Improvements in Fabrication of Sand/Binder Cores for Casting

Cores can be made stronger and more consistent.

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Three improvements have been devised for the cold-box process, which is a special molding process used to make sand/binder cores for casting hollow metal parts. These improvements are:

- The use of fiber-reinforced composite binder materials (in contradistinction to the non-fiber-reinforced binders used heretofore),
- The substitution of a directed-vortex core-blowing subprocess for a prior core-blowing process that involved a movable gassing plate, and
- The use of filters made from filtration-grade fabrics to prevent clogging of vents.

For reasons that exceed the scope of this article, most foundries have adopted the cold-box process for making cores for casting metals. However, this process is not widely known outside the metal-casting industry; therefore, a description of pertinent aspects of the cold-box process is prerequisite to a meaningful description of the aforementioned improvements.

In the cold-box process as practiced heretofore, sand is first mixed with a phenolic resin (considered to be part 1 of a three-part binder) and an isocyanate resin (part 2 of the binder). Then by use of compressed air, the mixture is blown into a core box, which is a mold for forming the core. Next, an amine gas (part 3 of the binder) that acts as a catalyst for polymerization of parts 1 and 2 is blown through the core box. Alternatively, a liquid amine that vaporizes during polymerization can be incorporated into the sand/resin mixture. Once polymerization is complete, the amine gas is purged from the core box by use of compressed air. The finished core is then removed from the core box.

The first-mentioned improvement is effected at the mixture-preparation stage by adding fibers to the mixture. In experiments, core specimens containing a variety of fibers were fabricated and subjected to tensile- and shear-strength tests. As shown in Figure 1, the strengths

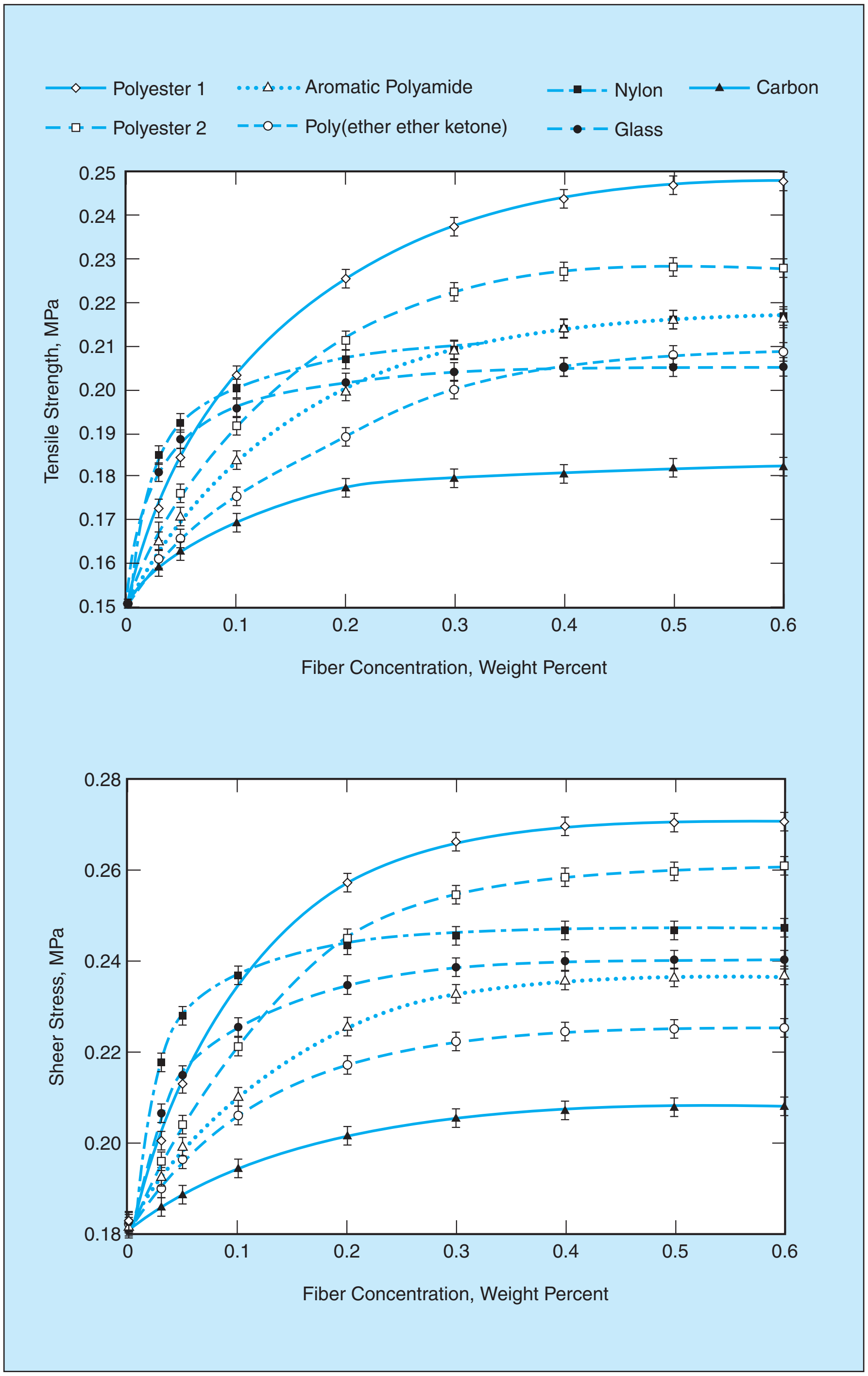

Figure 1. **Tensile and Shear Strengths** of core specimens were found to be increased by incorporation of a variety of fibers.

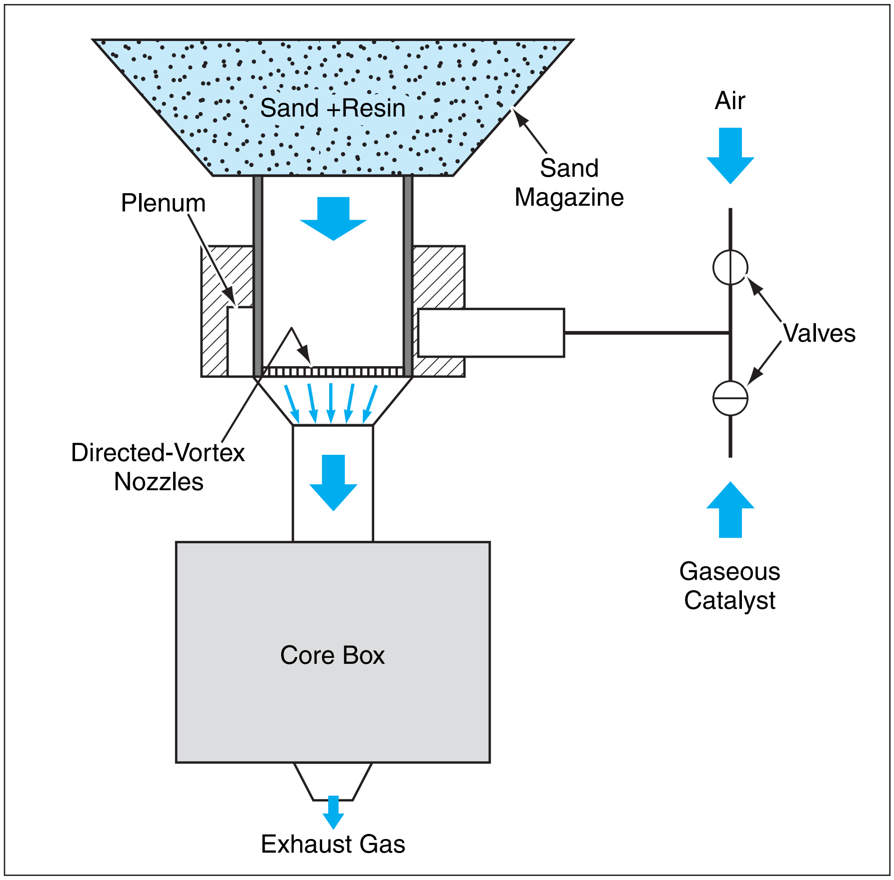

Figure 2. **Air Flowing From Directed-Vortex Nozzles** fluidizes the sand/resin mixture flowing into the core box.

of the specimens increased significantly with proportions of fibers up to about 0.3 weight percent.

The second-mentioned improvement — directed-vortex core-blowing — is directed toward obtaining more nearly optimum fluidization of the sand/resin mixture as the mixture is blown into the core box. In this subprocess, the sand/resin mixture is fed from an overhead sand magazine, through an inlet blow tube, into the core box (see Figure 2). Compressed air is fed into an annular plenum, from whence it flows into the core box through a number of directed-vortex nozzles. The nozzles are designed so that the flows from the nozzles generate a partial vacuum in the outlet from the sand magazine and pump a highly fluidized sand/resin mixture into the core box. Highly fluidized and accelerated sand particles travel long distances, the net result being more nearly complete and consistent filling of the core box. The directed-vortex nozzles are also used to feed in the amine gas for polymerization and the compressed air for purging the amine gas.

The third-mentioned improvement is directed toward preventing clogging of the exhaust vents of the core box. The total cross-sectional area of these vents should be about 80 percent of the cross-sectional area of the inlet blow tube — large enough for effective venting but just small enough to provide the back pressure needed to make the catalyst gas diffuse throughout the core to ensure a uniform cure. Vents are deliberately partially blocked by any of a variety of devices, typical ones being steel meshes or slotted steel disks. Heretofore it has been necessary to clean the vents at intervals during the process. By placing filters made of filtration-grade fabrics upstream of the vents, one prevents clogging of the vents, thereby eliminating the expense and loss of time associated with cleaning of the vents.

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Solid Freeform Fabrication of Composite-Material Objects

Parts specified by CAD data files could be fabricated as needed.

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Composite solid freeform fabrication (C-SFF) or composite layer manufacturing (CLM) is an automated process in which an advanced composite material (a matrix reinforced with continuous fibers) is formed into a freestanding, possibly complex, three-dimensional object. In CLM, there is no need for molds, dies, or other expensive tooling, and there is usually no need for machining to ensure that the object is formed to the desired net size and shape.

CLM is a variant of extrusion-type rapid prototyping, in which a model or prototype of a solid object is built up by controlled extrusion of a polymeric or other material through an orifice that is translated to form patterned layers. The second layer is deposited on top of the first layer, the third layer is deposited on top of the second layer, and so forth, until the stack of layers reaches the desired final thickness and shape.

The elements of CLM include (1) preparing a matrix resin in a form in which it will solidify subsequently, (2) mixing the fibers and matrix material to form a continuous pre-impregnated tow (also called “towpreg”), and (3) dispensing the pre-impregnated tow from a nozzle onto a base while moving the nozzle to form the dispensed material into a patterned layer of controlled thickness. When the material deposited into a given layer has solidified, the material for the next layer is deposited and patterned similarly, and so forth, until the desired overall object has