancement of ferrous Lost Foam casting was the development of copolymers, such as the patented Foseco low carbon bead, which helps to eliminate these defects and so make the process viable. (8)

Foseco low carbon bead

- Can be pre-expanded and moulded using conventional polystyrene moulding plant.
- Gives the strength required by the Lost Foam process.
- Eliminates lustrous carbon defects on the surface of iron Lost Foam castings.
- Eliminates subsurface carbonaceous inclusions.
- Widely used by ferrous Lost Foam foundries in the USA and Europe.

In much the same way, aluminium castings were affected by polystyrene degradation residues formed during the pouring operations. Defects caused by these residues gave rise to scrap from leaking castings. The cold fold defects that caused these leaks can now be eliminated by using specially designed Lost Foam coatings. It is now widely recognised that, in order to control the process, the filling of the mould cavity must be regulated. Once the plant, component design, running and gating, sand compaction, alloy and metal treatment aspects of the process have been established, the final step is to select the optimum coating.

Extensive research by Foseco and SMC has shown how the coating properties affect the mould filling process. By considering the degradation of the polymer pattern, we can see that, as the metal advances, the pattern melts and degrades to lower molecular weight polymers and monomers. These residues are then transported through the coating as both gases and liquids into the sand. This process is illustrated in Figure 5. Failure to remove the gaseous residues results in slow mould filling and mis-run castings. More seriously, failure to remove the liquid residues will result in defective castings being produced. If the gases escape too quickly, however, then the metal will fill the cavity in an

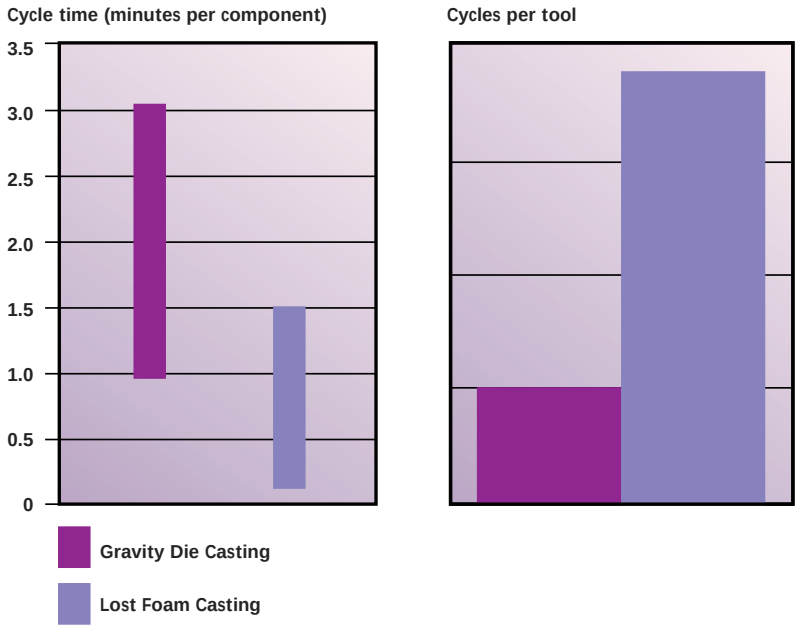

Figure 3: Casting production rates and cycles per tool for gravity die casting and Lost Foam casting.

Lost Foam casting process benefits compared to sand and permanent mould casting.

- Lower overall cost per component cast.
- Reduced casting weight.
- Higher productivity than conventional sand and die casting processes.
- Elimination of machining operations.
- More complex features cast in, for example: bolt holes and water jackets.
- Thinner walls.
- Reduced draft angles.
- Environmentally friendly reuse of sand, typically 95 to 99% after conditioning.

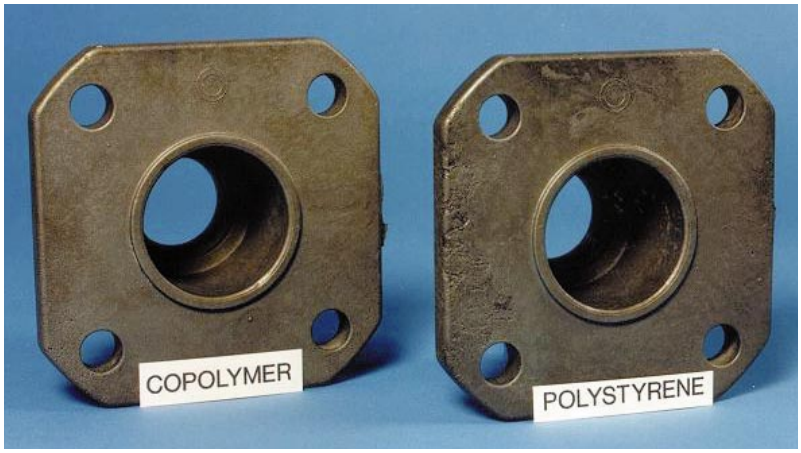

Figure 4: By using Foseco low carbon bead copolymer, carbon defects formed from the thermal degradation products of polystyrene are eliminated.

uncontrolled turbulent manner, giving rise to mould collapse, blowholes, oxide and inclusion defects. STYROMOL and SEMCO PERM Lost Foam coatings are designed to remove both the liquid and gaseous residues at the rate required to give controlled mould filling and defect free castings. Typically the casting process is optimised with defect formation and scrap levels minimised, by fine tuning and "tailoring" coating properties. SMC SEMCO PERM and Foseco STYROMOL Lost Foam coatings are available and meet the complete range of properties required. These coatings include:-

- Insulating STYROMOL 169 series coatings for aluminium.
- Non insulating STYROMOL and SEMCO PERM coatings for grey and ductile iron.
- High refractoriness STYROMOL and SEMCO PERM coatings for chrome irons, manganese and carbon steels.

Coating	Application	Benefit
STYROMOL 169 series	Aluminium cylinder head and manifold castings	Elimination of scrap from leaking castings
STYROMOL 142 series SEMCO PERM M65 series	Ductile and grey iron castings	Reduced fettling time by elimination of metal penetration
SEMCO PERM M66 series	Steel, ductile and grey iron castings	Higher productivity through the elimination of double dipping
STYROMOL 123 series	Chrome iron castings	High refractoriness eliminates burn-on and metal penetration

Foseco SEMCO PERM and STYROMOL Lost Foam coatings

- Products designed specifically to meet the demands of the Lost Foam casting process.
- Coating permeability chosen to regulate metal flow during casting filling to give sound, defect-free castings.
- Reduced casting finishing costs through reduced metal penetration and sand burn-on.
- Maximised thermal insulation to maintain the temperature of the molten aluminium during filling and so prevent cold laps and mis-runs.
- Optimised styrene oligomer absorption to aid the removal of harmful degradation residues, preventing leaks from cold fold defects.
- Coatings supplied with consistent batch-to-batch properties, giving the foundry complete control of the process.

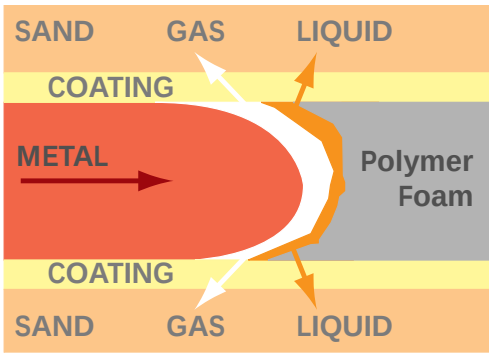

Figure 5: An illustration of the transport of gas and liquid polymer degradation residues through STYROMOL and SEMCO PERM lost foam coatings.

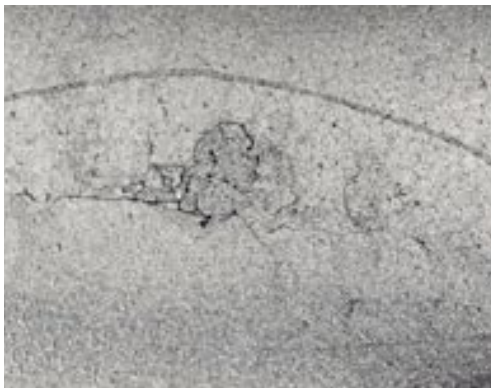

Figure 6: An example of a leaking casting with a cold fold defect caused by poor liquid residue removal. This defect is only visible after etching.

Figure 7: An example of a mis-run defect caused by the use of a coating with insufficient permeability or thermal insulation.

Figure 8: Turbulent mould filling caused by the use of a coating with too high a permeability created this aluminium oxide defect.

Foseco's expertise is not limited to coatings and polymers. Foseco MORVAL, currently operating from their manufacturing sites in the USA and Canada, supply high quality polystyrene and low carbon bead patterns, ready for final assembly by their customers. (3,7) This allows the foundries to concentrate on the casting operations, with no need to worry about the moulding of polystyrene patterns. Foseco and SMC have combined their latest product technology to provide a comprehensive range of coating products which meet the needs of current and future Lost Foam users. Ongoing commitment to product development programs and close partnerships with customers on specific projects, ensures that foundries utilising the Lost Foam method develop an operational process capable of delivering consistently high quality components.

References:

(1) The REPLICAST process, Foundry Practice 205, June 1982, p3-5.

(2) Polystyrene casting processes - The shape of things to come, Foundry Practice 213, August 1986, p12-15.

(3) Applications for the Evaporative Casting Process, Foundry Practice 217, April 1989, p6-10.

(4) Lost Foam, Showcasing the Process, American Foundryman's Society, October 27-29, 1998.

(5) Survey indicates bull market for lost foam foundries, Modern Casting, September 1998, p50-52.

(6) Lovink-Terborg hosts CIATF meeting, Foundry Trade Journal, November 1997, p455-6.

(7) The Foseco MORVAL 'dry ventless moulding' process for the manufacture of expanded polystyrene foundry patterns, Foundry Practice 219, April 1990, p14-15.

(8) European Patent No. 0 506 267 B1 and equivalents.

(9) United States Patent No. 4,627,946 and equivalents.

Foseco MORVAL patterns

- Vented and patented ventless mouldings for high quality castings. (9)
- Cost effective pattern manufacture.
- High quality patterns with consistent properties time after time.
- Controlled density for reproducible mould filling.
- Controlled dimensions for accurate casting production.
- Business focus on the supply of foam patterns to foundries.

Adding value with Foseco lost foam consumables

- Cost effective process consumables.
  - SEMCO PERM and STYROMOL coatings for process control in ferrous and non-ferrous lost foam casting.
  - Low Carbon Bead for carbon defect free ferrous lost foam castings.
  - Foseco MORVAL patterns for better castings.
- Consistent product quality.
- Technical support.
- Confidential research and development partnerships with customers.

Figure 9: The SMC Netherlands state of the art computerised coatings plant is used to manufacture high quality foundry products, including the SEMCO PERM and STYROMOL lost foam coatings.