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BMW advance with wide open throttle

Scepticism about the lost foam process capability is now, at least for professionally managed projects, not justified. Developments at BMW show why.

More than 480,000 lost foam BMWs are on the road today. The company's Landshut foundry last year achieved the projected 1500 per day cylinder head castings, produced at a quarter less cost than the low pressure permanent mould process traditionally employed by the company and at a higher overall equipment effectiveness (OEE) than for cylinder heads produced by low pressure or gravity diecasting.

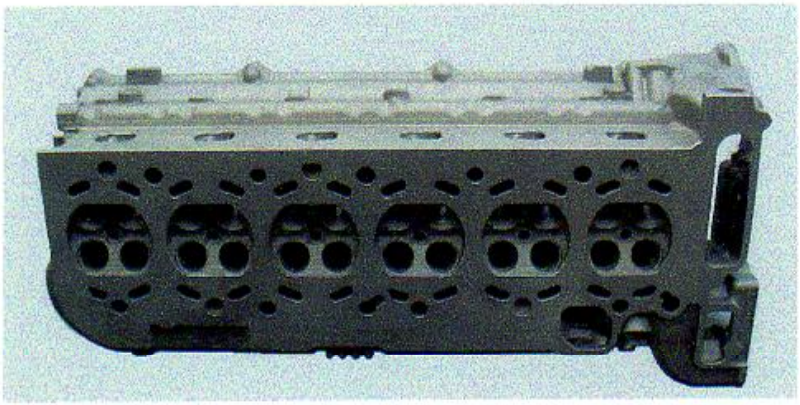
Most Popular BMW Engine - 6 Cylinder Inline

From the 'green light' given to the project in 1992 right through to the production phase, the foundry's partner in lost foam has been Vulcan Engineering Co. Around 75% of castings produced worldwide on lost foam systems are reckoned to be made on Vulcan lines. The company, headquarters in Helena, Alabama has over a dozen affiliates covering all aspects of the process technology, from robotics to tooling, from EPS foam process to furnaces, and from sand systems to casting cleaning.

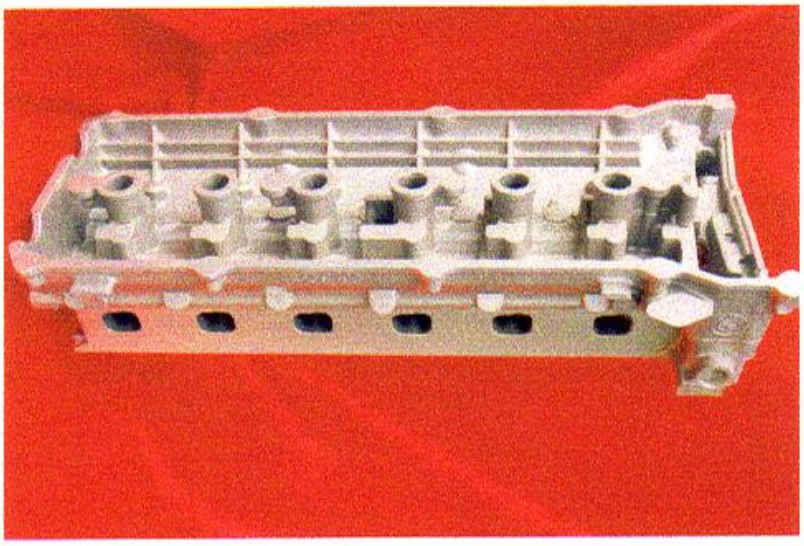
The attractions of the lost foam process are numerous; more as cast features, less machinery, added value and constant wall thickness and the ability to go to the functional section size. Tooling for the process is easier to modify than permanent mould and coremaking tools. There is simply less organic material involved and collection is from just two areas. High productivity, less maintenance and less overall floor space are also plus factors. Decisions on lost foam were influenced by basic tests and visiting the Saturn plant and other operations.

Vulcan installed a pilot plant and the first casting was made in 1993. Test castings were subjected to the thermoshock test, acknowledged as one of the most severe but essential to learn about the properties of metals cast by lost foam. In 1995 the plant order was initiated, involving simultaneous design of component tooling for foams, gluing nests, gating and the implementation of the casting line into an existing building.

Production began in 1998 of what was the world's first 6 cylinder heads. It is estimated that more than five million lost foam four valve per cylinder units from 2.0 l 110 kW output to 3.0 l / 172 kW output.



By Lost Foam poured Cylinder Head



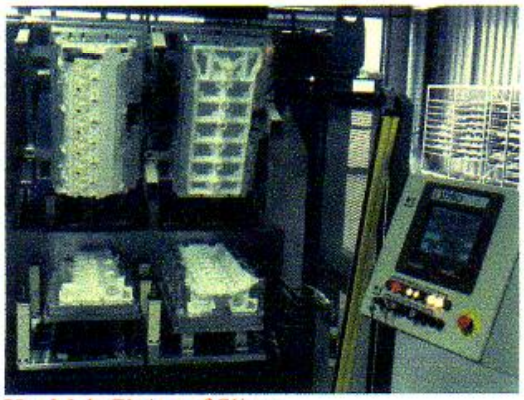
Vulcan insists that lost foam process chain is only as strong as its individual links and therefore is essential to integrate and control all the process links in house. Process interactions and equipment limitations need to be understood fully and success also requires the necessary resources including open minded people with specific qualifications.

The complete production system includes a polystyrene (EPS) bead pre- expander, bead storage, 11 moulding machines, 3 glueing machines, coating cell, drying and stabilisation ovens, complete casting line, backed by Vulcan Engineering's installation and training. Occupied floor space is 3400m² (including a mezzanine floor), and an additional 300m² outside for environmental control plant.

In production the first step on pre expansion of fine size polystyrene (EPS) beads to a density of 21g/l. Well dispersed direct steam as a heat source and a quick dump of bead batch are essential to ensure even bead size. Beads are dried in fluidising air and the bead room is air conditioned.

Foam Slice extraction

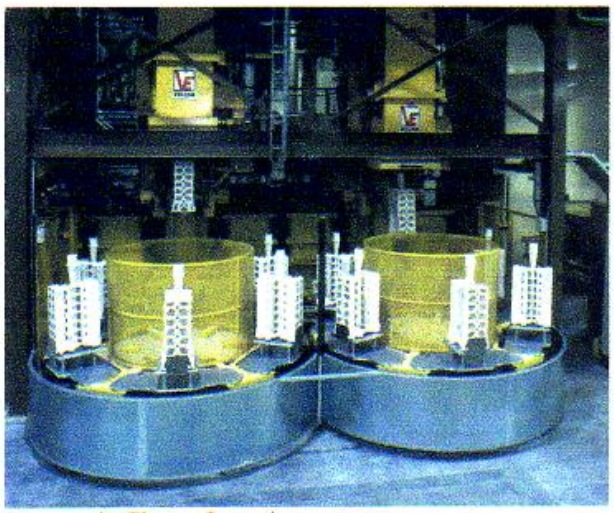
Five segments or slices are required to form one cylinder head. The individual segments are formed by filling aluminium tools with EPS beads, steam heating to expand and fuse, cooling to avoid distortion and then ejecting the pattern. The process is fully automated and the operators' functions are essentially confined to quality checks. At BMW the lost foam patterns reach dimensional stabilisation in a small drying oven over a four hour period at 58°C.



Hot Melt Gluing of Slices

The five segments are glued together, usually into subgroups, then clusters using hot melt glue. Fast machine motions are essential for an optimum gluing process. In the next step the foam cluster, compromising two cylinder heads and their sprue and ingates, is dipped in a heavily loaded refractory slurry (45% solids).

Even coating thickness is essential and robotic operation is necessary for repeatability. Naturally, residual moisture has to be removed before pouring and this is achieved by six hours drying at 52°C and < 20% relative humidity. Internal cavities such as the water jacket determine the dwell time. The clusters are placed in a buffer carousel. A rotating batch hopper with gripper located under a sand gate picks up the cluster, rises to its upper position to fill sand and rotates above the flask. The batch hopper then lowers and inserts the cluster into the flask and it is held during the sand filling phase.



Automatic Cluster Insertion

All cluster and undercuts must be filled in a carefully controlled way to avoid cluster deformation and casting defects such as penetration or mould collapse.

Compaction is crucial. Sand fill and compaction work hand in hand and BMW is utilising Vulcan patented longitudinal vibrating table developed through a wide experience, understanding of process requirements and the use of 3D modelling. Higher efficiency has been proven in field and laboratory tests for horizontal compaction, with densification up by 5% to 8%. The vibration characteristics, and their consistency are vital factors in optimising the process and standardising quality.

Moulds are poured via fused silica pouring cups, swung over and lowered to the downsprue. Two 25 t/h gas fired melting furnaces with an attached treatment and holding furnace feed the ladle which is manipulated by a gantry robot. Pouring rate is accurately controlled and good metallurgical practice is observed.

The poured clusters are extracted and quenched in water to remove most of the coating. Sand and volatiles are collected at this point. There is no shakeout and sand is easily recycled. Degating is by a special saw and internal cavities are cleaned using a shock wave system.

Radiography is on line and is only the final step in a chain of process and quality control measures applied to each process step. Details of these procedures and beyond the scope of this article but have been integrated into the BMW foundry, based upon Vulcan's huge experience in commissioning lost foam process plants worldwide and ensuring that they function to the performance criteria conceived with the customer. **Reader Reply No.**

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