



# Casting vs Forging

*There are a variety of methods to produce a given part. Each has its own set of advantages and disadvantages. Some of the important factors affecting the selection of a process include the following:*

- *Quantity of the material required*
- *Design of the part*
- *Tolerances required*
- *Metal specification*
- *Surface finish required*
- *Tooling costs*
- *Economics of machining versus process costs*
- *Delivery requirements*

*The aim of this e-Tip is to compare forging with casting.*

## ◆ Forging

Forging is a manufacturing process where metal is shaped by plastic deformation under great pressure into high strength parts.

## ◆ Fundamentals of forging

Forging or cold forming are metalforming processes. There is no melting and consequent solidification involved. Plastic deformation produces an increase in the number of dislocations resulting in a higher state of internal stress. Indeed, strain hardening is attributed to the interaction of dislocations with other dislocations and other barriers (such as grain boundaries). Simultaneously, the shape of primary crystals (dendrites) changes after plastic working of the metal. Dendrites are stretched in the direction of metal flow and thus form fibers of increased strength along the direction of flow.

We may distinguish hot working from cold working. Hot working is performed above the recrystallization temperature; cold-working is performed below it. In hot working strain hardening and distorted grain structure are very rapidly eliminated by the formation of new strain-free grains as the result of recrystallization. Rapid diffusion at hot working temperatures aids in homogenizing the preform. Initial porosity can also be significantly reduced, eventually completely healed.

Metallurgical phenomena such as strain hardening and recrystallization are important because these changes in structure result in an increase in ductility and toughness over the cast state.

## ◆ Casting

The casting process consists of pouring or injecting molten metal into a mold containing a cavity with the desired shape of the casting. Metal casting processes can be classified either by the type of mold or by the pressure used to fill the mold with liquid metal.

## ◆ Fundamentals of Casting

Casting is a solidification process. Therefore, the microstructure can be finely tuned, such as grain structure, phase transformations and precipitation. However, defects such as shrinkage porosity, cracks and segregation are also intimately linked to solidification. These defects can lead to lower mechanical properties. A subsequent heat treatment is often required to reduce residual stresses and optimize mechanical properties.



*Figure 1: Expanded view of a cast wheel with mold and core presenting the temperature distribution. Simulation realized with ProCAST.*



## ◆ Wheel Example

Most modern performance wheels are made from aluminum by casting or forging. Forged wheels are manufactured in multiple steps compared to the one step in the casting process.

## ◆ Cast wheel

Casting has the advantage of allowing the designer more styling freedom because the process is a more flexible method. Until recently, most wheels have been gravity cast (heavier and thicker). Today, low pressure die casting techniques are used to substantially reduce porosity. Indeed, castings tend to contain porosity which strongly influences the mechanical integrity of the component. Thus, cast wheels are generally designed larger and heavier in order to achieve an acceptable structural strength for a given application.

## ◆ Forged wheel

The forged wheel, because of the enormous pressures involved, compacts the metal, eliminating porosity and the voids that can be a source for cracks or corrosion. The result is that less metal is required to achieve a given strength, meaning lighter wheels can be made. Furthermore, due to the density of the grain structure, the polished forged wheel will maintain its luster for much longer than a polished cast wheel which is very porous.

To summarize, forging yield wheels with higher strength to weight ratio but the tooling due to the multiple steps process and the based alloy are comparatively more expensive than in casting processes. Furthermore, with lighter weight wheels, you will benefit from

increased fuel savings, and better acceleration due to less amount of inertial weight at the rotational axis. For those reasons, usually forged wheels are only used for high performance applications.

An important thing to keep in mind is that quality of materials and heat treating may be a more important factor than casting vs. forging in some cases.

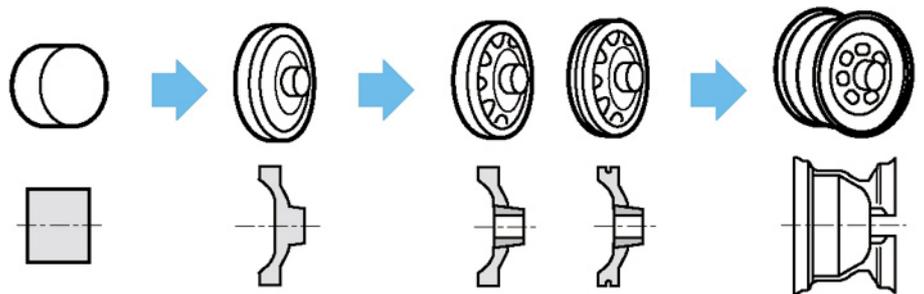


Figure 2: Simplified description of a one piece forging wheel operation from billet, forged preform, piercing and rim spinning respectively.

## ◆ Strength of forging:

- Good Mechanical properties (yield strength, ductility, toughness)
- Reliability (used for critical parts)
- No liquid metal treatment

## ◆ Strength of casting:

- Large and complex parts
- High production rate
- Design flexibility

## ◆ Weakness of forging:

- Defects
  - Laps
  - Die unfill
  - Die failure
  - Piping
- Shape limited when undercuts or cored sections are required
- Overall cost usually higher than casting
- Multiple steps often required

## ◆ Weakness of casting:

- Defects
  - Shrinkage porosity
  - Metallic projections
  - Cracks, hot tearing, cold shuts
  - Laps, oxides
  - Misruns, insufficient volume
  - Inclusions
- Requires close process control and inspections (porosity may occur)

**calcom** ◆

Calcom SA  
Parc Scientifique EPFL, CH-1015 Lausanne, Switzerland  
phone: +41 21 693 2918 / fax: +41 21 693 4740  
mail@calcom.ch / www.calcom.ch