Designing Thin Sections

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Metalcasting is unique in that it allows designers to place material where it is necessary and to do it in a non-uniform way, conforming with a nonlinear stress distribution field within the structure. When the part has minimal stress levels, the resulting mass distribution will call for a thin wall casting.

Thin wall castings often are advantageous because of their light weight structure, which allows for increased payload and reduced energy consumption in transportation applications. However, thin wall castings also can pose manufacturability problems associated with mold filling.

Rapid cooling of thin wall sections of the casting reduce the fluidity of the molten metal, which could cause the molten metal to prematurely freeze before it can completely fill the mold cavity, resulting in an incomplete fill or cold shuts. The mold filling capability in thin wall casting depends on a number of different process and design related variables, including the type of metal, pouring temperature, casting shape and metalcasting process.

Guidelines for different metals and processes are given in Table 1. The values given in Table 1 are reflective of compatibility with economical production and not necessarily with physical limitations of the process and material combination. These values are only suggestions for initial design and it is highly recommended that designers allow for modifications (increasing or reducing the values) based upon the results of the casting process.

Determing Wall Thickness

The practical minimum wall thickness for a particular casting configuration can be determined based on experiments using inexpensive and accurately made loose patterns. Often, a foundry engineer will recommend a value to start at based on prior experience. The wall thickness then should be adjusted depending upon if the defect rate is above or below the acceptable range.

For example, the 2.25-in., center-line radius aluminum elbow in Fig. 1 is cast via plaster molding. It has an 80% rejection rate for 0.04-in. wall thickness, 35% for 0.06-in., and 10% for 0.08-in. wall thickness. Since the cost of casting reflects both the complexity of the process and the number of quality castings, it is to the advantage of the designer to take this into consideration when specifying thin wall castings. The overall cost and performance advantage of a part with lower weight must overcome the potentially higher manufacturing cost.

Improving Castability

As indicated in Table 1, mold filling problems are rarely an issue when the wall

Table 1. Typical Minimum Section Thickness for Different Materials and Processes.

<table>
<thead>
<tr>
<th>Casting Method</th>
<th>Minimum Section Thickness (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aluminum</td>
</tr>
<tr>
<td>Sand</td>
<td>0.125 ± 0.007</td>
</tr>
<tr>
<td>Permanent mold</td>
<td>0.092 ± 0.015</td>
</tr>
<tr>
<td>Investment casting</td>
<td>0.02 ± 0.010</td>
</tr>
<tr>
<td>Die casting</td>
<td>0.042 ± 0.010</td>
</tr>
<tr>
<td>Master mold</td>
<td>0.050 ± 0.015</td>
</tr>
</tbody>
</table>
thickness exceeds 0.375 in. Alternately, when the wall thickness is reduced below 0.125 in, adequate mold filling is virtually impossible except for short distances. The problem is premature freezing of the molten metal. In such instances, a designer can allow for certain geometric features on the casting that can ensure fluidity of the molten metal for the entire length of the mold cavity.

An example of such a feature is shown in Fig. 2, where strategically placing ribs on a casting serves two purposes. They break the surface area of the casting into smaller sections by providing channels for the ready delivery of the molten metal, and they increase the strength and structural rigidity of the part.

Another feature that can be used to improve the castability of thin walled castings is the selection of a different alloy. As indicated in Table 1, different metals can produce different wall thickness. For example, aluminum can achieve thinner walls more successfully than steel.

In a number of applications, this drastic alteration of metal can not be made due to the significant difference in mechanical properties of these metals. However, in a situation when the casting is not structural or load bearing, a designer can take this fact into consideration to achieve thinner walls.

Even in a similar group of materials, small deviations in alloy composition can have a significant impact on material fluidity. For example, 300 stainless steels have better fluidity than 300 stainless steels with the addition of molybdenum. Hence, whenever possible, the designer should allow for a change in the material if that could lead to the desired casting configuration at a reduced cost.

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Tel: (717) 284-4114 Fax: (717) 284-3737
Cast Component: Manifold for fire-fighting equipment.
Material: 65-45-12 ductile iron.
Process: Green sand casting.
Casting Supplier: Versa Iron and Machine, St. Paul, Minnesota.

- This 90-lb manifold was converted from a stainless steel weldment at a per piece cost savings of $550.45 (annual savings of $220,180 with 400 part volume).
- The tooling payback for the pattern, coreboxes and machine fixtures was realized within the first 6 weeks of production.

For more information, please circle No. 001 on Reader Action Card.

Cast Component: Chassis for joystick tensioning in an aircraft flight simulator for S.C.T., Inc.
Process: Nobake sand casting.
Casting Supplier: Danko Arlington, Inc., Baltimore, Maryland.

- This 14-lb component was converted from an aluminum weldment at a cost (due to reduced welding and fabrication man-hours) and weight savings.
- Measuring 16 x 3 x 14 in., the casting is a simpler design than the weldment with improved rigidity.

For more information, please circle No. 002 on Reader Action Card.

Cast Component: Brake drum for commercial highway Class 8 trucks and trailers.
Material: Gray iron.
Process: Centrifugal casting.
Casting Supplier: Hayes Lemmerz-Chattanooga, Chattanooga, Tennessee.

- This 84-lb brake drum is produced by casting gray iron centrifugally into a steel shell. This shell acts as a protective jacket, resulting in superior drum strength and allowing for the removal of iron in the drum band and mounting areas normally required in a full cast brake drum.
- Through concerted efforts between the foundry, machine shop and engineering/testing resources, 6 lb were removed from the brake drum while providing the same performance, balance and reliability as the standard drum. With the weight optimized at 84 lb, the drums are ideal for weight sensitive applications such as refrigerated trailers, tankers and bulk haulers.
- Utilizing these drums on an 18-wheel tractor/trailer application can provide up to 224 lb of weight savings.

For more information, please circle No. 003 on Reader Action Card.

Cast Component: Annealing furnace pedestal for a steel mill.
Process: Nobake sand casting.
Casting Supplier: Wellsville Foundry, Wellsville, Ohio.

- This one-piece, 25-lb casting replaced a stainless steel fabrication at a 67% cost savings.
- The cost reduction is due to the elimination of fabrication and assembly man-hours.

For more information, please circle No. 004 on Reader Action Card.
**Cast Component:** Air-ride suspension arm for buses that suspends the bus frame on the front and rear axles.

**Material:** 80-55-06 ductile iron.

**Process:** Green sand casting.

**Casting Supplier:** Donsco, Inc., Mt. Joy, Pennsylvania.

- Converted from a steel stamping/fabrication, the 120-lb casting provided the customer a 50% total cost savings (including assembly time).
- The foundry casts and machines the component, and assembles a sub-system for the customer. The assemblies are shipped directly to the customer's manufacturing line.

*For more information, please circle No. 005 on Reader Action Card.*

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**Cast Component:** V6 cylinder block for a 3.9 liter automobile engine.

**Material:** 319 aluminum alloy.

**Process:** Cosworth precision sand casting.

**Casting Supplier:** Nemak Windsor Aluminum, Windsor, Ontario, Canada.

- This 82.8 lb aluminum block (after machining) saves 104 lb over cast iron.
- A cast-in cylinder liner process is used to achieve high quality and productivity. Cores for the molding process are made of zircon sand (which has superior thermal characteristics) to minimize machine stock and required wall thickness.
- Core oil galleries are as-cast, requiring no internal machining and minimal wall thickness. This provides a compact casting and reduced machining costs.
- The Cosworth casting process utilizes a rollover casting technique that improves casting yield for the block to 72%, reducing component cost for the customer.

*For more information, please circle No. 006 on Reader Action Card.*

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**Cast Component:** Bracket for a piston cooling system on a railroad locomotive.

**Material:** 953 aluminum bronze.

**Process:** Permanent mold casting.

**Casting Supplier:** Aurora Metals, L.L.C. (Hiler Industries), Montgomery, Illinois.

- This 0.8-lb component was converted to permanent mold casting to eliminate the leaks inherent in the previous manufacturing method. In addition, the conversion realized a cost savings by reducing man-hours and eliminating heat treatment as permanent mold casting achieves the required mechanical properties.
- Permanent mold casting allows a stainless steel tube insert to be cast directly into the bracket.
- The casting design and gating system were engineered using solidification modeling, ensuring a quality casting from the first shot.

*For more information, please circle No. 007 on Reader Action Card.*

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**Cast Component:** Cookware.

**Material:** Gray iron.

**Process:** Green sand casting.

**Casting Supplier:** Lodge Manufacturing, South Pittsburg, Tennessee.

- The cast iron cookware uses one common lid for a skillet, grill pan and dutch oven.
- The foundry designs the components for ergonomic use and provides a value-added ready-to-use seasoned finish to the cookware for consumer benefit.

*For more information, please circle No. 008 on Reader Action Card.*

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