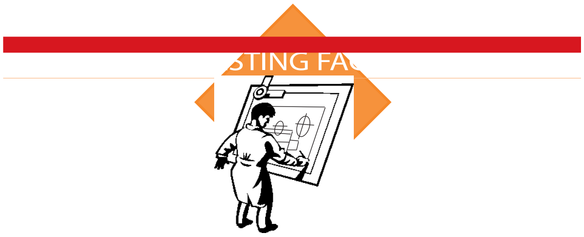

Patternmaking 'Tricks' for Better Castings

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Industry people will tell you that a casting only can be as good (and cost-effective) as its design. While there are numerous variables that impact casting quality, none can make up for a poor pattern design.

Thankfully, patternmakers have a few "tricks" in their toolbox to make designs more easily castable and, therefore, cost-effective. Draft, fillets and radii (each depicted in Fig. 1) are three such modifications that can be applied to foundry patterns to assist mold production and help eliminate casting defects. An explanation of each of these three "tricks" is given below:

- Draft—is the angle applied to the vertical surfaces of a pattern to aid in the removal of the pattern from the molding media;
- Fillets—are the rounding-out of internal corners of the pattern;
- Radii—are added to round-out the external edges of the pattern.

Since the casting is a replica of the pattern, draft, fillets and radii appear on the casting as well.

Design engineers should understand the reasons for these modifications and, when possible, consider them in their cast component designs. The result will be more easily manufacturable, higher quality and more cost-effective castings.

Draft

The term "draft" comes from the Old English word *dragan*, which means to pull or draw, as when a draft horse was used to pull a wagon.

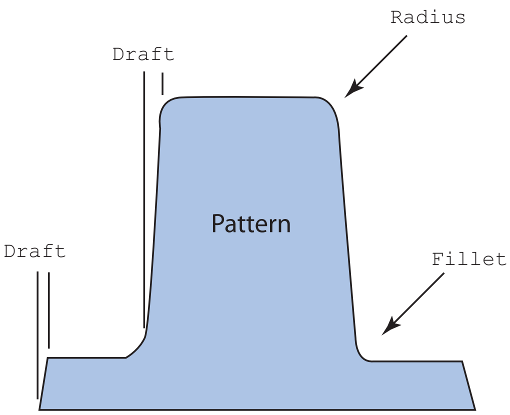

Fig. 1. This drawing shows three of the tools—draft, fillet and radius—that patternmakers arm themselves with to improve the casting manufacturing process.

Draft angles are normally factored into the pattern design to help the foundry extract the pattern from the mold prior to closing and pouring. Draft angles are used in most processes in which a pattern is withdrawn from the mold prior to pouring, such as green sand, nobake, plaster and shell molding. Draft is necessary with these processes to provide a clearance between the pattern and the mold during pattern extraction. Without sufficient draft, the vertical walls of the pattern would rub against the mold during pattern withdrawal, causing the mold to tear or rip. If the foundry poured molten metal into such a mold, defects, such as sand inclusions, would result on the cast part.

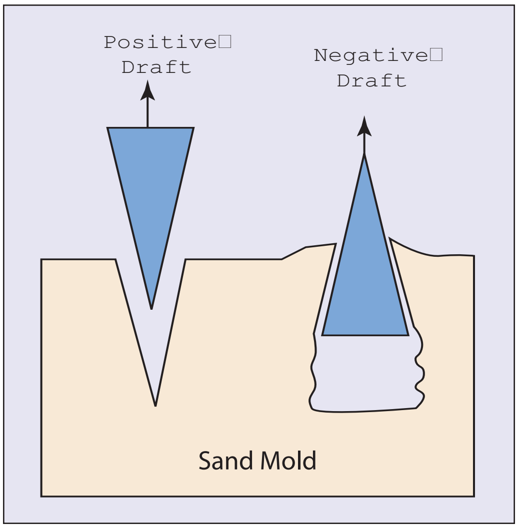

Fig. 2. The positive draft (l) will enable the pattern to be extracted from the sand mold after compaction. If a pattern was constructed with negative draft (r), it would tear the mold apart during the pattern removal process and cause a defect in the casting.

How much draft is needed? The foundry will push for as much draft as possible because it helps the molding process and reduces scrap. Most design engineers, meanwhile, will push for as little as possible, because many consider draft issues a nuisance. The correct answer lies somewhere in between. In green sand molding, a draft angle of 1/16 in. per ft is considered minimum. More typically, a draft angle of 1/8 in. per ft (about 1°) is used.

The draft angle required on the pattern depends on the molding process and the depth of the pattern in the mold. In horizontally parted molds, only the vertical surfaces require draft. Horizontal surfaces automatically separate the pattern from the mold during pattern withdrawal. A deeper draw needs less of a draft angle than a shorter one.

The draft angle illustrated in Fig. 1 is often referred to as "positive" draft. As shown at right in Fig. 2, "negative" draft would be described as the application of the angle in the opposite direction. If a mold was made from a pattern with negative draft, the pattern could not be extracted without tearing the mold apart. Some molding processes, like investment casting, permit a negative draft angle since the wax pattern is melted out of the mold rather than pulled out, as in the conventional sand molding processes. Rubber patterns used in plaster molding also permit negative draft because the flexibility of the rubber pattern allows it to be easily removed from the mold.

Some cast shapes have “natural” draft. This simply means that the inherent shape provides the necessary draft angle (Fig. 3), without requiring any further draft modification. Cylindrical shapes have natural draft if the diameter of the cylinder lies on the parting line of the mold (the parting line shows the separation of the casting into the two sides of the mold). Polygonal shapes also contain natural draft if the part is correctly oriented to the parting line of the mold.

The application of draft is not limited to patterns. Permanent mold processes (in which the mold consists of a reusable metal die) also require draft to facilitate the removal of the solidified casting from the die. Also, coreboxes may require draft to allow the sand core to be withdrawn from the box after the core has cured.

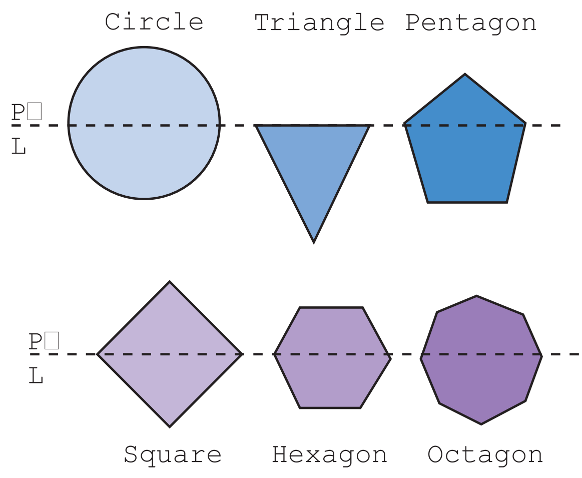

Fig. 3. These six component shapes, if used in the illustrated parting line orientation, do not require any additional considerations for draft.

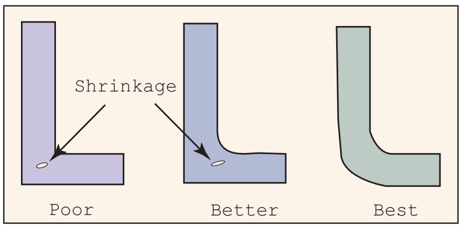

Fig. 4. The fillet is used to join two casting surfaces. By rounding the junction to the extent seen at far right, better heat transfer in the area of concern can be accomplished, resulting in less concern over shrinkage defects.

Fillets

Sharp, internal corners on a casting design should be avoided whenever possible. The small volume of mold media located in a casting’s internal corner quickly becomes superheated and limits the casting’s ability to transfer heat at this location. Most mold media are poor conductors of heat and, once heated to metal temperature, have no way of transferring the heat energy to other parts of the mold. This creates localized areas that solidify more slowly than the rest of the part, resulting in “hot spots” in the casting. Hot spots can cause many casting defects, such as hot tears, cracking, shrinkage, metal penetration and gas-related defects. Also, such sharp edges on the mold are prone to breaking off and can produce sand inclusions in the casting.

To avoid this problem, the patternmaker usually adds a concave junction, or fillet, where the two casting surfaces meet (Fig. 4). This fillet blends the two intersecting surfaces and modifies what would otherwise be a harsh internal corner into a rounded corner. This effectively removes the small volume of sand in the corner, reducing the hot spot in the casting and eliminating the resulting problems. Fillets also aid in the removal of the pattern from the mold and strengthen the pattern.

The size of a fillet is determined by its radius—it is not measured by its width. Fillet sizes vary, but it is possible for a fillet to be too large. A large fillet adds extra metal to the junction, which also can create shrinkage concerns due to the volume of metal. The best design is to maintain uniform section thickness whenever possible.

Radii

A radius is the rounding of external edges of a pattern to aid in removing the pattern from the mold and eliminating the sharp edges from the casting. It also can make the casting more aesthetically pleasing than a component with sharper corners. Sharp external corners also can produce casting defects. External corners rapidly lose heat to the surrounding mold material and, as a result, the corner may not fill completely, resulting in a misrun defect.

In gray and ductile iron castings, the microstructure of the casting also may be affected due to the rapid loss of heat. Rapid cooling of the external corners often can produce an inadvertent chilled structure of white iron or iron carbides. These chilled edges are extremely hard and brittle and can result in reduced tool life or breakage during machining.