Choosing The Right Alloy For The Right Custom Casting

The properties of aluminum alloys vary greatly. When specifying a custom casting, it's important to select the best alloy for your particular need.

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When choosing the alloy for an aluminum casting, it’s important to select a type that provides the best detail and weldability, while at the same time having good foundry characteristics. A good aluminum alloy should contain silicon for high detail retention and flowability, and it should not contain elements detrimental to weldability, such as nickel. Nickel is harmful because of its high melting temperature.

Other properties to consider when choosing an alloy are strength, good corrosion resistance, and bend-ability. The projects described in this article show the advantages of matching the best alloy for a particular need. Table 1 summarizes the chemical compositions described in these scenarios.

Castings That Bend

Fabricators in the trade desire to make jobs look good. And, it sometimes helps if they also look unusual. One way to achieve this combination is for the castings to have the ability to bend into unusual shapes. Most castings have metal combinations that are stiff and difficult to bend, but it is possible to find highly bendable alloys.

On the other hand, the casting in Figure 2 has a more consistent cross section of 3/8 inches by 11/4 inches, and we were able to achieve a much larger bend of 10 inches in a 27 inch length.

The most dramatic bends have been obtained in a leaf design, 4-1/2 inches by 40 inches, with a consistent 3/16 inch thickness., shown in Figure 3. These leaves were specially designed and a special alloy was chosen to provide maximum bending ability.

Good bending results can be obtained at room temperatures, and you can feel the casting stiffen as the hardening takes place. The twisting and compound bends of the leaves were obtained by heating the casting, bending, and reheating as necessary. It is a trial and error process, but it’s possible to make some very dramatic shapes.
Weldability

Most aluminum castings provided by foundries to the ornamental trade are provided in the 'as cast' condition (temper F). These castings are readily weldable and no special cautions are necessary.

The casting alloy is normally in the 300 series, which provides good castability for the foundry and good detail retention and weldability for the fabricator.

In those cases where there is a special application for high strength and/or corrosion resistance, extra care is necessary in selecting a welding rod. It's also important to remember that a casting given a special heat treatment cannot be welded without destroying the special treatment in the area affected by the weld. When welding, the fusion that occurs changes the microstructure of the metal and transforms the area back to an "as cast" condition.

Corrosion Resistance

Alloys that have good corrosion resistance show poor casting characteristics for the foundry and poor weldability to the fabricator. Figure 4 is a handrail panel that was made from alloy 514 (4 percent magnesium) and was used in a sea coast application. Alloy 514 exhibits good corrosion resistance properties.

On the other hand, alloy 535 (7 percent magnesium) shows a higher strength and a superior corrosion resistance because of its higher magnesium and lower and tighter specifications on trace metals. Alloy 514 was specified for the job, but for the same money 535 could have been used. This is a situation where the specifier did not take full advantage of available options. These two alloys are from the same family as the sheet and plate used for marine applications.

Those metals that strengthen aluminum the most, like copper and zinc, are the most detrimental to the corrosion resistance of aluminum.

Strength/Heat Treatment

Those alloys exhibiting high strength are normally poor in other characteristics. Alloy 713 (7 percent zinc, 1 percent copper) was chosen for the chair leg piece shown in Figure 5. Alloy 713 has high strength in the "as cast" temper and needs no heat treatment for maximum properties. The alloy, however, pours like molasses, has high shrinkage, and tends to lose detail. Fortunately, the rectangular leg cross section of 5/8 inches by 1 inch is plain and simple and showed shrinkage only in the hidden back side of the legs.

Another alloy commonly used in the "as cast" temper is alloy 319 (7 percent silicon and 3 percent copper). In this alloy, silicon has replaced the zinc and imparted more fluidity and detail retention. The strength loss through the elimination of the zinc is partially compensated by an increase in copper. Figure 6 shows some castings that have been cast in alloy 319 for good machinability. The holed clutch housing is designed to break under certain conditions and alloy 319 imparts a consistent microstructure for that predictable breaking.

Alloy 356 (7 percent silicon, 1/4 percent magnesium) is the aluminum foundryman's all purpose workhorse. It has good detail retention and pours well. It is the most commonly used alloy and is specified in either the 'as cast' or heat treated condition. The 'as cast' condition strength levels of 19,000 p.s.i. (pounds per square inch) can be raised 34,000 p.s.i in the T-6 temper. T-6 temper is soaking at 1,000 degrees F for 12 hours followed by an aging treatment of 310 degrees F for 3 to 5 hours. This strengthening occurs because of a hardening process caused by the 1/4 percent magnesium.
The heat treatment has a powerful influence on properties but can increase the casting cost by 20 to 40 percent.

Figure 7 shows some industrial tire spreaders that were cast in alloy 356 and tempered to T-6. The extra strength was a requirement. Because the heat treatment improves the metal’s ‘as cast’ microstructure, any subsequent welding destroys the heat treatment’s benefits.

Because of its reasonable cost and high strength, alloy 713 would always be chosen if strength and cost were the only criteria, but because of other needs like corrosion resistance, weldability, detail retention and castability, alloy 356 and the other alloys are more frequently specified.

**Polishing**

Some alloys polish better than others. The high strength alloy 713 has a good luster, but for my personal preference and use, I have chosen alloy 514 (4 percent magnesium) to impart a beautiful polish and high luster to the seashell cocktail table in Figure 8. The seashell and legs of this table are now four years old and have the same shine as they did when they were first professionally polished.

**Summary**

The job requirements for most ornamental work can be handled with decorative castings made from common everyday alloys. But for that special job requiring a unique set of physical characteristics, it is good to know what other alloys are available that can provide those unique properties. Strength, corrosion resistance, weldability, luster and benability can all be modified with an alloy that gives the right blend of unique properties.

This article is part of an ongoing series on custom castings. Alloy Casting has been a NOMMA member since 1974.

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<th>Table 1: Chemical Composition (%)</th>
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Different metal compositions greatly influence an alloy’s properties.