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# Effect of Magnesium as Spherodizer on Graphite Morphology in Ductile Cast Iron

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***Abstract*** **-** Cast Iron is an alloy of Fe-C-Si with carbon content greater than 2.11% and is used in the as-cast state or after treatment. Magnesium was added in varying quantities to cast iron and by studying the graphite morphology, nodularity and mechanical properties it was found that addition of 0.035% Mg to cast iron makes the mechanical properties of this cast iron comparable to graded heat treated material 65-45-12. Moreover due to increased nodulairty there could also be increase in machinability which needs to be investigated further.

***Keywords***- : Cast Iron; Magnesium, Nodularity, Microstructure, Mechanical Properties

## I. INTRODUCTION

Cast Iron is an alloy of Fe-C-Si with carbon content greater than 2.11% and is used in the as-cast state or after treatment. Cast Iron offers the design engineer a family of casting alloys that gives a unique combination of low cost with the properties of castability, damping and availability. [1], [2]. Spheroidal iron is produced by adding small quantities of magnesium and cerium which produces graphite spheroids instead of flakes. [3] .The production of ductile iron is 30-35% cheaper than steel and 3-4% cheaper than non-ferrous alloys and only 20-30% more costly than normal grey iron. Ductile iron finds application as a substitute for steel, malleable iron and non-ferrous alloys because of excellent casting properties and machinability which improves production efficiency and reduces cost of production.[2] In this work, magnesium was added in the form of ferrosilicon magnesium in varying quantities and its effect on graphite morphology, nodularity and mechanical properties was studied.

## II. SAMPLE PREPARATION

Calculation for the amount of magnesium required has to be done. In practice it is normal to allow for minimum residual magnesium content of 0.035 to 0.04 weight percentage in addition to the amount of magnesium required to neutralise sulphur in iron. The amount of magnesium content in the alloy would depend on: (a) Temperature of metal, higher the temperature, lower the recovery of magnesium.(b).Sulphur content of the base iron to be treated, higher the sulphur content, greater is the amount of Mg to be added. The commonly used formula to calculate amount of magnesium required to be added is: Percentage Mg to be added= [(Mg-content required %) / (Mg recovery % x 0.01)] + %S base. The samples have been prepared at Himcast Pvt. Ltd. Vadodara. To produce the samples scrap S.G. iron had been taken and melted at 1540˚C in the induction furnace for 45 minutes. The furnace capacity is 750 kg. Magnesium addition takes place before pouring starts depending on the calculation as detailed below. Adequate precautions are necessary as magnesium tends to vaporize on pouring.

Sample-1 (with 0.025% Mg)

Calculation for % magnesium required in the sample = [(0.025)/ (40x0.01)] + 0.03= 0.0925%

Sample – 2 (with 0.030% Mg)

Calculation for % magnesium required in the sample = [(0.030)/ (40x0.01)] + 0.03= 0.0105%.

Sample – 3 (with 0.035% Mg)

Calculation for % magnesium required in the sample = [(0.035)/ (40x0.01)] + 0.03= 0.1175%.

Sample – 4 (with 0.040% Mg)

Calculation for % magnesium required in the sample = [(0.040)/ (40x0.01)] + 0.03= 0.1300%.

 

## III. TESTING SAMPLES

3.1 Chemical analysis

For studying samples prepared spectro chemical analysis was used. This test uses the measurement of wave length and intensity of electromagnetic radiation to determine the arrangement of atoms and electrons in molecules of chemical compounds on the basis of energy absorbed during changes in the structure. The results of this analysis are shown in Table-1.

Table 1 Chemical Composition Analysis

| Element % | Sample 1 | Sample 2 | Sample 3 | Sample 4 |
|---|---|---|---|---|
| C % | 3.3370 | 3.580 | 3.330 | 3.460 |
| Si % | 2.740 | 2.060 | 2.630 | 2.820 |
| Mn % | 0.430 | 0.393 | 0.440 | 0.421 |
| S % | 0.015 | 0.020 | 0.009 | 0.026 |
| Mg % | 0.026 | 0.031 | 0.035 | 0.029 |

3.2 Nodularity analysis

The nodularity is also studied by the images obtained using the optical microscope at 100 X. The samples were prepared with and without etchant (2% nital). Nodularity analysis of samples is shown in Table-2 and also indicated in the Figures. 1 to Figue.4.

Table 2 Nodularity Analysis

| Description | Sample 1 | Sample 2 | Sample 3 | Sample 4 |
|---|---|---|---|---|
| Nodule % | 95.58 | 94.27 | 92.60 | 94.99 |
| Nodule Count | 408 | 345 | 521 | 369 |
| Pearlite % | Balance | Balance | Balance | Balance |
| Ferrite % | 90 | 87 | 88 | 85 |

 

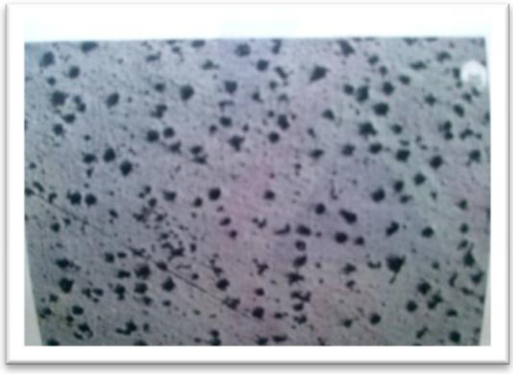

Figure-1 Sample 1 with 95.58% nodularity

Figure-2 Sample 2 with 94.47 % nodularity

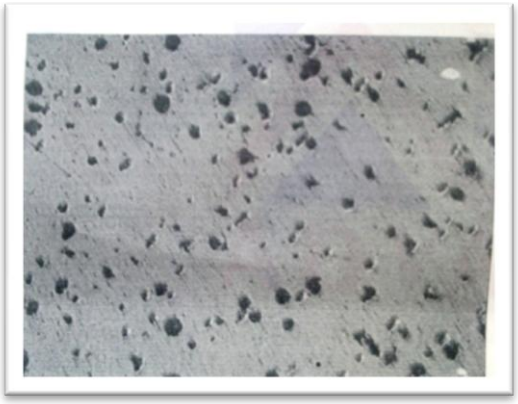

Figure -3 Sample 3 with 92.60% nodularity

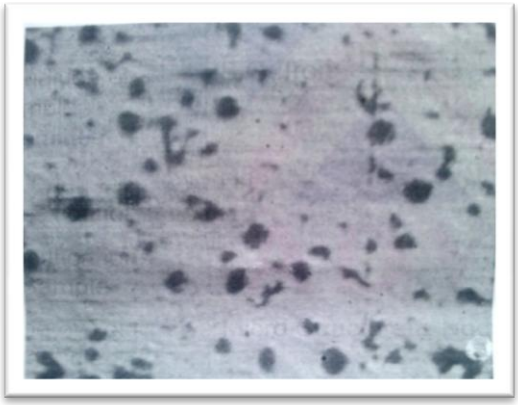

Figure-4 Sample 4 with 94.99% nodularity

3.3 Mechanical properties

For studying the mechanical properties the specimens were prepared according to ASTM E8 standard wherein the ratio of gauge diameter to gauge length was kept as 1:5. The samples were prepared by turning on lathe. The results of mechanical property analysis are shown in Table 3.

Table 3 Mechanical Property Analysis

| Mechanical Property | Sample 1 | Sample 2 | Sample 3 | Sample 4 |
|---|---|---|---|---|
| Tensile Strength $N/mm^2$ | 467 | 490 | 519 | 504 |
| Yield Strength $N/mm^2$ | 353 | 368 | 380 | 370 |
| Elongation % | 14.6 | 17.5 | 15.7 | 14.1 |
| Hardness (BHN) | 179 | 207 | 199 | 197 |

The mechanical properties of sample-3 with highest nodule count are compared with forged steel, Grade of heat treated (60-40-18) and Grade of heat treated (65-45-12) is shown **3.1** The Chemical Analysis of the samples is done using optical emission spectrometer and the results obtained are as given in Table- 1.

 

## VI. CONCLUSION

From the results obtained and comparisons the following conclusions can be made:

1. The use of magnesium as a spheroidizing agent produces spheriodal graphite cast iron having microscopic nodular graphite grains. On addition of 0.035%Mg in gray cast iron the properties of this new form of cast iron are very similar to graded heat treated material 65-45-12.
2. The small shape of the nodule produced on addition of magnesium increases the nodularity of the cast iron.
3. Further investigation could be done to study the effect of increase in nodularity on machinability
4. It could also be investigated if heat treatment processes enhances the properties of cast iron after increasing nodularity

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