Ceramic cores in the sand foundry

Once thought only for use with investment casting, ceramic cores are bringing new life for the sand moulding shop.

Fig 1: The cope and drag portions could be moulded of solid ceramic with the core being inserted before or after curing

A growing number of sand foundries are learning that they do not need to lose out to investment casting when it comes to internal precision and surface finish. Thanks to a new ceramic core process from Unicast, more and more sand foundries are taking back the work they once lost to investment casters.

Although the typical foundryman will associate ceramics with precision casting, he will not usually associate ceramics with low cost. However, over the past years, Unicast has been developing techniques that have exploited the benefits of ceramic precision and integrated them into the simplicity and cost benefits of sand moulding. This has proven especially effective in the production of impellers for the pump industry.

Investment cast impellers are usually preferred because a compound curve with excellent surface finish can be cast in that allows the impeller to pump with less energy and wear. The compound curve in the impeller acts in the same manner as the angle on a snowplow. Without the angle directing the snow to the side of the road, it would require much more energy to push the plough. To the extent that the internals of the impeller can be smoother and more accurately formed, the more efficient the impeller can be.

When traditional sand cores could not deliver the precision and surface finish that the industry was demanding, attention turned to very costly investment casting techniques. This satisfied design requirements, but also raised costs and extended lead times.

By introducing a molded ceramic core into a traditional sand process, the benefits of both processes can be obtained to create a smooth precision internal cavity at competitive costs and impressive lead times.

Preformed vs poured

The type of ceramic core typically used in investment casting is the preformed core. The manufacture of preformed cores is a highly specialized technique and requires a substantial capital and technical investment. This core is produced by extrusion or injection into a specially made die or corebox, and is usually supplied to the foundry by an outside company.

Preformed cores have features that make them useful in investment casting. They have the strength needed to withstand wax injection pressures and can be produced in extremely thin, finely detailed sections. They can also be transported from the core supplier to the foundry with relative ease and low risk of damage.

Common with preformed cores is the difficulty in removing the cores from the finished casting. Removal generally requires high pressure water blasting or leaching with hot caustic salts. This can limit the type of alloys that can be used.

A molded ceramic core is produced by a different technique. Quick setting investment slurries are used to make the core which can be either gravity fed, poured centrifugally, or low pressure injected. For this reason, it is sometimes referred to as a poured core.

The technology of a molded ceramic core is very similar to investment casting. The main difference between the two is that in ceramic moulding, the quick setting slurries are formed over conventional foundry patterns or in standard core-boxes made of wood, plastic, plaster or metal instead of an expendable wax pattern. Molds are of the cope and drag type and the pattern is not totally enclosed in a ceramic shell.

The production of ceramic cores is a relatively simple matter for the typical sand foundry. Some familiarization is needed in the handling of ceramic slurries and ceramic mold and core production since differences exist between these and normal sand operation. Setup and equipment costs can be quite modest, particularly when integrated into an existing sand operation.

Impellers

Perhaps the fastest growing application for molded ceramic cores is in producing impellers for the pump industry. Demand for high quality impellers has expanded rapidly in the past several years due to escalating energy costs and the need to obtain greater pump efficiency. When impeller vane

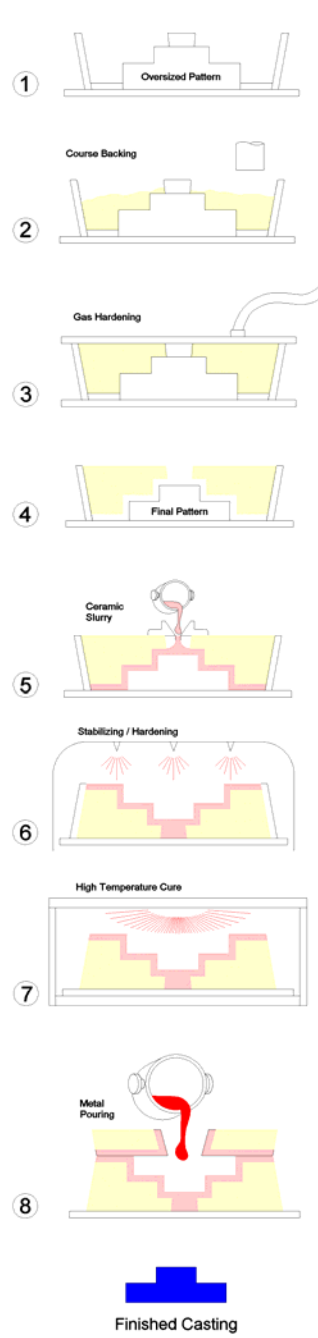

Fig 2: A combination of certain elements of conventional sand foundry practice

openings can be made to specific design limits with a high degree of accuracy and excellent surface finish, these efficiencies can be obtained.

Cores produced by ceramic moulding are ideally suited to this type of application. The core is prepared simply by pouring a fast setting ceramic slurry into a corebox, extracting the hardened core and precuring and firing before use.

Slurries used in the Unicast ceramic moulding process are based upon a modified ethyl silicate binder and a ceramic aggregate of controlled density and particle size distribution. In addition, most of the aggregates for core production incorporate a balanced distribution of ceramic fiber.

The slurry is prepared by carefully mixing the aggregate and binder, avoiding excessive turbulence. It is then chemically activated by the addition of a catalyst. Setting time of the slurry is usually adjusted to about four minutes. Variations can include the use of super-cooled slurries that set when raised to room temperature, but these offer little advantage except in limited applications.

Stripped cores are stabilized and then subjected to a two step curing method, first by flaming or by controlled drying and second, by high temperature firing using a high energy, quick cycle furnace.

Moulding Technique

Cured impeller cores can be cooled and stored, though it is preferable to use them directly in order to avoid possible moisture pickup. While some cores can be placed directly in sand molds at room temperature, it is usually best to have them preheated, particularly when casting certain steel alloys.

Placement of preheated cores in room temperature sand molds can be difficult unless done with special core placing equipment. An alternate method has been to preform an investment type cope and drag shell into which the core can be placed. Alternately, the cope and drag portions could be molded of solid ceramic with the core being inserted before or after curing. (Fig. 1)

A method of using preheated cores that is most adaptable to conventional sand foundry use involves a sand or chamotte backed ceramic shell. Applications of this method are growing rapidly since it is by far the lowest cost way to achieve quantity production of large size impellers and other larger precision castings.

The technique combines certain elements of conventional sand foundry practice and is illustrated in Fig. 2. A dual set of cope and drag patterns are used: one set is actual size and the other about quarter to half inch larger on all surfaces.

A silicate bonded chamotte of coarse sand is molded over the larger pattern to form an internal cavity. Following quick CO_2 gas hardening, the mold is stripped and automatically transferred to a second moulding station where the larger cavity is placed over the actual size pattern. The space between the true size pattern and the oversize cavity represents the thickness difference between the two patterns. Quick setting ceramic slurry is poured or injected into this space to form a shell liner.

The composite ceramic/sand mold is stripped, stabilized and dried or precured prior to core placement. The core and mold assembly is rapidly cured at high temperature, either at this stage or after closure of the cope and drag halves

Except for heat curing, molds of this type can be produced almost as fast as regular sand molds. Costs are proportionally low since the relatively expensive ceramic material represents only the thin cavity shell and not the entire mold.

Casting Technique

Casting of cored moulds deviates little from normal practice. Care must be taken to minimize metal inflow velocity against unsupported core sections. With impeller molds, uniform filling around thin cores is important to avoid movement or flotation. Bottom gating is frequently used for quiet filling. Impeller molds car be poured either horizontally or vertically and practices vary among different foundries.

The particular structure of ceramic molded Unicast cores allows easy removal after casting. Pressure exerted by the solidifying alloy as it contracts causes initial collapse of the cores. The dispersed ceramic structure permits a breakdown of the mechanical bond, which is further enhanced by the fibrous matrix.

Larger core sections can often be removed by standard vibratory techniques. Thinner sections that may be subject to greater localized compression during alloy solidification may be more difficult to remove. Water blasting may be helpful on difficult to reach sections, but simple hand work or the use of standard glass bead or fine grit materials are usually effective. Leaching procedures are rarely required.

Overall removal time is often only a fraction of that required for leachable cores and this can mean substantial savings in finishing costs. Considering the ease of manufacture as well as the relative ease of removal, the technique opens wide opportunities for production of precision cast impellers that are fully cost competitive with those produced by ordinary sand methods.

An additional feature of ceramic cores is that there are virtually no restrictions with regard to the alloy cast. Generally, cores requiring leach removal can only be used on alloys not affected by the leaching compounds. This is not the case with molded ceramic cores since leaching is usually unnecessary. In fact, impellers are being produced in copper-base and other non-ferrous materials as well as the usual ferrous and stainless alloys with very few limitations.

Coreboxes used to produce ceramic molded cores are often of simple construction and are frequently the same as those used for normal sand cores. Naturally, the quality of the finished core can be no better than the corebox it is produced from and this criterion will apply to the types of coreboxes used.

Ceramic slurries tend to react with the surface paints often used on wood core-boxes and it is usually necessary to completely strip and refinish with a binder compatible coating. Wherever practical, coreboxes should be made specifically for the ceramic moulding process. Epoxy and urethane materials are perhaps the best construction materials.

Fig 3: expendable wax vanes which are left in place for subsequent meltout in curing

Corebox vanes can be fixed or loose depending upon the particular design and characteristics of removal. In addition, there is now also a steadily increasing use of expendable wax vanes, shown in Fig. 3, which are simply left in place for subsequent meltout in curing. This alleviates the time consuming removal associated with ordinary loose vanes made of metal or plastic.

Certain impeller cores use curved vanes of such design that they would be impossible to remove in a standard corebox. Past procedure has required such cores to be fabricated from numerous segments using an expensive, segmented corebox. By making the curved vanes in wax, the segmented box can often be replaced by a single box to produce one-piece cores. Not only is the box less expensive to produce, but the cores themselves are of greater accuracy since the difficulties of assembly and register normally associated with segmented cores are eliminated entirely.

Additional Applications

There are many other applications for ceramic moulding in the modern foundry. The process lends itself ideally to foundry diversification and is a low cost alternative to investment casting, particularly on larger parts that would be impossible using this technique. There are few size limitations and castings can frequently exceed several tons in weight.

Besides typical precision castings, the process also enjoys wide use in the production of "cast-to-size" molds, dies and tooling for a variety of industries. Forging dies, plastic, glass and rubber molds, die-casting and extrusion dies, permanent molds and cast patterns and coreboxes all represent ideal applications for ceramic moulding. Accuracy and surface detail are excellent and often sufficient to require little or no finish machining.

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