# INVESTIGATING THE EFFECT OF INOCULATION ON MECHANICAL PROPERTY OF IS: 210 IN CASTING OF BRACKET

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***Abstract***

*Present research is an attempt to investigate the possibility of improvement in the microstructure and mechanical properties through inoculant treatment and varying chemical composition like carbon percentage and the silicon percentage. Effect of the different weight percentage of the carbon, silicon, and inoculant is investigate through experiment and correlated with microstructure. Effects of the inoculant were investigated through metallurgical analysis of the matrix microstructure and the mechanical properties of the cast bracket. Inoculant resulted in improved properties of the molten iron over the original un-inoculated molten iron.in present research Sr based inoculant is used. Sr show better effects, in favour Of Sr inoculation at high cooling rate, in preventing the formation of undercooled graphite and Carbides. The inoculants produced smaller graphite particles, reduced tendency to form shrinkage cavities and porosities during the solidification of the molten iron, decreased super cooling degree, reduced formation of non-metal inclusions, and enhanced mechanical properties (of the cast irons).inoculant is added during the transfer of molten metal from furnace to ladle in iron stream. Result shown that with increase in percentage of carbon and inoculant hardness and tensile property of gray iron is decrease.*

*Key words: inoculant, gray iron, mechanical property, microstructure.*

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## 1. Introduction

Cast iron offer a tremendous range of the metallic properties of strength, hardness, machinability, wear resistance, abrasion resistance, and corrosion resistance and other properties. Furthermore, the foundry properties of cast irons in terms of yield, fluidity, shrinkage, casting soundness, ease of production, and others make the material highly desirable for casting purpose. Due to this property most of the automotive part is made from the gray cast iron. Inoculation is defined as the late addition of the certain alloy in molten iron. Three method is used for the inoculation 1) ladle inoculation 2) mold inoculation 3) in stream inoculation. With inoculation get significant effect at a low cost.

It was found that gray iron inoculation can improve the morphology and distribution of type a graphite in the matrix. Inoculation also can increase the pearlite content, decrease the interlamellar spacing of pearlite [1] Inoculation is a means of controlling the structure and properties of cast irons by increasing the number of nucleation sites available for the growth of graphite particles. This reduces undercooling during eutectic solidification, thereby minimizing the risk of forming hard iron carbides or 'chill' in the structure, particularly in thin sections. [4] Yan Li et al. studied effects of the inoculants and mechanical properties such as Tensile strength and hardness. They used different inoculant like FeSi and SiC of different rate. He concludes that after inoculation with FeSi tensile strength increase and its hardness decreased with the increasing amount of the inoculant. [1] S.O Seidu investigated effect of Ferro silicon inoculant on tensile, microstructure and hardness. Silicon contains increase with increase of inoculants. He is reported that with increase carbon equivalent mechanical property such as tensile and hardness is decrease. [2] Mihai Chisamera et al. Studied that by inoculating at the last possible instance control over Microstructure and hardness values are easily achieved and inoculant fade is eliminated. [3] M. Chisamera et al [4] is investigated the effect of different inoculating element, he conclude that barium is powerful nucleating element but at high cooling rate Ba is less effective. Sr-FeSi inoculation is beneficial for the thin wall casting. L. Elmquist et al [5] is found that hardness decreases as dendritic arm spacing, secondary dendritic arm spacing increase. Hardness decrease as the cooing rate decreases. M.M. Jabbari Behnama et al [6] carried out experiment on effect of cooling rate on the primary dendrite arm spacing, secondary arm spacing and thickness of ferrite cementite layer and the hardness. High cooling rate produce fine structure it is resulted in high strength cast alloys. Cooling rate is slow produce mottled zone (mixture of gray and white iron) white iron disappears, the microstructure becomes a mixture of ferrite and type D graphite, which is responsible for the low hardness Aravind Vadiraj et al [7] investigated Silicon enhances graphitizing potential in cast irons. Alloying elements such as Mo,Cu, Ti and rare earth elements can modify the graphite flake and matrix morphology.Mn,Ni and Cu and Mo are increase the hardenability of gray iron. M. Bazdar et al [8] studied that excessive phosphorus content raises the brittleness of gray iron because of the brittle and inter granular steadite and reduces tensile strength. K. Edalati et al [9] investigate that cast iron treat with ferrosilicon and silicon carbide ,as the temperature is increase the A-type graphite content as well as the eutectic cell count decrease. He also concludes that at higher temperature SiC is effective then the FeSi, and increase the hardness value compared the FeSi. A. Wazzan et al [10] studied that cooling rate was to dramatic effect on the size and distribution of the graphite crystals. M. Ferryb et al [11] investigates type E graphite forms in all alloys regardless of the amount and type of alloying addition. G.L. Rivera et al. [12] investigate macrostructure of sand cast hypo, hyper and eutectic gray cast iron show relatively large grains. Janina M. Radzikowaska [13] has studed about effect of specimen preparation on evalution of cast iron microstructure addition of elements such as silicon promotes graphite formation. Slow cooling rate also promote graphite formation. Ya Li Sun et al [14] investigate the effect of carbon content on the microstructure. He studied that carbon and silicon is main constituent of carbon equivalent. Carbon and silicon promote the precipitation of graphite. Author investigate influence of carbon content on the morphology of graphite cast iron. Nabil Fatahalla et al [15] vary C, SI, and NI percentage and vary the carbon equivalent of the austenitic ductile cast iron and investigate the effect on microstructure and mechanical properties. B. Senthilkumara et al [16] investigate defects in iron castings with the help of statically analysis software author prepared design of experiment through software, first step of doe is to identify process parameters through literature. M.I. Onsoien et al [17] investigate The effects of preconditioned choice on microstructure, mechanical properties and casting performance in larger gray cast iron. The experimental approach involves preconditioning of gray iron melts, with either high purity ferrosilicon (HP-FeSi), standard ferrosilicon (Std. FeSi), abrasive grade silicon carbide (Abr. SiC) or metallurgical grade silicon carbide (Met. SiC) as the preconditioning agent. sheng da et al [18] have investigated the effect of addition of REFeSi to grey cast iron. By experiment he conclude that addition of REFesi improve the properties of the higher and lower carbon equivalent (CE) gray cast iron.

## 2. Experiment

Experiment were carried out in medium frequency induction furnace of 170kg capacity. Metallic charges were composed of 100kg boring(high quality steel scrap) , 20kg mild steel, 40kg foundry return (runner and riser). Other alloying element like carbon, silicon, and manganese add during the melting as per the calculation and requirement. According to the requirements for casting production and the Indian standard the composition of the molten iron adjusted to meet the require specification. The furnace was turned on at low power level during the initial melting stage. Then gradually increase the power of the furnace. After 20mint later its power was increase to 90% of full power then material started quickly melting, when half of the material was melted, the carburizing agent and FeSi alloy were added in to molten iron to adjust the content of C and Si. For checking the %c and %si carbon equivalent meter is used. After melting of the material inoculation is performed during transfer of metal from furnace to ladle. Sr-Fesi is used as inoculant of size1-3mm added in flow of molten metal chemical composition of inoculant as in table1 during the experiments inoculant is added in the quantity equal to 0.100, 0.125, and 0.150% of weight in molten iron. Melting is occur at 1420-1450 ˙c charges of the melting is shown in table 2

Table 1: composition of inoculation

| **Element** | Si | Al | Ca | Sr |
|---|---|---|---|---|
| **Percentage** | 75-78% | 0.5%max | 0.1% max | 0.621% |

Table 2: Charge of Gray iron

| Charge | Weight (kg) |
|---|---|
| Boring(Turning scrape) | 100 |
| Mild steel | 20 |
| Foundry return | 40 |
| Inoculant | As par calculation |

Then this metal is poured into mould and allow to solidify the metal. Specimen for the tensile test is prepared

According to Indian standard 1608. And then after microstructure test is carried out as per IS: 7757.

### 2.1 Design of experiment

In this study three variable name percentage of carbon, percentage of silicon and the inoculant is select as input variable. And tensile strength is as response. Design of experiment is carried out using each machining parameter at three levels as shown in table 2.1.1

Table 2.1.1 Parameters and their levels

| Parameter | Levels | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Carbon | 3.2 | 3.3 | 3.4 |
| Silicon | 1.9 | 2.0 | 2.1 |
| inoculant | 0.100 | 0.125 | 0.150 |

The experimental design of full factorial design of experiments is carried out using MINITAB (Version 17). Based on general full factorial design 27 experimental runs are required. General full factorial design for 27 experiments & Responses is given in Figure 2.1.1

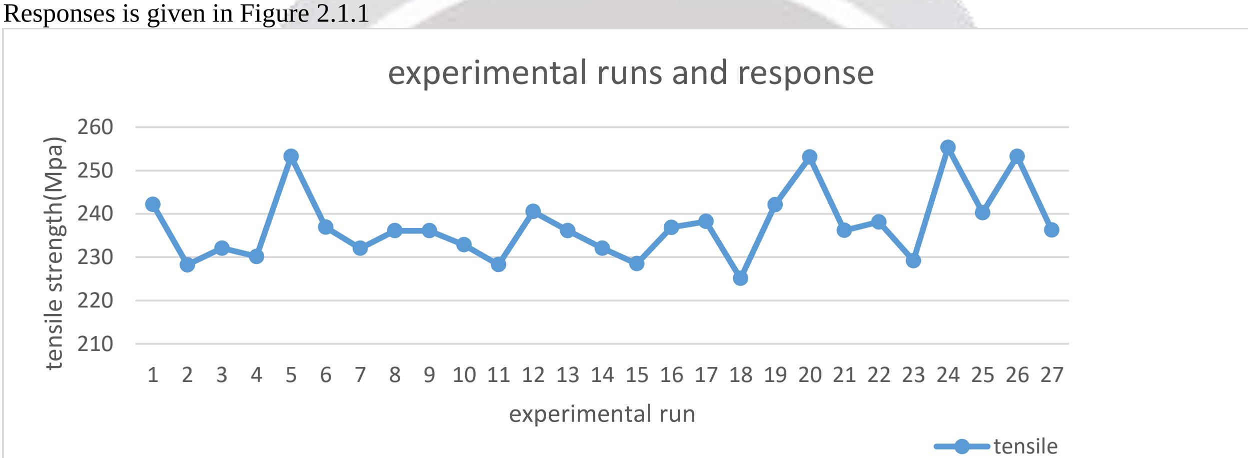


Figure 2.1.1: Experimental runs and Response

**RESULTS & DISCUSSIONS:**

**3.1 ANALYSIS OF VARIANCE (ANOVA)**

Analysis of variance (ANOVA) is a collection of statistical models used to analyze the differences among group means and their associated procedures (such as "variation" among and between groups).Anova gives significant input variable for selected experiment results. Also examine interactions between independent variables. In present work, Anova is performed at 95% confidence level. Anova for response variable are shown in table 3.1.1 from the results of anova it is clear that carbon and inoculant is most significant variable.

Table 3.1.1 : Anova result for tensile strength

| Source | DF | Seq SS | Seq MS | F- value | P - Value | Contribution (%) |
|---|---|---|---|---|---|---|
| % c | 2 | 854.12 | 427.06 | 29.05 | 0.000 | |
| % si | 2 | 222.09 | 111.05 | 7.55 | 0.014 | |
| % inoculant | 2 | 345.85 | 172.92 | 11.76 | 0.004 | |
| %c*%si | 4 | 64.28 | 16.07 | 1.09 | 0.422 | |
| %c*%inoculant | 4 | 79.26 | 19.81 | 1.35 | 0.333 | |
| %si*%inoculant | 4 | 81.93 | 20.48 | 1.39 | 0.319 | |
| Error | 8 | 117.62 | 14.70 | | | |
| Total | 26 | 1765.14 | | | | |
| Model summary | | | | | | |
| s | R-sq | R-sq(adj) | R-sq(pred) | | | |
| 3.83435 | 93.34% | 78.34% | 24.10% | | | |

**3.2 Graph plot**

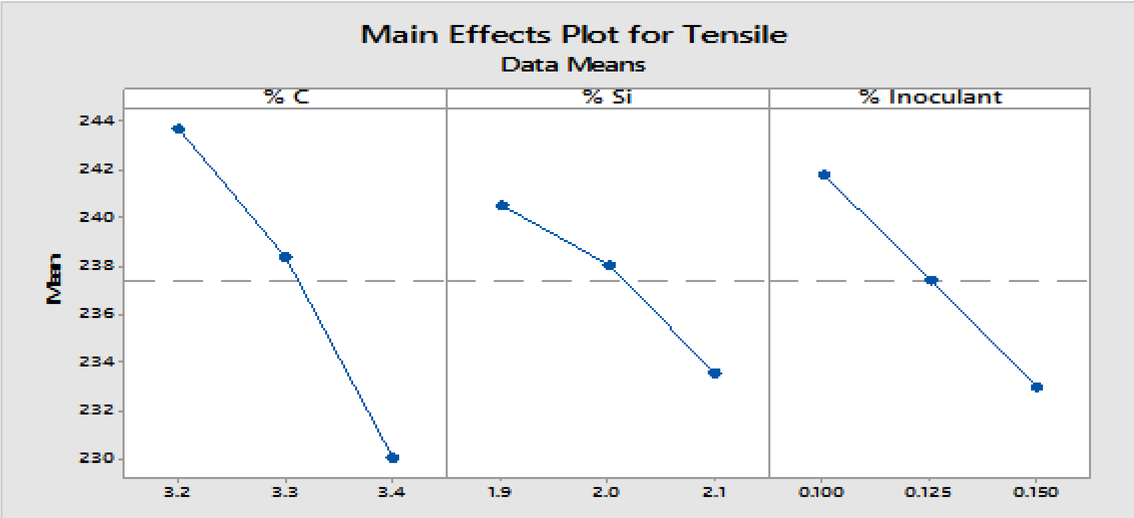


Fig: 3.2.1 Main effect plot for tensile strength

Main effect plot for tensile strength is shown in fig 3.2.1. It represent an effect of carbon, silicon and inoculant on tensile strength. Tensile strength is increase as the carbon percentage is decrease it is increase from 3.4% of carbon to 3.2% of carbon. As silicon percentage is decrease from 2.1% to 1.9% tensile strength is increase. As percentage of inoculant is increase tensile strength is linearly decreasing.

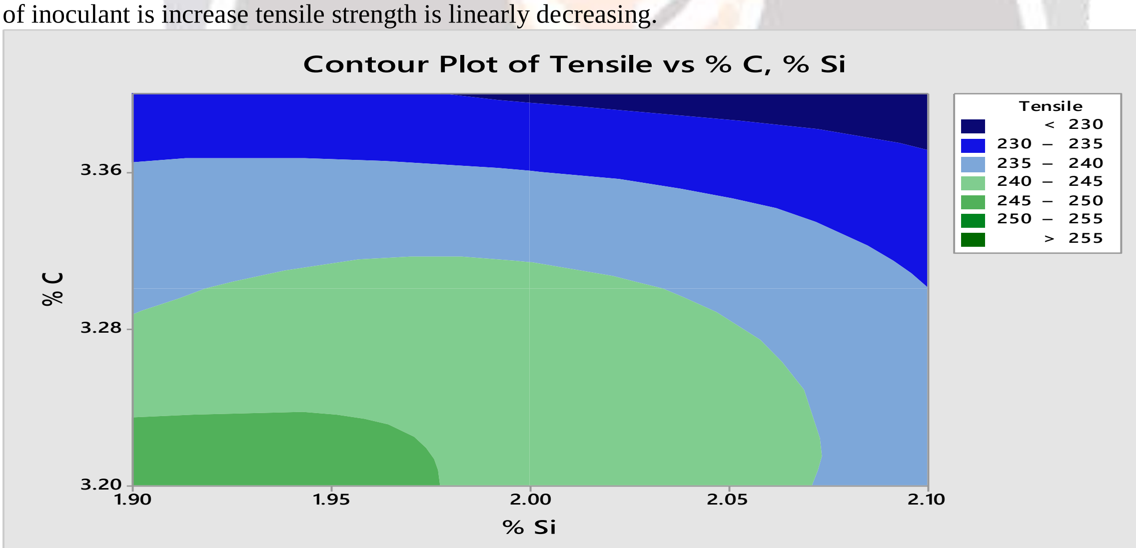


Fig: 3.2.2 Contour Plot for tensile

Contour plots show how the fitted response relates to two continuous variables. A counter plots provide a two dimensional view where all points that have the same response are connected to produce contour lines of constant responses. Fig 3.2.2 shown contour plot for tensile strength. Highest tensile strength found where value of carbon and silicon is low.

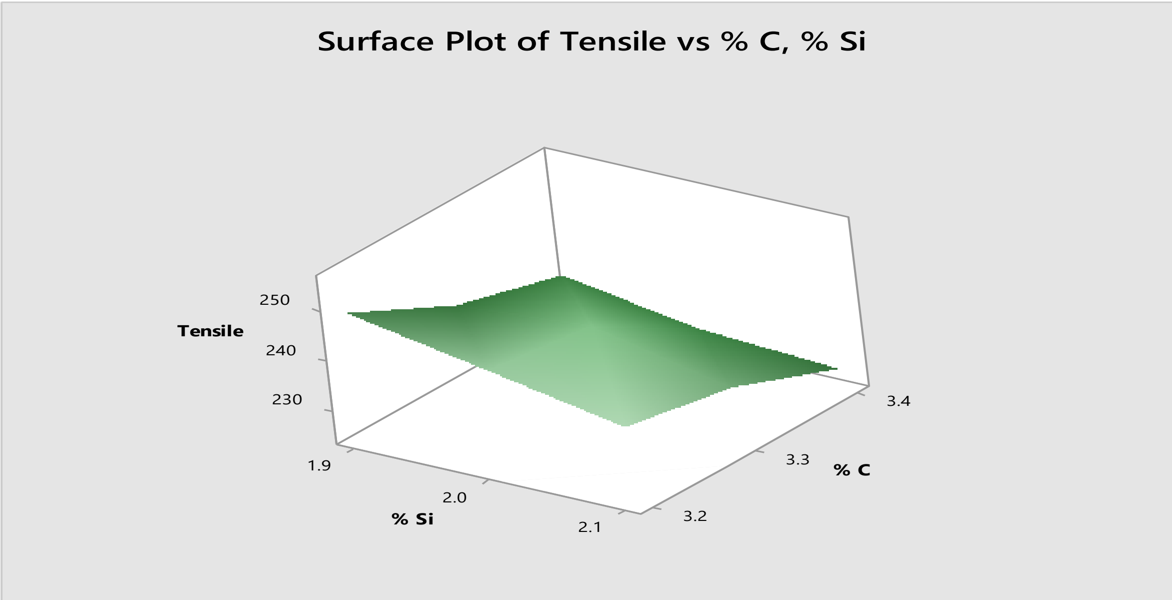


Fig: 3.2.3 Surface Plot for tensile

Surface plot is used to evaluate relation between three variable. In fig 3.2.3 surface plot for carbon, silicon, and tensile strength is shown. From the graph as the percentage of silicon and percentage of carbon is higher the value of the tensile strength is getting lower.

**CONCLUSIONS:**

In this paper the effect of inoculant on the mechanical property of the gray iron bracket is investigated through experiment.

After performing experiment with general full factorial method. Analysis of variance is carried out for finding significant parameter.

Anova result is shown that carbon and inoculant is most significant parameter and affect the tensile strength,

From graph plot it is conclude that as carbon percent, silicon percent and inoculant percent is increase value of the tensile strength is decrease and increase with decrease value of carbon, silicon, and inoculant.

From the literature survey it is conclude that Inoculant also promote type “A” flack graphite.

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