Enhancing machinability of nodular Cast iron 600-3

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ABSTRACT

Nodular Cast iron is one of the most important material used in general engineering applications. One of the varieties of this material is SG 600-3 and popularly called as Spheroidised graphite iron. It is a special variety of cast iron having carbon content more than 3% and has graphite present in compact, spherical shapes. The Alloying element addition greatly affects the mechanical properties of SG iron with Si, Mn, and Cu. While copper supports increasing the tensile strength and hardness cause no embrittlement in the matrix, Ni helps enhancing the U.T.S without affecting the impact test values. The paper describes to fix the tensile strength constant but hardness has to minimize to obtain good machinability and increase the number of work piece machined per tool insert used by changing the chemical composition of the particular SG 600-3.

KEY WORDS: SG iron 600-3, Chemical composition, Machinability, Mechanical properties.

INTRODUCTION

The ductile iron had a phenomenal increase in use as engineering material and the rapid increase in commercial application continues today. The high carbon and silicon content of ductile iron provide the casting process a few advantages, but the graphite spheroids have only a nominal influence on the mechanical properties of the metal. The different grades are produced by controlling the matrix structure around the graphite either simply by casting or by subsequent heat treatment. Only slight compositional differences exist between the regular grades and these adjustments are made to promote the desired matrix microstructures. Additions of alloy may be prepared to ductile iron with a view to control the matrix structure (as-cast) in order to provide response to heat treatment. The fact that ductile iron castings are used for such critical automotive applications as crankshafts, front wheel spindle supports, and connecting rods is a further testimonial to the high reliability and process economics associated with ductile iron castings. The versatility of ductile iron is especially evident in the area of mechanical properties where ductile iron offers the designer the option of choosing high ductility, with grades guaranteeing more than 18% elongation, or

High strength with tensile strength exceeding 825Mpa.Spheroidal graphite irons were produced directly by the nodulising and desulphurization and also inoculation of the melt. Remelting causes reversion to flake graphite due to

the loss of magnesium. Thus the raw material for producing spheroidal graphite iron should have low sulphur or remove sulphur from iron in melting, or by mingling iron with a desulphurising agent such as calcium carbide. And also by the nodulising process, and in which the magnesium is added to remove sulphur and oxygen still present in the liquid alloy and provides a residual 0.04% magnesium, which causes development of graphite to be spheroidal. Mg treatment desulphurises the iron to below 0.02% sulphur, before alloying with it magnesium and such elements have strong attraction for sulphur, and hence scavenge sulphur from the molten alloy as an initial step for producing spheroidal graphite iron. Magnesium can be added when molten is neared to 1500°C, but it can vaporize at 1150° C. it floats on the top of the melt because of its lighter nature. In this case it is added as Ni-Mg and Mg-Si-Ni alloy or coke of magnesium to produce the violence of reaction and to have saved magnesium. Tempered ductile iron have desirable mechanical properties like hardness, tensile strength, elongation and impact energy and damping capacity, which are most used in different structural applications. The need of ductile iron in various such as agriculture, automotive parts, structural and many more applications is increasing continuously. Every application has specific mechanical property and morphology aspect, which can be achieved by opting different heat treatment processes, hence in order to meet the market demand more work to be carried out to improve the properties of ductile iron. It is commonly recommended that the machining operation is done on SG Iron products prior to hardness, on the base SG iron. However, one of the challenges in the application of SG iron is to maximize the machinability of the material after casting by choosing a suitable chemical composition. Present work aims to improves the machinability of SG Iron 600-3 developed from four commercially viable SG irons alloyed with different chemical compositions.
The influence of C, Mn, Cu, Mg content lead to made changes in pearlite and ferrite values of SG iron. The table shows that chemical composition of SG iron 600-3 below

TABLE 1

CHEMICAL COMPOSITION OF SG 600-3

Elements	C	Si	Mn	P	S	Cu	Mg	Mo	Fe
SG Iron 600-3(0)	3.66	2.468	0.362	0.020	0.012	0.41	0.043	0.009	Rest
SG Iron 600-3(1)	3.617	2.457	0.39	0.041	0.01	0.555	0.041	0.008	Rest
SG Iron 600-3(2)	3.704	2.583	0.392	0.030	0.012	0.33	0.041	0.006	Rest
SG Iron 600-3(3)	3.782	2.425	0.387	0.025	0.018	0.33	0.069	0.008	Rest

MATERIALS AND METHODS

Four ductile irons of compositions given in Table 1 was produced in a commercial foundry using an induction melting furnace of medium high frequency. In present work, commercially viable SG irons with minimum possible manganese content were produced. Copper was chosen to compensate for reduction in elongation due to lowering of molybdenum and manganese contents. The molten metal was poured from about 1420oC in a ladle preheated to 800oC for sandwich treatment by spheroidization technique using Fe-Si- Mg alloy (5 to 7% Mg) for nodulizing and FeSi (65% Si) for inoculation. Post inoculation was performed with FeSi (65% Si). The molten metal was cast immediately in the shape of rectangle blocks shown in Fig. 2. The qualitative and quantitative analysis of microstructure of the as-cast ductile iron (SG) was observed under optical microscope with spectra Image Analyzer attachment. The structural parameters of four SG irons are presented in Table II. The samples of 200 mm length with 14mm diameter rods were machined from the rectangle-block castings.

TABLE 2

STRUCTURAL AND MECHANICAL PROPERTIES OF SG IRON 600-3

Elements	Nodule count, mm-2	Nodule size, mm	Nodularity %	Amount of Ferrite, %	Amount of Pearlite, %	Hardness BHN
SG Iron 600-3(0)	220	0.04	95	20	80	240
SG Iron 600-3(1)	160	0.04	70	10	90	245
SG Iron 600-3(2)	230	0.04	98	25	75	187
SG Iron 600-3(3)	225	0.04	97	20	80	229

MECHANICAL PROPERTIES

a) Tensile Strength

Mechanical properties of the casting samples were determined using standard methods. For tensile properties, tensile specimens were loaded into a 400kN capacity TUE CN-400 UTM. After that, the stress-strain graphs were obtained from recorded load-elongation data. By the stress-strain graph, ultimate tensile strength, yield strength, young's modulus, percentage elongation were determined, in accordance with ASTM (Automated materials testing system) standard test procedures. The tensile test has been performed at given parameter: gross head speed=2mm/min. and max. Load=400kN, ASTM E8.The tensile test specimen was prepared from the rectangular casting block shown in fig.2 as per the ASTM E8 standard. The Grip section 45mm,Width of grip section 20mm,Gauge length 90mm,Width 14mm,Reduced section 70mm,Overall length 210mm. The Tensile The distance between the jaws was fixed according to the gauge length of the specimen. The specimen was inserted into the machine and gripped by the jaws. Maximum load was set to 400KN and loading was done till the specimen failed.

The corresponding readings generated for Yield Strength, %elongation & Ultimate Tensile Strength was noted.

Fig.1. Rectangular casting blocks

Fig.2. Tensile test specimen

Test Input Parameters are given in Table 3.The specimen's dimensions (thickness/gauge length/total length in mm etc.) were measured accurately with an electronic slide calipers. The details were fed into the testing machine.

TABLE 3

TENSILE TEST INPUT DATA

Specimen shape	Solid round
Specimen diameter	14 mm
Gauge length	50 mm
Pre load value	0 KN
Maximum load	400KN
Maximum elongation	200

b) Hardness test

For hardness testing, oxide layers of heat treated samples were removed by stage-grinding and Polished. By the micro hardness testing the average Brinell hardness numbers were determined from taking five hardness readings at different positions on the specimens. Micro-hardness test has been performed at given parameter: load=3000kgf and dwell time=105sec.

The method utilized for hardness testing was brinall Hardness Testing. In this process the specimen was put on the specimen holder the minor load of 10kg was applied by rotating the axle when the reading on the display became zero the rotating was stopped and final loading was applied by pressing the loading button. The scale used was A-scale. The hardness testing was done in the specimen displayed in Fig.3 given below.

Fig.3. Hardness and microstructure specimen

The tensile strength and hardness values measured by the experiment are given in the table.4 for the four different compositions.

TABLE.4

TENSILE STRENGTH & HARDNESS VALUES 4 FOR THE FOUR DIFFERENT COMPOSITIONS.

	Minimum	**SG Iron 600-3(0)**	**SG Iron 600-3(1)**	**SG Iron 600-3(2)**	**SG Iron 600-3(3)**
Hardness	190-260HRC	240	245	187	229
Tensile strength	600-620MPa	641	650	580	610

c) Micro structure evaluation

For Microstructure examinations, the treated samples were carried out. Each sample was carefully grounded progressively on emery paper in decreasing coarseness (1/0, 2/0, 3/0 and 4/0).The grinding surface of the specimens was polished on Al2O3 contained micro cloth. The above fig.4 shows the sample specimen for the microstructure analysis. The crystalline structure of the specimens were made visible by etching using solution containing 2% Nitric acids and 98% methylated spirit on the polished surfaces.

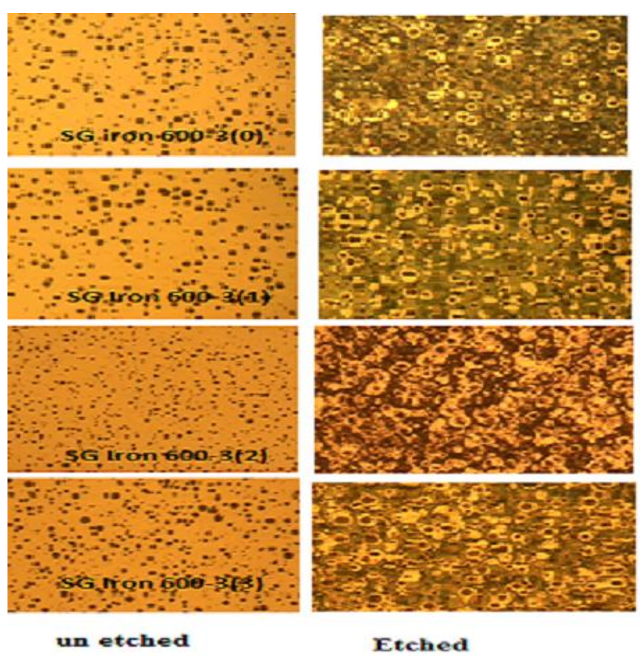

Fig.5. Microstructure of four different SG Iron compositions

Microscopic examination of the etched surface of specimens was successfully completed using a metallurgical digital microscope through which the resulting microstructure of the samples was all photographically recorded. The photographs are given below in fig.5.

1. RESULT AND DISCUSSION

After changing the chemical composition the casting made for the testing taken to the spectra analyzer for chemical composition verification. In SG Iron 600-3(1) the graphitizes (carbon, silicon) content is slightly reduced and manganese, copper is increased and Pearlite content also reduced to 10%.This trail also the hardness, tensile strength and elongation meets the specification. But machinability not achieved. In SG Iron 600-3(2) the graphitizers (carbon, silicon) content is increased some more to get good machinability by softening the material. The copper content still reduced with increased manganese. Pearlite is reduced by 5% from previous trail. The properties are gets closer to the required specifications. In SG Iron 600-3(3) the carbon content is increased some more to get good machinability by softening the material. Pearlite and ferrite content maintained in 80 and 20 % respectively. In the result the hardness value meets the requirements. And the tensile strength value also within the specification.

TABLE.5

RESULT MECHANICAL PROPERTIES

Elements	C	Si	Mn	P	S	Cu	Mg	Mo	Tensile strength Mpa (600)	Hardness BHN (190-260)	Work pieces/tool insert
SG Iron 600-3(0)	3.66	2.468	0.362	0.020	0.012	0.41	0.043	0.009	641	240	7
SG Iron 600-3(1)	3.617	2.457	0.39	0.041	0.01	0.555	0.041	0.008	650	245	7
SG Iron 600-3(2)	3.704	2.583	0.392	0.030	0.012	0.33	0.041	0.006	580	187	16
SG Iron 600-3(3)	3.782	2.425	0.387	0.025	0.018	0.33	0.069	0.008	610	229	15

2. CONCLUSION

As of the results attained it can be concluded that the properties of Spheroidal Graphite Cast Iron can be enhanced & altered according to service condition & application requirement. The consolidated result for the trails taken is given in Table. In this the chemical composition and the mechanical properties also the tool life is given in terms of number of work pieces. It states that,

1. While reducing the carbon, silicon content the mechanical properties tensile strength, hardness, and % of elongation are getting increased.
2. When the graphitizer's carbon and silicon kept minimum and the manganese value kept in high will lead to good mechanical properties. But the machinability was poor.
3. The nodule count will vary according to the pearlite and ferrite content. The mechanical properties of Ductile Iron can be influenced by the nodule count.
4. Good metallurgical quality can be indicated by high nodule count is present there. The microstructure is affected by the nodule count but it has not affected tensile properties.
5. By increasing the copper content the mechanical properties will get optimized and the % of elongation reducing, hence the machinability also will reduce.
6. Finally the chemical composition is optimized to mechanical properties and machinability and the number of work pieces per single tool insert is doubled.

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