A Review on Analysis and Optimization of Parameters for Spheroidal Graphite (SG) Iron Casting

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Abstract— The quality of SG Iron casting is fully depends on its parameters like melting of base iron, nodulisation treatment, inoculation process as well as pouring practices etc. The quality of casting checked with hardness, elongation & tensile strength also microstructure analysis. Microstructure analysis is a process to be carried out on ready castings. The main purpose of this paper is to present literature survey regarding measuring parameters of SG Iron casting process including image processing methodology for microstructure analysis of Spheroidal Graphite Iron (SGI) castings to determine the quality assessment parameters of SGI casting such as nodularity, nodule count, nodule size and percent of ferrite-pearlite. The strength and hardness of the SGI castings is dependent on these quality parameters.

Key words: Spheroidal Graphite, Iron Casting

I. INTRODUCTION

Production of SG iron involves firstly melting of base iron of right chemical composition and of right physical condition followed by treatment with either pure magnesium or an alloy containing magnesium with or without cerium, so as to leave a residual magnesium content of 0.03 to 0.05 percent in the treated iron. Magnesium is essentially a desulphuriser and its addition to the base iron first reduces the sulphur content to a very low level and then results in the formation of graphite in a spheroidal form instead of the flake form present in the normal grey iron. The magnesium treatment is invariably followed by the late addition of ferro-silicon as inoculation treatment in order to ensure good ductility in the SG iron produced. Simultaneous addition of spheroidizing and inoculating agents is also sometimes practised.

Nodulisation – Nodulisation is a process for converting flex to nodules of graphite present in metal. For this Nodulisation process treatment of FeSiMg (Ferro Silicon Magnesium) is done in the ladle at time of tapping & pouring.

II. LITERATURE REVIEW

A. Miss. ShilpaGodbole, Dr. (Mrs).V. Jayashree [1]

The microstructure analysis is a process to be carried out on ready castings. The main purpose of this paper is to present image processing methodology for microstructure analysis of Spheroidal Graphite Iron (SGI) castings to determine the quality assessment parameters of SGI casting such as nodularity, nodule count, nodule size and percent of ferrite-pearlite. The strength and hardness of the SGI castings is dependent on these quality parameters. Sample images of SGI casting obtained from inverted microscope were subjected to segmentation and boundary detection algorithm to find the nodules present.
B. I. Imasogie and U. Wendt [2]

A procedure and specification for evaluating the degree of spheroidization of graphite in spheroidal graphite iron (SGI), using a computer-based image analyzing system has been developed as an aid to structure-property-quality assessment. Both global and feature-specific numerical indices have been programmed and implemented using a Zeiss Jenaphot 2000 projection microscope and SEM interfaced to a computer-based MACROS III analyzer and a CCD video camera. The modular procedure has been tested and used to evaluate the effect of variation in the degree of spheroidization of graphite on the 0.2 % offset yield strength for an iron series ranging from ASTM type I (fully nodular) to ASTM type II-III-IV (mixtures of nodular and compacted/vermicular graphite) and were found to indicate good correlation.

C. Kazumichi Shimizu, Yaer Xinbai, Masahito Tanaka and Hideki Shudai [3]

The reduced pressure frozen mold casting process has been known as a recycling-based casting method with several advantages, such as improvement of the work environment, reduction of industrial waste and significant improvement of product yield. In this method, only water and silica sand were used to make mold, which was rapidly frozen at 400 C, then molten metal was poured into it. In the present investigation, samples were made by the reduced pressure frozen mold casting process and previous processes, and comparisons of their mechanical properties, especially the fatigue strength, were reported. As a result, it was clarified that cast iron made by the reduced pressure frozen mold casting process has a sufficient strength; therefore the reduced pressure frozen mold casting process was expected to be applicable to other castings that have been made by previous casting processes.

D. V. D. Shinde, B. Ravi and K. Narasimhan [4]

Achieving the desired mechanical properties in thin wall ductile iron castings poured in industrial production foundries is a challenge. In this work, the effect of copper addition (up to 0.74%) and melt processing (Ba based stream inoculation) on the matrix structure, mechanical properties and fracture behaviour of ductile iron castings with varying section thickness (4–16 mm) were investigated in a regular jobbing foundry. It was possible to obtain 80% pearlitic structure without carbides in 4 mm sections, giving a tensile strength of 658 MPa with 2.5% ductility and 264 Brinell hardness. The solidification behaviour represented by the cooling curves helped in checking the effectiveness of the melt treatment by observing the amount of undercooling. Fractography studies of tensile specimens showed the change in fracture mechanisms due to increase in copper content on fracture paths. The increased amount of pearlite in the matrix exhibited brittle fracture with river pattern.

E. Lisa ShifaniMadtha, Prof. B.R Narendrababu [5]

Ductile cast Iron also referred to as nodular iron or spheroidal graphite iron. The Ductile cast iron contains graphite it is in the form of discrete nodules or spheroids. This paper deals with some factors influencing microstructure and mechanical properties of ductile cast iron (DCI). Ductile cast iron have been used for a wide variety of application in 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 properties. The properties of ductile cast iron are dependent on both chemistry and heat treatment. Nodular cast iron are primarily heat treated to create matrix micro structure and associated mechanical properties not readily obtain in the as-cast condition. Final structure and properties of DCI are obtained by exactly controlled process of heat treatment. Experiments are conducted on 600/3 and 500/7 grades of ductile cast iron and following observations are made to know the properties of metal. Results of the experiment shows that it dependence of temperature and various matrixes can be obtained (i.e. mixture of graphite, ferrite and pearlite). Different quenching medias are selected to check the behaviour of the materials. Quenching medias like vegetable oil, mineral oil and water are used for this experimental analysis. After heat treatment the tensile strength, hardness, elongation and yield stress of the specimens are obtained with respect to different quenching medias.

F. Sanjay Waghule [6]

In current scenario the foundry industry is experiencing tremendous changes because of global competition, increasing demands and requirements to be produced in time and at very competitive price. It is necessary to set new objectives and strategies in order to increase actual competitiveness. Advance Thermal Analysis System can help to improve the foundry's actual competitiveness, by way of the more effective process control. Even small improvements such as reduction in rejection will have a substantial impact on profitability, since the improvements will affect the total poured tonnage. It can help to reduce rejection due to metallurgical causes, improve yield, less variations in mechanical properties, reduced amounts of inoculants and Mg-alloys. Thermal Analysis gives us information not only about Carbon Equivalent, % Carbon, %Silicon but also about contribution of melt quality in achieving Tensile strength, Hardness, Microstructure, %Nodularity, Nodule count, Effectiveness of inoculants, Eutectic Cell Count. It also gives information of shrinkage tendency, chilling tendency, Carbide index, Chill depth etc.

G. Mr. Karan Thacker, Prof. Himanshu Joshi, Prof. N.J. Patel [7]

Ductile iron Pipes are casted by Horizontal centrifugal process in which liquid iron is filled through an open channel into a fast rotating mould that is slightly tilted. The mould is water cooled from outside. In order to distribute the metal, the spinning mould including its cooling system is shifted axially in a controlled movement. The quality of ductile iron pipe largely depends on microstructure as well as mechanical properties like Ferrite %, Carbide %, Elongation % and Hardness. These can be improved by analyze and optimize the process parameters during the casting process. In this research paper, Design of Experiment (DOE) based Taguchi Method is used to analyze and optimize the parameters like Pouring molten metal Temperature, Inoculation Quantity and inlet cooling water flow rate. By using Taguchi Method L16 orthogonal array is generated in MINITAB 17 and responses are analyzed by experimental work at different levels of factors.
From S/N ratio the best combination of parameters are analyzed by which the predicted Taguchi result is generated. The confirmation experimental test is done and predicted result is compared with actual results. Also the Significance of factors and interactions of parameters are analyzed by Analysis of variance (ANOVA). By performing all this an attempt has made to analyze and optimize the parameters to improve the pipe quality and its life by supplying optimized resources.


Water works fittings and accessories are important applications for ductile irons. Although, in the design of these components the graphite nodularity is a critical attribute for material selection, the International Standard ISO 2531 does not include the minimum required value of graphite nodularity and its definite effect on mechanical properties. In this research the effect of graphite nodularity on tensile strength, elongation, impact strength and wear rate was studies. Different samples from four heats of cast iron containing several of graphite nodularities were cast. Different degrees of graphite nodularities from low graphite nodularity of about 21% up to high graphite nodularity of 94% were produced by treatment cast iron by different amount of spheroidizing (Mg) and antispheeroidizing (Ti) elements. It is concluded that all properties relating to strength and ductility decrease as the graphite nodularity increase, and those properties relating to failure, such as tensile strength and impact strength are more affected by changing of graphite nodularity.

III. CONCLUDING REMARK

By collecting & referring different research papers &study, the results from the inoculation process &Nodulisation process of SG iron casting are as follows.
1) As per grade & standards chemical composition can be changed & set for a specific heat. For a research work we select a single one grade for analysis with grade restrictions.
2) The selection of charge material is mostly depends on grade of material. For S G Iron CRC scrap, low sulphur pig iron are used.
3) If sulphur is present in raw or molten metal desulphurization is to be needed to give effectiveness of nodulisation process
4) For making of S G Iron from CI molten metal, nodulisation treatment is to be needed. For that Mg is introduced in molten metal.
5) The treatment with Mg the graphite contain in the molten metal converted in to the nodule.
6) Inoculation increasing the number of cells means that at a given rate of heat transfer flowing into the mold, the amount of heat generated increases during solidification and therefore, the degree of undercooling decreases. As a result, the cell growth rate decreases, while the interfacial distance increases. There is a critical growth rate of cells that corresponds to the transformational number of cells at which the eutectic.

IV. PROBLEM DEFINATION

SG Iron casting now mostly demanded in market. And 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, temperature or percentage of inoculation but effect of % of FeSiMg (Ferro Silicon Magnesium) with variation in % of inoculant yet to be diagnosed.

V. INPUT & OUTPUT PARAMETERS

<table>
<thead>
<tr>
<th>Input/Controlling Parameters</th>
<th>Output Parameters</th>
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<tbody>
<tr>
<td>1) Chemical composition as per std. grade – IS 1865 GR 500/7</td>
<td>1) Hardness (Mechanical property)</td>
</tr>
<tr>
<td>2) % of FeSiMg</td>
<td>2) Microstructure Analysis</td>
</tr>
<tr>
<td>3) % of Inoculant</td>
<td>– Nodularity</td>
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<tr>
<td>– Ferrite Count</td>
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Table 1: Input & Output Parameters

VI. METHODOLOGY

1) Collection of data.
2) Identification and Selection of major parameter affecting on process.
3) Controlling process parameter.
4) Optimization of process parameters, Use of DoE based Taguchi Method.
6) DoE for identification of optimized levels.
7) Mechanical property & Microstructure analysis.
8) Check results.

VII. EXPECTED OUTCOME

Due to the quality of SG Iron casting mostly depends on its process parameters, this research work expect the exact process of SG Iron casting with specific percentage of its treatment alloys.

VIII. CONCLUSION

From above literature survey concluded that for the SG Iron casting process studied with its parameters like temperature, % of inoculant, chemical composition etc. From these parameters its mechanical properties & microstructure study carried out with various conventional as well as advanced technologies.

In this research work in the different angle with standard chemical composition & variation in % of FeSiMg, &% of Inoculant is studied with advanced analyzing tools.

REFERENCES

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