ABSTRACT

Indian Foundry industry produces several MMTs (Million Metric Tons) of castings every year, offering wide employment opportunities, results in national economic growth. However, industries design and develop engineering components for automobiles, railways, power sectors etc. Components such as pumps, compressors, pipes, valves, pipe fittings, electrical components, textile machinery (power looms), cement machinery, machine tools, furnaces, sanitary castings, sugar mills, granite stone polishing machines are usually manufactured by these industries. Cast irons are preferred in place of steel due to relative economical factors and manufacturing advantages such as low production cost, moderate machinability, able to cast intricate shapes, ability to cast into huge sizes, high wear resistance, high hardness and improved damping capacity with economical benefits or advantages. Many engineering customers attract these properties and eventually make engineering components.

Mechanical properties of grey cast iron are largely influenced by its chemical composition and presence of its alloying elements. Next to carbon, silicon is the most important alloy, which helps in formation of graphite and reduces shrinkage. Manganese, sulphur, phosphorus are other major constituents of cast iron which ranges from 0.05 to 1%. Silicon helps to form carbon into graphite resulting to produce softer iron, reduces shrinkage, strength and density. Addition of sulphur forms iron sulfide, which prevents graphite formation and increases hardness. Sulphur makes molten cast iron sluggish, which causes short run defects. Manganese counters the effects of sulphur, addition of manganese leads to form manganese sulfide instead of iron sulfide. Copper decreases chilling effect, refine graphite, and increases fluidity. Titanium addition helps in degassing, deoxidizing and to increase fluidity. Addition of vanadium to cast iron stabilizes cementite, which increases wear and heat resistance. Zirconium helps to form graphite, acts as deoxidizer and increases fluidity. Vanadium, neubium, or titanium is added to white iron to increase the ductility. Molybdenum is a weak carbide stabilizer and when added increases the hardness. Nickel is one of the most common alloys because it refines the pearlite and graphite structure, improves toughness, and maintains uniform hardness for various section thicknesses. When chromium is added to cast iron, a portion of it enters the iron carbide and forms complex Fe-Cr carbides. Carbide present in the form of pearlite is primarily stabilized, addition of chromium results in massive carbides stabilization. The primary role of chromium is
therefore to act as a carbide stabilizer leads to form chromium carbides resulting in high wear resistance, fracture toughness and hardness.

Cast iron properties can be enhanced by using chills during solidification process. Chilling promotes directional solidification. Chilling effect leads to increase the eutectic cells. The number of cells is significantly larger in case of chilled cast iron (or chilled portion) than the cast iron that is poured under sand-cast conditions. High hardness was observed near the chill end than the surface away from the chill end. High wear resistance is obtained near the chill end due to high carbide content and high hardness.

Experiments were carried out in three different stages. In the first stage, induction furnace was used to melt the cast iron scrap along with other alloying elements. Cryogenic chilling (~-60°C) was provided by using liquid nitrogen. Mild steel chills (MSC) were used as external chill material. Small quantity of chromium up to 0.3% was added as inoculant in addition to general constituents. Mild steel chill was located at far end of the sprue. Liquid nitrogen was supplied indirectly using compressor to maintain chill temperature to subzero level. Various tests like hardness, compression strength and sliding wear test were performed. Microstructural examination at the chill end (C/F), middle surface (M) and back end (B- far end from chill surface) was examined and analyzed in detail.

In the second stage, cupola furnace was used to melt the cast iron scrap and other required materials. Mild steel chill of various thicknesses were used to optimize the effect of chill thickness on hardness, compression strength and sliding wear properties. Nickel and chromium were added as inoculants (~1 to 1.5%) to study the behavior of cast product with and without using MS chills.

In the stage 3, once again cupola furnace was used to melt the cast iron. Mild steel chill was placed parallel and perpendicular to the flow of molten metal to evaluate chilling effect on hardness.

The results clearly demonstrated that chilling of grey cast iron during solidification has significant influence on mechanical and tribological properties. Addition of chromium and nickel to cast iron was responsible for enhanced mechanical and wear properties.