Investigation of the Effect of Composition on the Quality of Sand Casted SG Alloy Products

Ashok Kumar Prasad[1], Arif Varsi[2]

[1]M.E Student, Production Engineering, S.N.P.I.T &RC Bardoli, (India)

[2]Prof.Mechanical Department, S.N.P.I.T &RC Bardoli, (India)

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 experimental 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 required mechanical properties like tensile strength and hardness and the microstructure as per the given specification. As a result, this will provide optimal chemical composition to achieve required mechanical properties as well as microstructure.

Keywords: SG alloy, Chemical Composition, Sand casting, Quality.

I. INTRODUCTION

The history of metal casting has been linked with the ability of the man to work with materials, beginning with the stone age and through the eras of copper and bronze, the iron age and recently the age of steel. Materials processing has been defined as the science and technology by which a material is converted into a useful shape with a structure and properties that are optimized for the proposed service environment. Numerous operations and processes are involved in the manufacture of products and components. Casting process is the oldest known manufacturing process, which uses liquid metal.

The nodular or spheroidal graphite 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.

II. BACKGROUND OF WORK

M.M. Haque [1] 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.

Mario Rosso et al [2] conclude that the effect of the Mg content and of the cooling rate on the microstructure of three different self-hardening aluminum alloys were investigated and evaluated. The aim was to define the optimal alloy composition for getting high mechanical properties. According to the obtained results, high cooling rate as well as high Mg content allow obtaining modified silicon particles with the lowest area. Silicon particles with a fibrous morphology and with roundness value as close as possible to one was obtained with high values of cooling rate and higher Mg content. With this system, the probability of the silicon particles to act as initiation site for cracks is reduced. Finally, also the equivalent diameter value is reduced when cooling rate and Mg content increases. Based on the results obtained up to now, 3% of Mg content seems to be the best self-hardening aluminum alloys composition with a fine modified silicon particles development. Moreover, a high value of cooling rate allows amplifying the modification effect achieved by the addition of Mg, and the obtained microstructure allows achieving high mechanical performances.

R. S. Rana et al [3] conclude that alloying elements are selected based on their effect and Suitability. Silicon lowers the melting point and increase the fluidity (improve casting characteristics) of Aluminum. A moderate increase in strength is also provided by Silicon addition. Magnesium provides substantial strengthening and improvement of work hardening characteristic of aluminium alloy. It can impart good corrosion resistance and weldability or extremely high strength. Copper has a greatest impact on the strength and hardness of aluminum casting alloys, both heat treated and not heat treated and at both ambient and elevated service temperature. Its improve the machinability of alloys by increasing matrix hardness. Nickel (Ni) enhances the elevated temperature strength and hardness. Tin(Sn) improves antifriction characteristic and fluidity of aluminum casting alloys. Its decrease electrolytic potential which is desirable in sacrificial anodes. It is concluded that selection of alloying element depends on use of materials requirement.

Oji J.O et al [4] gives that Statistically designed experiments based on Taguchi method was performed using L9 orthogonal array to analyze the ultimate tensile strength as response variable. From the results obtained, a Regression Model has been developed for ultimate tensile strength. From equations, they can predict the value of ultimate tensile strength if the values of mould temperature, pouring temperature and runner size are known. Within the experimental level ranges, the most significant influencing parameter is the pouring temperature, which accounts for 40.40% of the total effect, followed by the mould temperature (27%), and runner size (22.73%) respectively. The maximum ultimate tensile strength is calculated as 87.92N/mm2 by Taguchi's optimization method. The UTS decreases with increase in the mould temperature and pouring temperature. An increase in runner size however produced increased in UTS.

III. OBJECTIVES

The following objectives are formulated for this research work.

1. Performing casting experiments by varying composition of basic elements of SG alloy like carbon and silicon and keeping manganese, magnesium, sulphur and phosphorus constant for required mechanical properties like hardness and tensile strength.
2. Also, to study the effect of alloying elements on the resultant microstructure of the casting product.
3. To minimize the number of experiments for achieving required output.
4. To increase profit by minimizing rejection % of the products.
5. To provide required properties of the end-product to the customer.
6. To set the optimal composition for the standard grade SG 400/12 normally used in the medium scale foundry.

IV. EXPERIMENTAL WORK AND TESTING

4.1 Experiment Design

Table 4.1 Experiment Design

Factors:	2	Base Design:	2, 4
Runs:	20	Replicates:	5
Blocks:	1	Center pts (total):	0

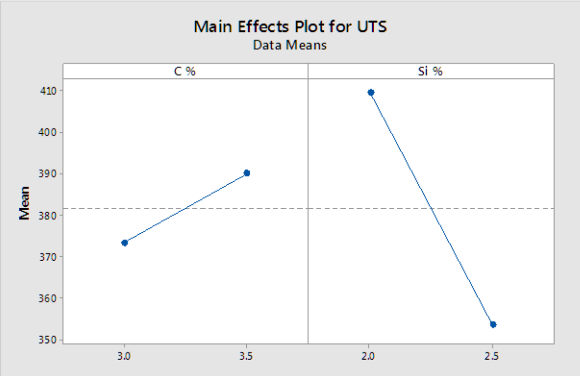
4.2 ANOVA Result

Table 4.2 ANOVA for Hardness

Source	DF	SS	MS	F-value	P-value
C %	1	273.80	273.80	1.90	0.187
Si %	1	57.80	57.80	0.40	0.535
C % * Si %	1	720.00	720.00	5.00	**0.040**
Error	16	2305.60	144.10	_	_
Total	19	3357.20	_	_	_

Table 4.3 ANOVA for Tensile Strength

Source	DF	SS	MS	F-value	P-value
C %	1	1399	1399	0.62	0.442
Si %	1	15642	15642	6.99	**0.018**
C % * Si %	1	9291	9291	4.12	0.059
Error	16	36084	2255	_	_
Total	19	62417	_	_	_



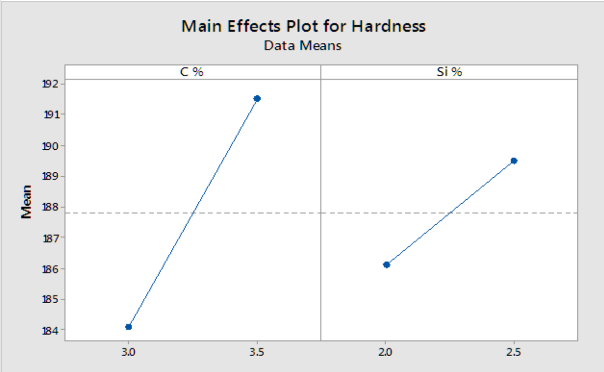
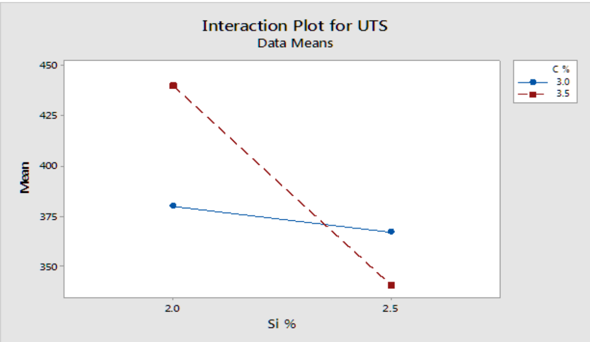


Figure 4.1 Main Effect of Ultimate Tensile Strength N/mm^{2}Figure 4.2 Main Effect of Hardness HBW



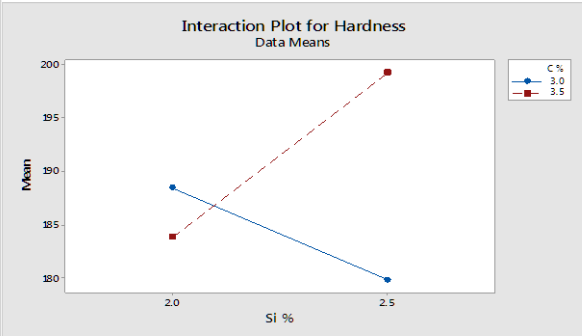


Figure 4.3 Interaction Plot of Ultimate Tensile Strength N/mm^{2}Figure 4.4 Interaction Plot of Hardness HBW

V. RESULTS AND DISCUSSION

After performing the experiment for all runs and from the testing data like hardness and tensile strength as well as microstructure, whatever results generated are discussed.

1. Fig 4.1 shows that C % seems affects the tensile strength because the line is not horizontal. tensile strength mean at carbon 3.5 % is higher than the carbon 3.0%. Si % also affects the tensile strength, Si 2.0% had higher tensile strength mean than 2.5% Silicon. The reference line represents the overall mean.
2. Fig 4.2 shows that main effects plot for hardness mean value. From the graph observed that hardness mean has higher at 3.5 % carbon as well as 2.5 % silicon, and also observed that lower Carbon 3.0% and Silicon 2.0% had a lower hardness mean.
3. Fig 4.3 shows that interaction between % C and % Si. It observed that higher tensile strength mean at carbon 3.0% and 3.5% with Si 2.0%. Also observed that lower mean value at Si 2.5% for both carbon percentages.
4. Fig 4.4 shows that interaction between C % and Si %. It observed that higher hardness mean at Carbon 3.5% with Silicon 2.5%, and 3.0% Carbon with 2.0% also observed that lower hardness mean at silicon 2.0 %, carbon 3.5% and Si 2.5%, C 3.0%.

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VI. CONCLUSION

In the present work experiment are carried out for mechanical test as hardness and tensile strength of SG alloy product with chemical composition varying in the range. There are 20 experimental reading taken for all variable to conduct the parametric study. The following conclusions are drawn:

1. Small variation in carbon percentage vary the mechanical properties like hardness and tensile strength. Increase in carbon percentage causes increase in hardness and tensile strength. Experimentally, it is found that for combination of carbon (3.5%) and silicon (2.0%) shows higher mean 439.59 MPa tensile strength and carbon (3.5%) and silicon (2.5%) shows higher mean 199.2 HBW hardness.
2. Silicon percentage affects the properties concerned for the experiment, but more amount of silicon reduces the tensile strength. Experimentally, it is found that with the carbon (3.5%) and silicon (2.0%) shows higher tensile strength.
3. From ANOVA, it is found that most significant factor for tensile strength is Si. It is also found that most significant factor for hardness is combination of carbon and silicon.
4. Carbon and silicon both affects the mechanical properties like hardness and tensile strength. Experimentally the optimal composition is found to be carbon with 3.5% and silicon with 2.0%.

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