Effect of Inoculants on Grey Cast Iron

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Abstract- *Attempts have been made to study the effect of inoculation on grey cast iron melted in induction furnace. The inoculants like calcium silicide, ferrosilicon, aluminum silicon and silicon carbide have been used in the present investigation. The effect of these inoculants on the micro and macro properties of grey cast iron have been investigated. The results reveal that the calcium - silicide is a better inoculating agent than others. It has been found that when calcium silicide is used as an inoculant the cell count of base metal is improved by about 8 to 10 times. It has also been found that calcium silicide increases the tensile strength of the base metal by an extent of 40%. There has been no appreciable increased in tensile strength and eutectic cell count when silicon carbide is used as an inoculant.*

Keywords— **Inoculant; Eutectic Cell Count; Wedge Value; Graphite Flake.**

INTRODUCTION

The process of inoculation involves the addition of small amounts of certain material known as inoculant to the molten metal either during tapping of the metal into the kiddie or during pouring it into the mould. Its main purpose is to prevent the formation of eutectic carbide, particularly in rapidly cooled thinner sections of the castings (1 -3). The inoculation changes the graphite structure of the iron resulting in an improvement of physical and mechanical properties of the product. The effectiveness of an inoculating agent can be assessed by measuring the number of eutectic cells present in grey iron, the count indicating the number of points at which the eutectic solidification took place (2). The inoculation procedures currently available can be divided into two main methods Ladle inoculation and Late inoculation. Ladle inoculation includes all procedures in which the inoculating material is added either as the metal is being poured into the mould or within the mould itself (2). In the present investigation the term inoculation, is restricted to Ladle Inoculation i.e., addition of inoculant to the stream of molten metal falling from the induction furnace into the ladle. In the present investigation an attempt has been made to optimize the use of inoculants like calcium silicide, Ferro silicon, aluminum-silicon and silicon carbide.

METHODOLOGY

The moulds for tensile test bar and wedge test bar were prepared by oil bonded sand. These moulds were heated for about 180 ° C for two hours in an oven before pouring liquid metal.

Three different charges were used to melt grey cast iron. The charge mixes used are as follows and arc designated as A, B and C.

Charge Mix	Heat A	Heat B	Heat C
Heel	20%	25%	30%
Steel scrap	15%	18%	20%
Pig iron	25%	20%	10%
Foundry	40%	37%	40%

For all the above heats the standard test bars and wedges were cast using different inoculants. In addition, constitutional wedges and uninoculated test bars were obtained for all the heats

The melting of grey cast iron has been carried out in mains frequency induction furnace after charging in pre-determined charge mix. The melt was analyzed for total carbon and addition of petroleum coke was made to arrive at aimed value of carbon. Addition of Ferro-Silicon was made to maintain the silicon content within the range of 1.6-1.8%. Melts were super-heated between 1470 °C to 1520 °C and were again analyzed for total carbon and silicon before pouring.

In the present work inoculants tried were calcium silicide, Ferro silicon, aluminum silicon, silicon carbide and mixtures of calcium silicide, Ferro silicon and silicon carbide. The inoculation was carried out during tapping with the help of pneumatic inoculator. The amount of inoculant added was kept constant at 0.35% of the molten metal tapped.

The tensile test bar casting was made in accordance with IS; 210-1962 and the tests were carried out in a 30T universal testing machine. 20 mm dill specimens were cut out from the tensile test bars for hardness, microstructure and eutectic cell count. The surface of each specimen was polished carefully and was made din free. After cleaning the specimen thoroughly it was etched in Stead's reagent. The specimen was quickly transferred to running water and was finally dipped in acetone and dried. The specimen was ready for microscopic observation. The constitutional and process wedges with different inoculants were obtained from each heat. After quenching to 600 °C, the wedges were hammered and broken centrally. The chill depth of wedges so obtained were measured by -using a guage having varying slot depths.

After thorough polishing of the surface of the specimen the unetched surface of each specimen was examined for graphite flake type, size and distribution. The same specimen was then etched in 2% nital for 30 seconds and was observed at higher magnification. Eutectic cell count was done in specimens eteched with Stead's reagent. The area counting method adopted by Dawson (4) was followed for this purpose. The number of cells per square cm was given by

$$\text{Number of cells/cm}^2 = \frac{\text{Number counted within 25 mm square on ground glass screen}}{\text{Actual area}}$$

Hardness values of all samples were obtained by Brinnel hardness testing.

RESULTS AND DISCUSSION

TYPE AND SIZE OF GRAPHITE

The typical micro structures of uninoculatcd and inoculated irons are shown in Figs. 1-6. It appears from the micrographs that

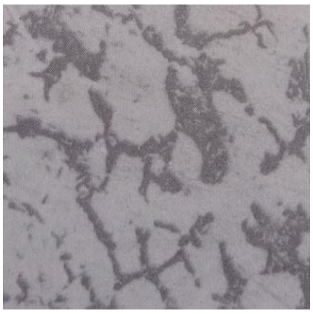

Figure 0.1 Uti-inoculated, unetched, heat A, 100X.

Figure 0.2 Inoculated with SiC, Unetched, heat A, 100X.

Figure 0.3 Inoculated with Fe Si, unetched, heat A, 100X

Figure 0.4 Inculated with Ca si, unetched, heat A, 100X

Figure 0.5 Inoculated with Fe Si-Ca Si(1:1), unetched, heat A, 100X

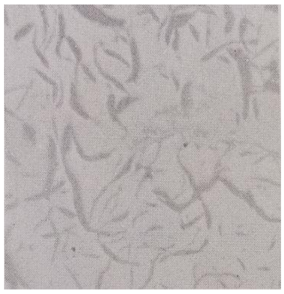

Figure 0.6 Inoculated with SiC - Fe Si (1:1), unetched, heat A, 100X

Calcium silicide has modified graphite to A-type with 4-6 flake size. It has been found that there is no existence of any other type of graphite than A-type. Ferro silicon as inoculant is also seen to produce A-type, 4-6 flake size graphite.

However aluminium -silicon when used as an inoculant does not have much influence in modifying the graphite in base metal structure. This is also true for silicon carbide.

Silicon carbide - calcium silicide mixed in the ratio of 1:1, 2:1, 3:1 and 4:1 have modified the graphite to A-type, 5-7 flake size. However such combinations of inoculants are unable to avoid the formation of B, D and E types of graphite.
Silicon carbide - ferrosilicon mixed in the ratio of 1:1, 1:3 and 2:1 have also produced A-type, 5-7 flake size graphite. Again these combinations have failed to avoid the formation of D and E types of graphite.

EUTECTIC CELL COUNT

Histogram shown in Fig. 3.7 reveals the following:

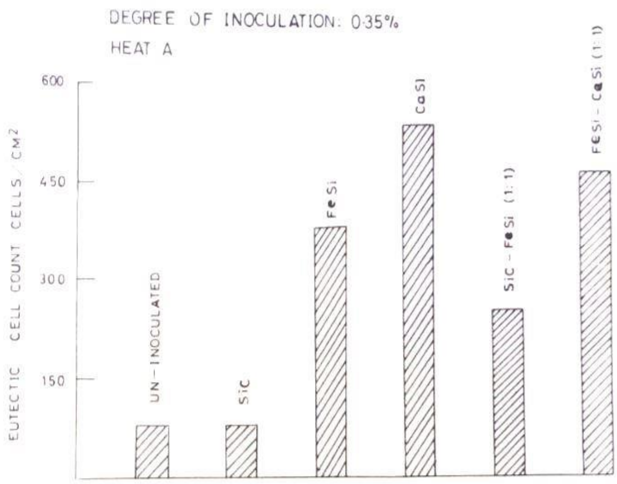

Figure 0.7 Variation in cell count with inoculant.

a) Calcium silicide has improved the cell count of the base metal by 8-10 times.
b) Ferro silicon also has improved the cell count of the base metal by 5-6 times.
c) Ferro silicon and calcium silicide in the ratio of 1:1 have improved the cell count of the base metal to the extent of 6-8 times.
d) Aluminum silicon has improved the cell count of base metal to an extent of 3-4 times.
e) The mixtures of silicon carbide and Ferro-silicon in various proportions are also found to improve the cell count of the base metal by 3-5 times.
f) The mixtures of silicon carbide and calcium silicide in various proportions are also FOUND TO IMPROVE the cell count of the base metal to an extent of 7-8 times
g) Silicon carbide has failed to increase the eutectic cell count of the base metal.

ULTIMATE TENSILE STRENGTH

It is observed from Fig. 3.8 that

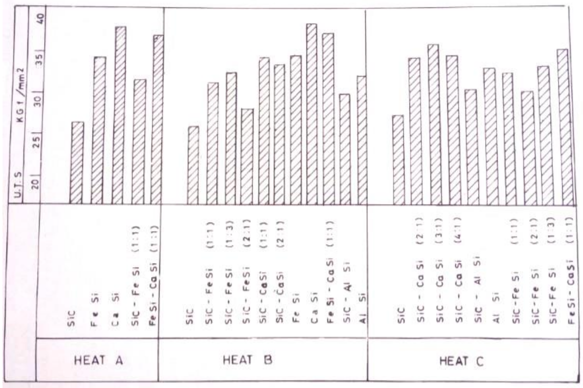

Figure 0.8 Variation in ultimate tensile strength with inoculant.

I. Grey cast iron inoculated with calcium silicide has got a tensile strength about 40% greater than that inoculated with silicon carbide and base metal.
II. Grey cast iron inoculated with Ferro-silicon has got a tensile strength about 25-30% greater than that inoculated with silicon carbide.
III. Grey cast iron inoculated with aluminum silicon has got a tensile strength about 15% greater than that inoculated with silicon carbide.
IV. grey cast iron inoculated with silicon carbide exhibits a very low ultimate tensile strength
V. Grey cast iron inoculated with mixture of ferrosilicon-calcium silicide in the ratio 1:1 has got a tensile strength about 35% greater than that inoculated with silicon carbide.
VI. grey cast iron inoculated with mixture of silicon carbide, calcium silicide, and silicon carbide-ferrosilicon in different ratios have got a tensile strength about 15 - 35% greater than that inoculated with silicon carbide.

WEDGE VALUE

Figure 3.9 indicates that

a) Calcium silicide and ferrosilicon have aided in bringing down the chill depth to almost nil
b) Addition of aluminum silicon, the mixture of silicon carbide-calcium silicide and the mixture of silicon carbide-ferrosilicon have aided in decreasing the chill depth
c) Silicon carbide has not appreciably changed the wedge depth of base metal.

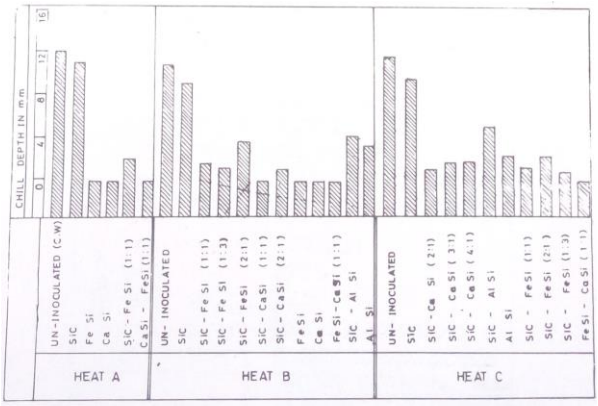

Figure 0.9 variation of chill depth with inoculant

HARDNESS

There has not been much variation in the hardness value of grey cast iron inoculated with calcium silicide, Ferro silicon, mixture of Ferro silicon-calcium silicide in the ratio 1:1 aluminum silicon and mixture of silicon carbide-Ferro silicon and of silicon carbide-calcium silicide (Fig 3.10).

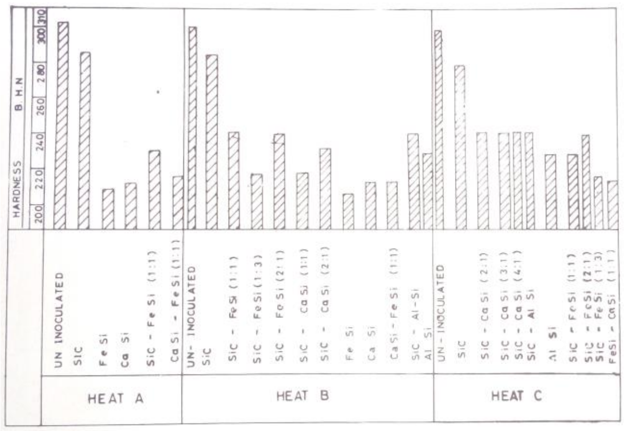

Figure 0.10 variation in Brinell hardness number with inoculant

CONCLUSIONS

1. The present investigation has revealed that calcium silicide is a better potential inoculant when compared to other inoculants tried.
2. Both ferrosilicon and mixture of CaSi & FeSi (1:1) act as good inoculants.
3. AISi also acts as an inoculant but does not modify the graphite structure.
4. Silicon carbide is not a potential inoculant of grey cast iron.

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