A Review: Effect of Chemical Composition on SG Alloy Product

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***Abstract*— Casting is a manufacturing process to make complex shapes of metal, during mass production, we have experienced many defects due to number of reasons like improper runner, riser, gating design, improper melting and poring practice, mould and core materials etc. Improper metal composition is one the reason for the defects in casting process. Spheroidal graphite cast iron is defined as a high carbon containing, iron based alloy in which the graphite is present in compact. It has high fluidity, castability, tensile strength, toughness, wear resistance, weldability, machinability and it is generally used in hydraulic cylinder, cylinder heads, rolls for rolling mill and centrifugal cast product. These research deals with study of chemical composition of SG alloy in sand casting process. Chemical composition in ductile iron are always considered in the range so that it is difficult to achieve the targeted mechanical properties like tensile strength and hardness and the microstructure as per the given specification. This review paper is based on the notable research work done by various researchers in the area of composition of casting.**

***Index Terms*—Casting, Chemical Composition, SG alloy, Mechanical Properties.**

I. INTRODUCTION

The nodular or spheroidal graphite(SG) cast iron is also called ductile cast iron or high strength cast iron. This type of cast iron is obtained by adding small amounts of magnesium (0.1 to 0.8%) to the molten grey iron. The addition of magnesium causes the graphite to take form of small nodules or spheroids instead of the normal angular flakes. It has high fluidity, castability, tensile strength, toughness, wear resistance, pressure tightness, weldability and machinability. It is generally used for castings requiring shock and impact resistance along with good machinability, such as hydraulic cylinders, cylinder heads, rolls for rolling mill and centrifugally cast products. According to Indian standard specification (IS: 1865-1991), the nodular or spheroidal graphite cast iron is designated by the alphabets 'SG' followed by the figures indicating the minimum tensile strength in MPa or N/mm2 and the percentage elongation. For example, SG 400/15 means spheroidal graphite cast iron with 400 MPa as minimum tensile strength and 15 percent elongation[1].

Production of SG Alloy [2]

1.Desulphurisation: Sulphur helps in the growth of graphite flakes. Thus, while producing SG iron the raw materials should have low sulphur content.

2.Nodulising: Magnesium is added to the bath to tie up sulphur and oxygen and radically change the graphite growth morphology. Magnesium reacts with oxygen to form highly stable MgO which floats on the surface and can be skimmed off easily. Oxygen content thus reduces from typical levels of 90-135ppm to about 15-35ppm. Magnesium also reacts with sulphur to produce less stable MgS. Due to low solubility of magnesium in the metal and due to its volatile nature, reaction can become reversible if losses are not taken care of. Si is added for additional deoxidation. Group 1A, 2A, 3B elements can also be added for tying up sulphur and oxygen. Cerium forms highly stable oxides with S and O and is less volatile than Mg. Addition of Mg is done when the melt is at 15000C but Mg vaporizes at 11000C. Magnesium being lighter floats on the bath and being reactive burn off at the surface. Hence it is generally added as Ni-Mg, Ni-Si-Mg alloy or magnesium coke to reduce the violence of the chemical reaction and to have saving in Mg. Thus, magnesium addition plays an important role in the manufacture of SG iron. After nodulising treatment inoculants like Mg have their spherodising effect on the graphite structure so that graphite nodules can be formed.

3.Inoculation: The inoculation of cast iron involves the addition of small amounts of a material (inoculants) to the molten metal either just before or during pouring. Inoculation increases the number of points available for the precipitation and subsequent growth of graphite. This effect is often described as increasing the degree of nucleation of the iron. It can be seen that high levels promote graphite structure whilst low levels can result in the formation of either mottled structure or white irons. The need for a high level of nucleation increases as cooling rate increases, i.e. section size decreases. In addition to its effect on graphite morphology, magnesium is a powerful carbide promoter and as a result, compared with the gray irons, there is a far greater tendency for ductile irons to solidify with white or mottled structure. The primary purpose of inoculating ductile irons is to suppress formation of chill and mottle. In addition, inoculation is important in maintaining good nodule shape and also high nodule numbers. Graphite is not effective inoculants for ductile irons and all effective inoculants are based on silicon. The most widely used is foundry grade ferrosilicon, containing about 75% silicon. This alloy must contain small amounts of aluminum and calcium, in order to be fully effective; the amounts required are about 1.5-2.05 aluminum and about 0.3-1.0%. The inoculating effect produced initially increases as the number of inoculants is increased, but the effect soon begins to level off. A situation is reached where the extra inoculating benefit obtained is too small to justify for the increased addition. Usually, suppliers recommend smaller additions of the proprietary inoculants to achieve the same degree of nucleation. This partly compensates for their increased cost and has the advantage of decreasing the amount of silicon added.

4. Solidification of SG iron: Solidification of SG iron is always associated with proper under cooling. Graphite nuclei grow slowly and then are surrounded by austenite. The combination of austenite and graphite corresponds to the eutectic point at eutectic temperature. Austenite which gets supersaturated with carbon cools and a new equilibrium is established at the graphite/austenite interface. The excess of carbon diffuses towards the graphite nodule where it precipitates out.

II. LITERATURE SURVEY

Roney Eduardo Lino et al [3] The aimed calcium content and the calcium range on the castability window were estimated by computer thermo-dynamics calculations. The amount of calcium in alloy is very important because it allows the modification of the inclusions and the sustainability of the continuous casting process. Under the evaluated conditions, an increase in carbon, aluminium and sulphur contents reduces the castability window. On the other hand, an increase in silicon content expands the castability window. A multiple linear regression equation with suitable correlation factor R2has been built, that provides a faster calculation than the thermodynamic calculation. The equation calculates the aimed calcium content in function of the aluminium, silicon, carbon and sulphur contents. The ternary diagrams produced from SEM semi-quantitative analysis showed the formation of the following type of inclusions: spinel, corundum, and CaS/aluminates. The spinel and corundum phases specify a heterogeneous process of inclusions after calcium treatment. The inclusions analysis of a 0.20%C–0.02%Si–/0.01%S–0.02%Al–0.0015%Ca-steel billet shows 20% of the inclusions with liquidus temperature below the casting temperature and 42% of the inclusions present over 90% of liquid phase. Regardless of heterogeneous characteristics, the calcium treatment allows continuous casting of aluminium-killed steel.

L. Alvarez et al [4] conclude that an increment in the equivalent carbon brings, as a direct consequence, a decrease in the mechanical properties. Both the hardness and the tensile strength of the material were seen to diminish. The decrease in hardness was greater in the area inside the cylinders, this being one of the areas which are to be subjected to the highest stresses in the cylinder block. Without a doubt, this aspect is of great importance when trying to obtain similar properties in workpieces obtained from different batches, as it is possible to adjust these properties. With this present work, it has been demonstrated that it is possible to obtain an improvement in the mechanical properties of grey cast iron cylinder blocks. The improvement in the properties does not always have to be in the sense of increasing them. In the case described, it has been seen that it is possible to come out with a decrease in the mechanical properties, that is to say, Brinell hardness and tensile strength. This has direct repercussions in the posterior machining of the workpieces, namely improving it and also, this decrease does not affect the functioning of the cylinder block. Therefore, as it has been seen, the decrease in mechanical properties is appropriate in certain cases in such a way that the machinist is supplied with homogeneous workpieces, independently of whether the supplier may change. **K. Kanthavel et al** [5] gives the design of experiment investigation of shrinkage defect was carried out on the actual production line of the steel ball valve's flange area using MS chills. In this analysis, it is observed that the chill thickness has a greater influence on the formation of the macro shrinkage cavities. The size of shrinkage cavities is influencing by thickness of chill, which is a critical parameter over other parameters like chill distance, pouring temperature and pouring time. The statistical analysis tool has identified that chill thickness has contribution of 92.68% in formation of shrinkage cavity. The combination of chill distance of 30.64 mm, chill thickness of 37.09 mm, pouring time 48.47 sec and pouring temperatures 1574.91ºC is identified as the optimum parameter for getting minimum shrinkage defect. Further direction of research can be focused on identified other chill material to minimize the shrinkage cavities.

Hanguang Fu et al [6] conclude that the mould, paint, pouring speed, pouring temperature, and cooling rate have obvious influences on the crack formation of a HSS roll. After composite modification with RE–K, the hot-tearing force of a HSS roll is increased by 32.77% and reaches 158 N. The adoption of variable-speed centrifugal casting, variable flux pouring and variable-speed solidification cooling adjusts the temperature field and stress field of the roll, and thereby improves the filling and solidification of the molten steel and eliminates the cracks of the HSS roll.

SUN Shao-chun et al [7] conclude that the mechanical properties and microstructures in the Sr-modified A356 aluminum casting alloy using chromite sand are the best among the quartz, alumina and chromite moulding sands because the cooling speed of the chromite sand is the fastest. The chromite sand with higher cooling speed is less sensitive to wall thickness and can bring smaller DAS, grain size and size of eutectic silicon particles. In contrast, higher wall thickness in the case of the quartz sand significantly decreases the Sr modification effect and therefore deteriorates the microstructure and the properties. As the cooling speed increases, the dendrite arm spacing decreases significantly and the mechanical properties increases. The elongation is more sensitive to the cooling speed as compared with the tensile strength. The increase of the properties is primarily attributed to the decrease of the DAS and the increase of the free strontium atoms in the matrix. The regression models established based on the experimental DAS and property data can not only predict the tensile strength and the elongation, but also help to fast detect the product quality of the alloy manufactured using the three moulding sands.

M.M. Haque [8] conclude that Fluidity length of the SG–Si cast iron is higher than that of the SG–Al cast iron, indicating that the SG–Si cast iron is more fluid than the SG–Al cast iron. As the section thickness increases, the density decreases for both cast irons, meaning that the shrinkage porosity increases. However, it is more pronounced in SG–Al cast iron. The degree of nodularity for graphite and ferrite rings are better in the matrix structure of SG–Si cast iron compared to those of SG–Al cast iron. The tensile properties of SG–Si cast iron are almost consistently higher than those of the SG–Al cast iron irrespective of section thickness. This is probably because of the presence of higher shrinkage porosity in the SG– Al cast iron, which needs better inoculation technique and feeding arrangement.

Sunil Chaudhari et al [9] Modern method of casting components using various software and simulation technique is really a boon for the industrial sector. It offers number of advantages and in the form of intelligent tool to enhance the quality of cast component. This will definitely helpful in improving the quality and yield of the casting. If castings are inspected with such technological way, it keeps foundry men to alert condition for control of rejections. Many researchers have conducted experiments to find the sand process parameters to get better quality castings. They have successfully reduced the casting defects considerably up to 6% by proper selecting sand parameters. Now looking to their recommended process parameters, they vary in each case. So, we can conclude that the sand process parameters should be decided experimentally depending on quality of sand. We should not select these parameters directly from other manufacturers. This is called customization of process parameters depending on sand quality, and environmental conditions etc. Rejection of the casting on the basis of the casting defects should be as minimum as possible for better quality. One can continuously strive for change in sand mixing process parameters until rejections are under control.

Bhushan Shankar Kamble [10] conclude that the foundry had not standardized its production processes in different areas. In this review, several casting defects and their occurrence cause were identified. This will help in analysing the defect and remedies to overcome them. Casting Rejection on the basis of the casting defects should be as minimum as possible for improved quality. One can continuously control rejections by taking in to consideration different parameters at every stage of production. Therefore, it is essential for a metal caster to have knowledge on the identification of type of defect and be able to identify the exact root cause, and their remedies. Hence this systematic work will be fruitful or quality casting manufacturing.

Shruthi Y. C. et al [11] provides brief idea about overall change in production parameters of interest in a foundry when casting production is shifted from green sand mould process to shell mould process. This study was done considering various parameters as discussed above, it is because results of which clears provides how and to what extent various parameters increased which intern have great influence customer satisfaction and hence on profit margins. Effort was made to improve quality, delivery of castings, and yield in a foundry. Apart from these raw materials required for the process is less and also manual work comparatively can be reduced. All these improvements prove to be beneficial for any foundry which wants to survive in competitive market condition as well as to see growth in profit margin.

III. CONCLUSION

After detailed literature survey comes on this conclusion as:

In SG alloy, small change in composition directly affect the Mechanical properties as well as microstructure. Small increase in Carbon % results increase in Brinell hardness number. Change in silicon % vary the hardness and tensile strength. Copper addition improves tensile strength. Increase manganese % increase in the hardness in other side residual manganese affects the microstructure of the SG Iron. By heat treatment process mechanical properties and microstructure improves. To improve quality of Cast also focus on chemical composition and improve quality of the final product.

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