CENTRIFUGAL CASTING

Amit M Joshi
(B.Engg. Mechanical, A.M.I.Prod.E, A.I.E)
Dept. of Metallurgical Engg. & Material Science,
Indian Institute of Technology – Bombay, India.

Email: amitjoshi@iitb.ac.in
amitjoshi1000@yahoo.ca

Centrifugal casting consists of producing castings by causing molten metal to solidify in rotating moulds. The speed of the rotation and metal pouring rate vary with the alloy and size and shape being cast. The following operations include in centrifugal casting - rotation of mold at a known speed, pouring the molten metal, proper solidification rate, and extraction of the casting from the mold. The idea of employing centrifugal force to make castings had been known for a long time, it was A. G. Eckhardt's original patent of 1809 which revealed understanding the basic principles involved. Centrifugal casting has greater reliability than static castings. They are relatively free from gas and shrinkage porosity. Many times, surface treatments such as case carburizing, flame hardening and nitriding have to be used when a wear resistant surface must be combined with a hard tough exterior surface.

One such application is bimetallic pipe consisting of two separate concentric layers of different alloys/metals bonded together. Such pipes can be economically used in many applications and can be produced by centrifugal casting process. Typically, in centrifugal casting, the following structure or zones may occur, Chill Zone – This layer is of fine equiaxed structure which forms almost instantaneously at the mould wall, Columnar Zone – This is next to chill zone. It consists of directionally oriented crystals approx. perpendicular to the mould surface, Equiaxed zone – this region may occur next to columnar zone characterized by large number of uniformly grown crystals. Centrifugal casting is suitable for the production of hollow parts, such as pipes. The process is suited for producing structures with large diameters - pipes for oil, chemical industry installations and water supply, etc.

Centrifugal force acting on a rotating body is, $C.F = \frac{mv^2}{r}$

where, m – mass (kg), V – peripheral speed (m/s), r – radius (m).

Gravitational force, G.F = mg
where, g = acceleration due to gravity (m/s^2).

$$G\ factor = CF/GF = \frac{mv^2}{r.\ mg} = \frac{v^2}{rg}$$

Solving, further we get $N = 42.3\sqrt{\frac{G\ factor}{D}}$

Thornton[1] suggested 50 – 100 G speed range for die cast (metal mould) and 25 – 50 G for sand cast pots and shaped castings. Too high speed results in excessive stresses and hot tears in outside surfaces.

Defects in Centrifugal Casting

Conventional static casting defects like internal shrinkage, gas porosity and nonmetallic inclusions are less likely to occur in centrifugal casting.

Hot Tears – Hot tears are developed in centrifugal castings for which the highest rotation speeds are used. Longitudinal tears occur when contraction of casting combined with the expansion of the mould, generates hoop stresses exceeding the cohesive strength of the metal at temperatures in the solidus region.

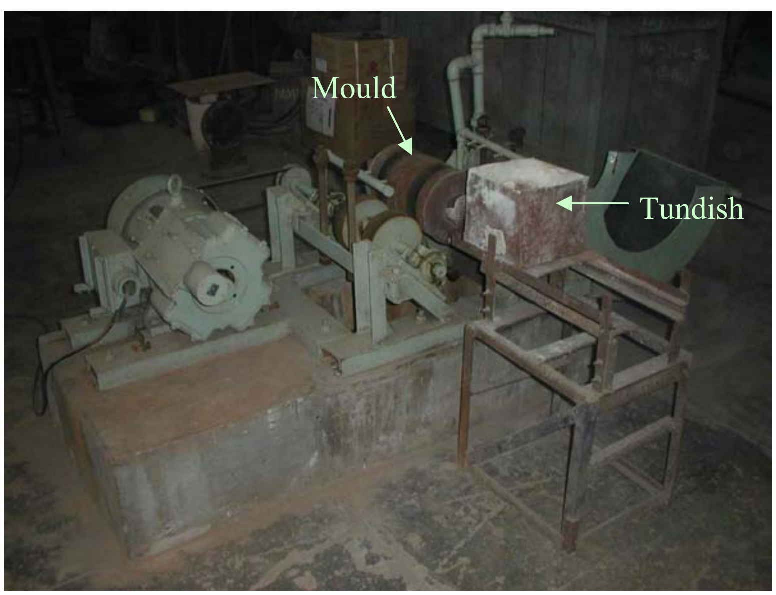
Segregation - Centrifugal castings are under various forms of segregation thus pushing less dense constituents at centre.

Banding – Sometimes castings produce zones of segregated low melting point constituents such as eutectic phases and sulphide and oxide inclusions. Various theories explain this, one states vibration is the main cause of banding.

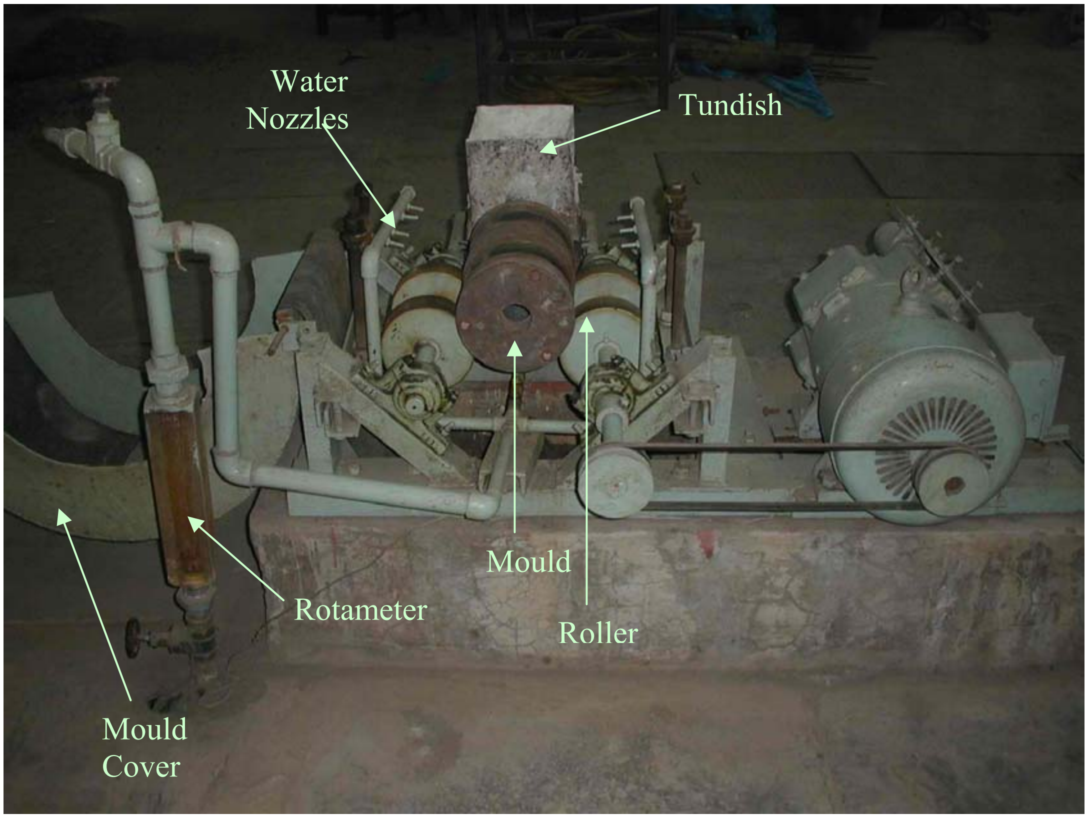
Characteristics of Centrifugal Casting

1) The casting is relatively free from defects.
2) Non metallic impurities which segregate toward the bore can be machined off.
3) Less loss of metal in tundish compared to that in gating and risering in conventional sand casting.
4) Better mechanical properties.
5) Production rate is high.
6) Can be employed to manufacture bimetallic pipes.
7) Centrifugal casting process can be used for fabricating functionally gradient metal matrix composite material.

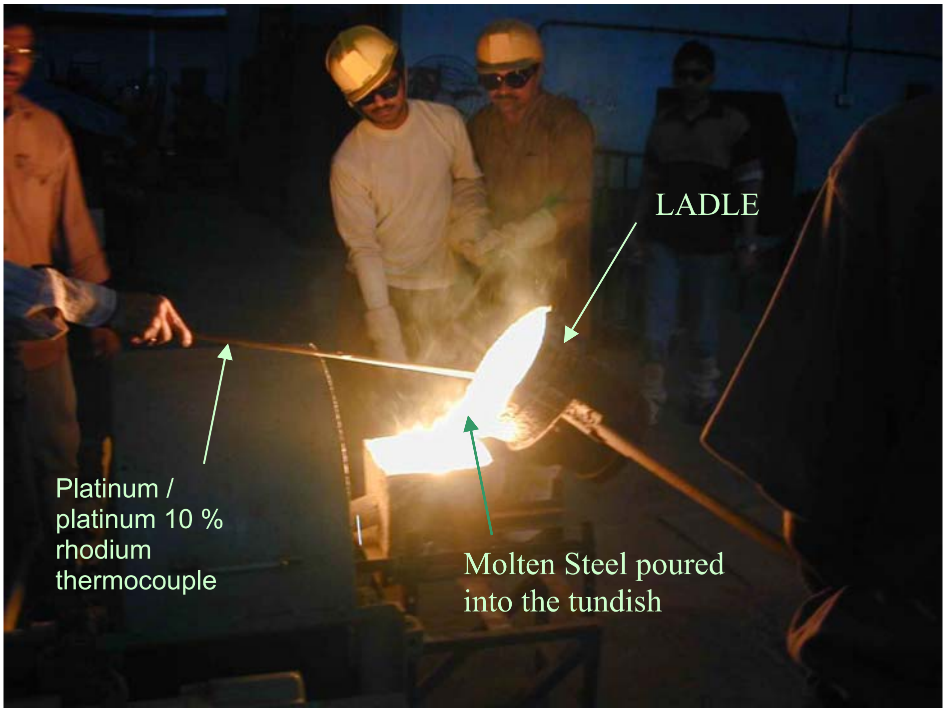
Bimetallic pipes can be produced by centrifugal casting by using a cheaper material in place of a highly alloyed material. This will reduce cost of the bimetallic casting. Initially outer metal is poured in the rotating mould (mould is coated with a refractory coating) followed by pouring of second material with some time gap. When the freezing is complete the tube has an annular weld or diffusion zone. The second metal should be poured in the rotating mould after the first metal has lost fluidity. If second metal is poured earlier then the composition and thickness of second metal will be changed. Also if second metal is poured late than the first metal then there won't be good bonding.



Centrifugal Casting Set Up (front side view)



Centrifugal Casting Set Up (backside view)



Pouring Operation in Rotating Mould

Some bimetallic combinations [2, 3, 4]

Outer Layer	Inner Layer
5 % Cr steel	S.S
SS	MS
MS	Cu
MS	Al
Cu	G.C.I
Al	G.C.I
S.S	G.C.I
M.S	Ni – hard

Second metal is poured inside the mould after some time. This time lapse after solidification for first metal and before pouring of second metal is calculated by
$D = k \sqrt{t}$, where D – thickness solidified, k – solidification constant, t – time.

The centrifugal casting can be used for metal matrix composite (MMC) melts. For example if stir cast aluminium/graphite melt is poured in the rotating mould, graphite particles will segregate in the inner periphery of the centrifugal casting as graphite density is lower than aluminium. Thus such casting can be employed for bearing applications[5].

Applications

Pipes for water, gas and sewage; bearing bushes; cylinder liners; piston rings, paper making rollers; clutch plates; pulleys.

Some Centrifugal castings

Aluminium Castings

Bimetallic Pipe (Outer layer – Stainless steel, Inner layer – mild steel)

Mild Steel Casting

Lead Casting

<u>References</u>

1) Thornton, British Foundryman, 51, 559, 1958.
2) Cumberland J, 'Centrifugal casting techniques', British Foundryman, pg. 26-46, Jan 1963.
3) Jones M C, 'Investigation of Centrifugal casting techniques', Foundry trade journal, June, 1970.
4) Samuels M L, Schuh A.E, 'Some recent developments in centrifugal casting', Foundry, pg. 84, 1951.
5) P. K. Rohatgi, 'Nonferrous Casting Alloys', ASM Handbook, Volume 15: Casting.