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A Review on Effect of Process Parameters on Microstructure and Mechanical Properties of Spheroidal Graphite (SG) Cast Iron

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Abstract: ***The mechanical properties of SG cast iron can be improved by changing the process parameters like melting of base iron scrap, nodulisation treatment, percentages of Nodulariser, magnesium treatment, inoculation process, type of inoculant. percentages of inoculant as well as pouring practices etc. The quality of casting checked with tensile strength, hardness test, wear test & microstructure analysis. Also, in micro structure of SG iron extra amount of hard carbide generates. Due to this hard carbide structure, there are some of mechanical properties affects like reduction in ductility and machinability. The main aim behind this paper is to present literature review on effects of various process parameters on mechanical properties and microstructural properties of spheroidal graphite cast irons.***

Keywords: Inoculation, Mechanical properties, Microstructure analysis, Nodulisation treatment, Process Parameters, SG Iron.

I. INTRODUCTION

Ductile iron or also known as spheroidal graphite cast irons, which use have been increasing over the past two decades, just because of it has a better combination of strength as well as toughness as compared with other types of cast irons. The graphite is existed in form of small spherical shape. Therefore, the concentration of inside stresses can be reduced, so its mechanical properties are very well and improved. Due to graphite spheroids can get mechanical properties like very high tensile strength, yield strength, better wear resistance and elongation. Hardness of SGI cast iron can be also control by change in chemical composition.

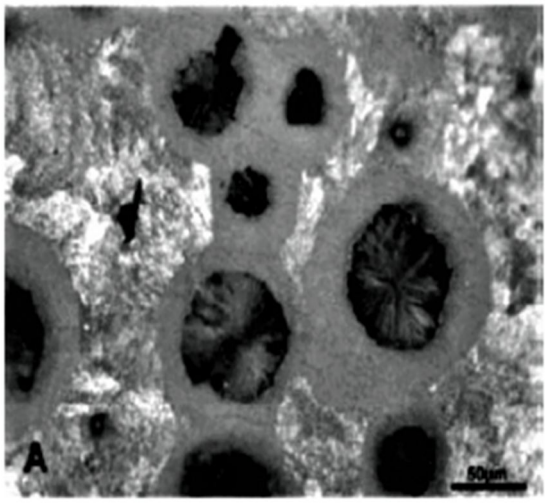

Fig-1: Graphite in form of spheroids or nodule shape in SGI

In microstructure of SG iron spheroids cause higher mechanical properties along with better wear resistance capacity. In addition of ductile and graphite cast iron carbon percentage present is also same. Due to addition of alloying elements like magnesium and cerium graphite spheroids generates in microstructure. These alloying elements can help to improve its dimensions in all the directions uniformly. When silicon is added above 2% it may cause graphitization rate increases. In SG iron microstructure graphitization rate is increases when silicon added more than 2%. The mechanical properties of SG cast iron can be improved by either changing the process parameters or using various heat treatment processes. In SGI casting, effective parameters are raw material, Type of furnace, temperature of adding metal, type of moulding sand, ladle size, inoculation method, percentage of inoculant.

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A. *Nodulisation*

Nodulisation is a process for converting flex to nodules of graphite present in metal. To remove sulphur and oxygen which is still present in liquid alloy Magnesium is added and it provides a residual 0.05% of magnesium, this results in growth of spheroidal graphite, probably the interfacial energy has a high value to have a 180 degree this implies that the wetting of graphite does not occur. This treatment with magnesium desulphuriser iron to less than 0.02%. In nodulisation process Ferro silicon Magnesium (Fe-Si-Mg) is used as nodulariser for SG cast iron. For SG cast iron, nodulariser is added to ladle at time of pouring or tapping. Nodulisation process is also known as Magnesium treatment.

B. *Inoculation*

Inoculation is a process in which microstructure structure and mechanical properties of cast irons by increasing the number of nucleation sites available for the growth of graphite nodules or spheroids in ductile irons. For molten SG iron inoculation process is most important parameter and it is done during pouring of molten metal. Inoculant is a material that is used for improvement in grain structure of SG cast iron.it also helps to improve cooling of molten metal and gives significant effect in microstructure of SG cast iron. Now a days there are many types of inoculants are available in industries like Ferro silicon Barium, Ferro silicon zirconium, Ferro silicon Manganese, Ferro silicon Bismuth. Most of inoculants for cast iron are based on ferrosilicon and containing small amount of active elements like Calcium (Ca), Aluminium (Al), Barium (Ba), Zirconium (Zr), Strontium (Sr) and Rhenium (Rare Earth metals).

II. LITERATURE REVIEW

Gaurav S. Biraje, Digvijay M. Jadhav (2016) [1] After referring this research paper found that there are large of scope to do study on process parameters and casting materials of SG cast iron. From their three trials following results are obtained. At 1% Fe-Si-Mg & 0.3% Inoculant, Nodularity 79.1 % & Hardness is 170. At 1% Fe-Si-Mg & 0.35% Inoculant, Nodularity 79.7 % & Hardness is 185. At 1% Fe-Si-Mg & 0.4% Inoculant, Nodularity 93.0 % & Hardness is 210. With variation in % of Fe-Si-Mg & % of Inoculant with specific chemical composition & temperature gives different mechanical properties as well as Microstructure properties. From the above experimentation it is found that with combination of process parameters as 1% Fe-Si-Mg & 0.4% Inoculant, gives the improved results which are, Hardness is 210 & Nodularity 93.0 %.

Dhruv Patel, P.K. Nanavati, C.M. Chug (2011) [2] In this work Microstructural examination showed that the generation of pearlite in SG600 cast iron (20.73%) without inoculation was much lower as compared to those with Fe-Si-Ba-based inoculant (85.94%) and conversely, the amount of ferrite in sample of SG-1 was (79.28%) greater than those in sample SG-2 (14.06%). The effect of inoculation on graphite structure was significant. Moreover, Barium based inoculants resulted in refinement of graphite nodule as compared to those without inoculation. The result showed that increasing the pearlite content on SG iron and increasing the ferrite content on grey cast iron. Moreover, grain size would be increase. Thus, hardness, tensile and elongation are depending on this grain size.

Miss. Shilpa Godbole, Dr. (Mrs.). V. Jayashree (2014) [3] Main aim of this research paper is to present microstructural analysis of SG Iron by using image processing methodology. It can be helpful for determine the suitable and efficient parameters of SG Iron casting such as nodule count, nodularity, nodule size and percent of ferrite and pearlite. The tensile strength and hardness of the Spheroidal Graphite Iron casting is dependent on these types of quality parameters. They got test specimen images of SG Iron casting by use of inverted microscope were subjected to segmentation.

Sanjay Waghulde (2006) [4] In this Research Paper, by use of advance thermal analysis system any casting foundry can improve their product quality and also can select effective parameters for quality products. Also, even small amount of improvements such as reduction in rejection rate of casted component will have a substantial impact on profitability and other costing parameters, since the improvements will affect the total poured tonnage. It can help to reduce rejection rate due to metallurgical causes, less variations in mechanical properties, improve yield, reduced amounts of inoculants and Mg-alloys (magnesium treatment). Thermal Analysis gives us information not only about Carbon Equivalent, %Silicon, % Carbon, % other elements, but also about contribution of melt quality in achieving Microstructure, Tensile strength, Hardness, Wear resistance, percentage of Nodularity, Nodule count, Effectiveness of inoculants and effectiveness of Mg-alloys.

V. D. Shinde, B. Ravi, K. Narasimhan (2012) [5] In this presented research paper, in thin wall ductile iron casting the effect of copper addition up to 0.74% and melt processing (Ba-based in-stream inoculation) on the matrix structure, fracture behavior and mechanical properties of ductile iron castings with varying section thickness 3–17 mm were investigated in a regular foundry. It was possible to gain 81% pearlitic structure without generation of carbides in 3 mm sections, with considering 2.5% of ductility and 264

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Brinell hardness. Also, tensile strength of this section is 658 MPa. The solidification behavior can be determined by the cooling curves to check the effectiveness of the melting treatment by observing the amount of undercooling effect. Also, from this research paper got information about effect of variation of section thickness and variation in other parameters are effective for improvement in mechanical properties.

Lisa Shifani Madtha, Prof. B.R Narendra Babu (2013) [6] In this research paper, there are some factors affecting on microstructure and mechanical properties of ductile cast iron (DCI) like melting process, inoculation method, inoculant, heat treatment, etc. Ductile cast iron has been used for a wide variety of application in piping, pump equipment, automotive, rail and heavy engineering industry because of its excellent mechanical properties such as high strength with good ductility, good wear resistance and good fatigue property.

Mr. Karan Thacker, Prof. Himanshu Joshi, Prof. N.J. Patel (2015) [7] According to presented research paper, the quality of ductile iron pipes mainly depends on chemical composition, microstructure as well as mechanical properties like percentages of Perlite, Ferrite, Carbide, percentage of elongation, tensile strength and hardness. These can be improved by analyses and optimization of the process parameters during the casting process. Design of Experiment (DOE) of this research paper is based on Taguchi Method. Taguchi method is used to analyse and optimization of the parameters like pouring temperature of molten metal, Method of inoculation and Inoculant Quantity. By using Taguchi Method L16 orthogonal array is generated in MINITAB 17 and results are analysed by experimental work at different levels of factors.

Doru M. Stefanescu (1973) [8] This research paper presents that, master alloys containing barium or cerium permit a high nodule count (exceeding 130 nodules/mm^2) event without post-inoculant. The most efficacious master alloy contains 0.2% Ce and the inoculant containing 1-2% Barium was the very effective inoculant. Maximum nodule count (250 nodules/mm^2) was obtained by treatment with the barium-containing master alloy and post-inoculation with the barium-containing inoculant. The cerium-based post inoculants cannot be recommended for ductile irons, because they do not produce a significant increase in nodule count. Similarly, they cannot eliminate the hard carbide in the structure. However, when master alloy of the Ni-Mg type is employed for magnesium treatment, post-inoculation with cerium-based inoculant can produce interesting results.

Izudin Dugic and Ingvar L Svenson (1998) [9] From this research paper, the best inoculant found in an earlier experiment, containing silicon, aluminum and zirconium was selected. Experiments were made with different amounts of inoculants, on a casting. A clear coupling between a low amount of inoculant and castings free from penetration can be observed. In the commercial casting, too much inoculant and sub-optimal composition has been used. At inoculation additions of 0.20 % and 0.40 %, the penetration decreased with reduction in pouring temperature. From the microstructure analysis it is clear that the penetration is associated with a mixture of large and small eutectic cells. The best results were obtained with help of inoculant additions of 0.05 %, with pouring temperature above 1390 °C. There were no penetrations, bulb formations or shrinkage defect could be found on the castings. This research is not including recent inoculants but deliver important information based on inoculation parameters and temperature.

III. PROBLEM FORMULATION

Spheroidal graphite iron casting now mostly demanded in market. Also making of SG iron is most important & challenging task in foundry. For analysis of SG iron many researchers used either mechanical properties or microstructure analysis. Many researchers used microstructure analysis by digital microscope & digital image analyser. As per as input process parameter concern most of researcher used either chemical properties of SG iron, temperature, percentage of inoculation and hear treatment but effect of percentage of Fe-Si-Ba (Ferro Silicon Barium) with variation in % of inoculant and change in percentage of nodulariser Fe-Si-Mg not yet to be diagnosed. in micro structure of SG iron extra amount of hard carbide generates. Due to this hard carbide structure, there are some of mechanical properties are affected like reduction in ductility and machinability.

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IV. CONCLUSION

From above literature survey concluded that for the Spheroidal graphite iron casting process studied with its parameters like heat treatment, temperature, inoculation method, percentage of inoculant, type of inoculant, chemical composition etc. From these parameters its mechanical properties & microstructure study carried out with various conventional as well as advanced technologies. By changing process parameters like percentage of inoculants, percentage of other alloying elements, we can get improvement in properties like ductility, wear resistance, machinability. Also, we can reduce the formation of hard carbide structure and increase nodule count.

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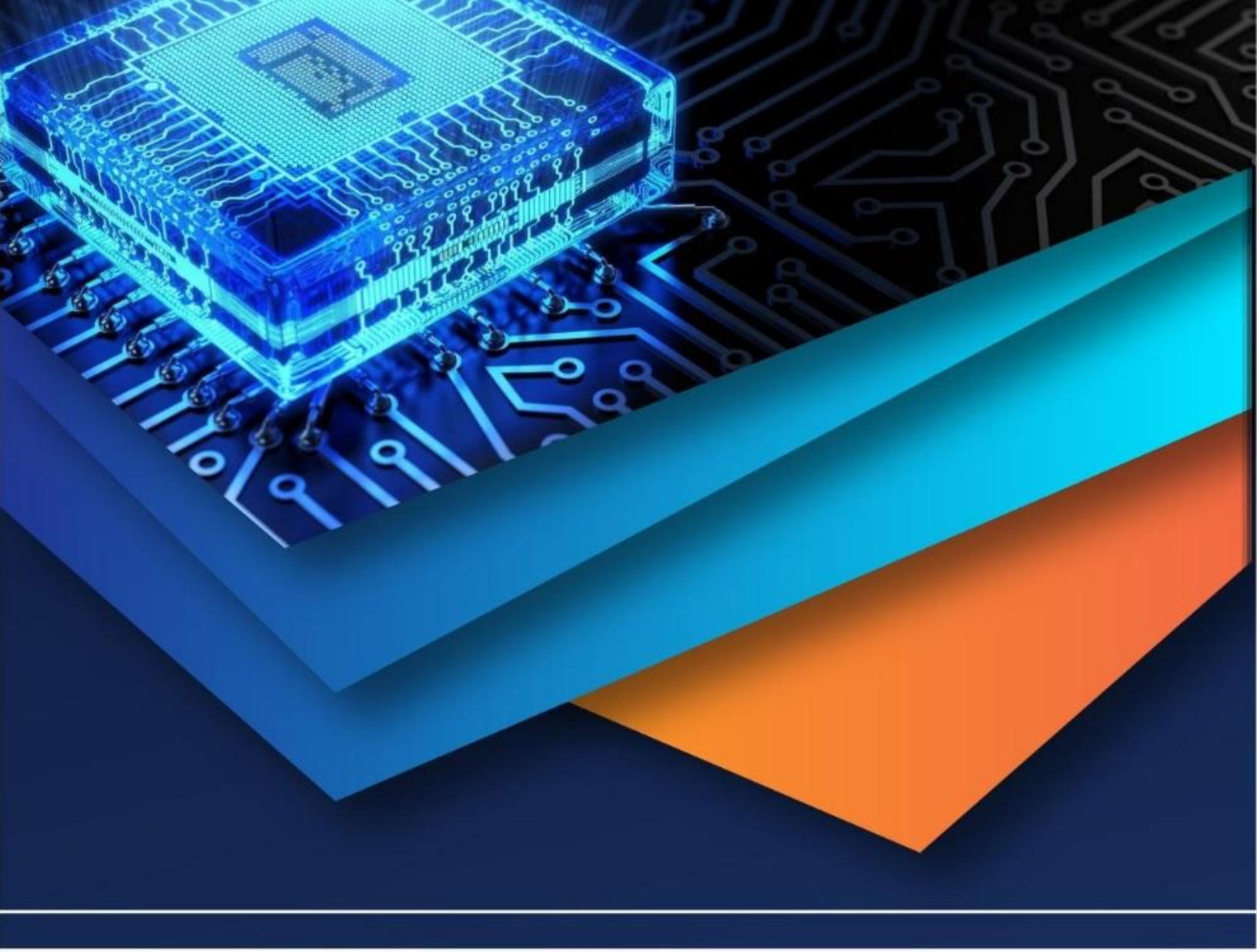

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