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Experimental Analysis and Investigation of Groove Porosity in Rear Cross Over Brake Disc of FG260 Material

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ABSTRACT: Most severe problem that foundry industries always face named casting defects especially 'porosity', since it's occurrence is 82% among all in case of our research. This paper presents the experimental analysis and investigation of groove porosity occurred near the groove on brake disc. This paper reflects the research done in Ashta Liners Pvt. Ltd. Ashta for reduction in rejection of casting due to groove porosity defect. This is achieved by altering the casting parameters like binder ratio, casting temperature, addition of Titanium, Zirconium as inoculant and Iron oxide. Result obtained shows that the additions of 0.25% red iron oxide, 0.3 to 2.5% Titanium and 0.5 to 2.5% Zirconium are surprisingly more effective as compared to others in eliminating porosity. Use of core coating by Iron oxide results in reduction of porosity occurrence. The results obtained in this research will help metal casters to reduce porosity defects in grey iron castings.

KEYWORDS: Casting defects, Groove porosity, Inoculants, Binder ratio, casting temperature, Grey iron

I. INTRODUCTION

The foundry industries are mostly suffered from the problem of casting defects. Our research is based upon the experimental analysis of groove porosity occurred at rear cross over brake disc of school bus made from FG 260 material. Our aim was to reduce the percentage of rejection of casting due to groove porosity. The total contribution of porosity defect we found almost 82% among all the defects for the same product. Hence we focused on metallurgical as well as other parameters, by altering experimentally which we were going to reduce rate of rejection considerably. The casting made from material FG260 which has great toughness.FG260 material has tensile strength of 260 N/mm and its hardness range is in between 180 to 230 BHN. It was challenging work to alter existing material composition as well as binder parameters without affecting the properties of base material so that expectations from final product i.e. brake disc as far as performance as concern should not be deviated.

II. BACKGROUND AND RELATED WORK

At initial stage during understanding of the problem from industry, we analysed the each and every parameter regarding its effect on properties, effect on occurrence of different types of defects. After studying this problem thoroughly we decided the methodology, after implementation of which we have reached to the expected results. Hence our research will be guide for all foundries and metal casters to reduce the porosity defect especially in grey iron castings. For this we focused on the metallurgical parameters because it will not affect to the existing foundry set up as well as not bring drastic change in the management levels. Hence at the initial stage the important task we performed i.e. of "Literature Review". We came across different researches and related workings regarding casting reduction. As mentioned earlier, we have to alter the materials as well as suggest new methodologies to reduce the porosity by considerable amount without affecting the final properties to be required for the casting of brake disc. Hence first of all we studied all material properties of FG260 and its microstructure so that we can find the scope for improvement as well as research.

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Then we came across detailed study of inoculant methods, materials used in it, different binders used in sand along with its ratios, effect of various temperatures on porosity existence etc. and prepared the research methodology as under. Along with this we learned basic things about tools and techniques used in the foundry to check material composition (i.e. Spectrometer), to check microstructure (i.e. Electronic Microscope), different methods to detect the occurrence of porosity (i.e. Ultrasonic test method, dye penetrant test method etc.) which were really helpful in our research.

III. RESEARCH METHODOLOGY

Our experimental analysis based on methodology followed as under-

A. Varying the Metallurgical Parameters-
- Change in existing inoculant material composition
- Addition of Titanium
- Addition of combination of Titanium and Zirconium
- Addition of Aluminium and Calcium

B. Varying the Sand and Mould parameters-
- Varying the binder ratio
- Addition of Iron oxide as a coating for core

C. Analysing the Physical parameters-
- Analysis of holding time
- Analysis of melting temperature
- Analysis of pouring temperature

All these steps in the methodology mentioned as above analysed experimentally and optimum result is investigated.

IV. EXPERIMENTAL ANALYSIS

A. METALLURGICAL PARAMETERS-

Addition of materials into base material to achieve uniform grain refinement and excess carbide formation, method is called as inoculation method and material is called as **Inoculants.** The formation of iron carbide is referred to in the trade as "chill". The formation of chill is quantified by measuring 'chill depth' and the power of an inoculant to prevent chill and reduce chill depth is a convenient way in which to measure and compare the power of inoculants. There is constant need to find inoculants which reduce chill depth and improve the machinability of grey cast iron. Hence as grain refinement increases porosity can reduced by considerable level. So following experiments were taken in foundry named Ashta Liners Pvt. Ltd. Ashta,regarding varying the inoculants.

Fig-1 Brake disc casting free from Porosity defect

Fig-2 Microstructure for defect free casting

Fig-3 Brake disc casting with groove Porosity defect

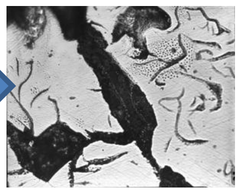

Fig-4 Microstructure for defected casting

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The figure-1 shows the casting of brake disc which we have considered for our research along with its defect free microstructure followed by fig.-2.In fig.-3, the defected casting view is shown which is along with porosity defect near to the groove of the brake disc and corresponding defected microstructure is as per fig.-4. All the above microstructures are as per the images obtained during research with the help of electronic microscope up to 100 to 500 X resolution.

Experiment 1-Addition of Titanium in strontium based inoculant

It has been found that addition of Titanium in silicon-bearing inoculant, containing strontium become highly efficient inoculant. This is surprising because a silicon-bearing inoculant containing titanium is less efficient than a silicon-bearing inoculant containing strontium. Thus, the addition of titanium to a silicon- bearing inoculant containing strontium would be expected to decrease the porosity percentage. It has been discovered that in accordance with the present invention the amount of titanium should be about 0.1 to 20% and preferably about 0.3 to 10%. Best results are obtained when the titanium is about 0.3 to 2.5%. Titanium can be obtained from any titanium-rich material.

Experiment 2-Addition of Titanium and Zirconium in strontium based inoculant

It is within the scope of the present invention that when both zirconium and titanium are present in a silicon-bearing inoculant containing strontium the amount of zirconium is between about 0.1 to 15% and the titanium is between about 0.1 to 20.0%. Preferably the inoculant of the present invention containing both zirconium and titanium has about 0.1 to 10.0%zirconium and about 0.3 to 10% titanium. Best mode of the present invention is with an inoculant containing about 0.5 to 2.5% zirconium and about 0.3 to 2.5%titanium.

Experiment 3-Addition of Aluminium and Calcium in any material based inoculant

In any inoculant, addition of Aluminium and Calcium gives good results. The general amount by which calcium can be added is 0.1 to 0.35%. Also Aluminium can have general composition is about 4.5 to 5% or below. The percentage of aluminium never exceeds the amount of 5.00%. The best results are obtained with calcium below about 0.1%.

RESULT ANALYSIS:

The experiments were conducted at foundry and with reference to the above experiments; the results were obtained as follows-

Table-1:

Experiment No.	Inoculant Used	Average % of Main Constituents	% reduction in casting over existing % of rejection
01	Titanium in strontium based inoculant	0.3 to 2.5 % Ti	59.4 %
02	Combination of Titanium and Zirconium in strontium based inoculants	0.5 to2.5 % Zr , 0.3 to 2.5 % Ti.	94.3 %
03	Aluminium and Calcium addition	Upto 5.00% Al, <0.1% Ca	39.8 %

The results discussed in the above table indicate that % reduction in the foundry's current % of rejection of casting of brake disc. The various experimental values which we have implemented during the pouring of test castings regarding alteration of different materials as far as inoculants as concern along with their % of addition are shown in the above table.

B. SAND, MOULD AND CORE PARAMETERS-

This section includes experimental verified results related to the parameters named binder and its ratio, binder level, core coatings and core treatments done at foundry.

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Experiment 1- Effect of variation of Binder Level on porosity formation

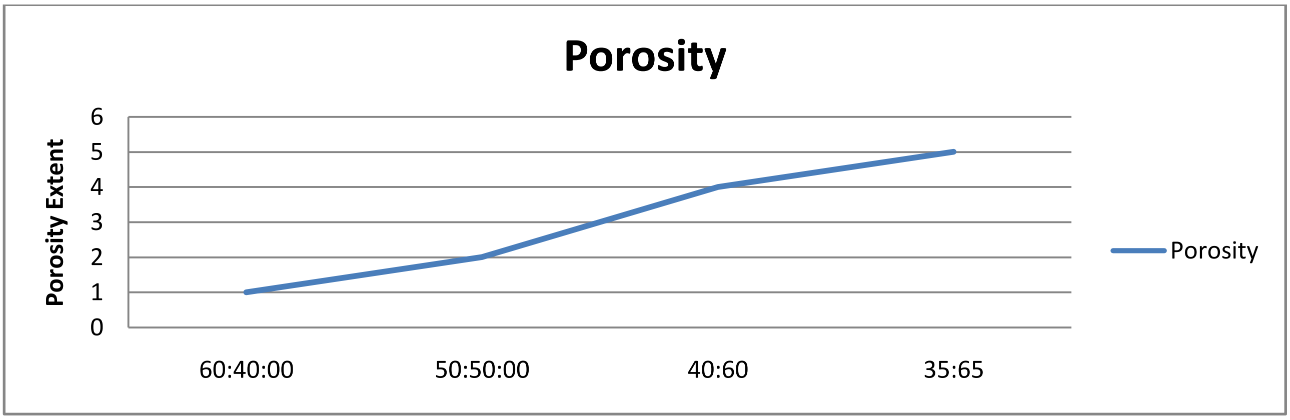
This experiment includes the various parameters that altered during analysis. It consist of % binder level, Binder ratio etc. and result was compared with the behaviour of porosity occurrence. Observations are tabulated as follows-

Table 2--Effect of Binder Level on Porosity Formation

Binder Level(%)	Binder Ratio (PT1:PT2)	Porosity Behaviour
3.0	60:40	Least Occurrence
3.0	50:50	Medium Occurrence
3.0	40:60	High Occurrence
3.0	35:65	Highest Occurrence
1.8	60:40	Negligible Occurrence
1.8	50:50	Less Occurrence
1.8	35:65	High Occurrence
1.5	60:40	Negligible Occurrence
1.5	50:50	Least Occurrence
1.5	35:65	High Occurrence
1.25	50:50	Least Occurrence
1.25	35:65	Medium Occurrence
TEST CONDITIONS- PUN on W/D silica sand Iron Chemistry: 4.3 C.E. Grey Iron Binder Ratio: Part1:Part2 ratio varied Pouring Temperature-1482°C		

The above table shows experimental values of different binder levels and its effect on behaviour of porosity occurrence during the pouring of test castings.

Graph 1-Effect of Binder Ratio on Porosity Formation in test castings poured at four different Binder Ratios.



Binder Ratio

Above graph clears the results occurred by varying the binder ratios during our experiments. This variation gives different optimum values of porosity extent as shown in the above graph.

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Experiment 2- Addition of new material as coating for cores

Poor binder dispersion from sand mixing was also responsible for increasing the overall susceptibility to porosity defects. Porosity defects resulting from use of unfavourable binder and casting practices could be eliminated by adding relatively small additions of **red iron oxide (hematiteor Fe_2O_3)** to the sand mix. The use of magnetite or black (Fe_3O_4) grades of iron oxide were not nearly as effective in preventing porosity. The purity of red iron oxide must be minimum 82% during mixing with sand silica for porosity reduction.

Experiment 3- Core treatment

The core treatment and its analysis include the following sub-categories to be analysing during experimentation;

- Post baking of Cores
- Varying temperature during post baking of the core

To determine the effect of core baking on porosity reduction, various experimental test cores were subjected to post-baking for three different times (i.e. for 1, 2 and 4 hours). The results of these tests are summarised in following

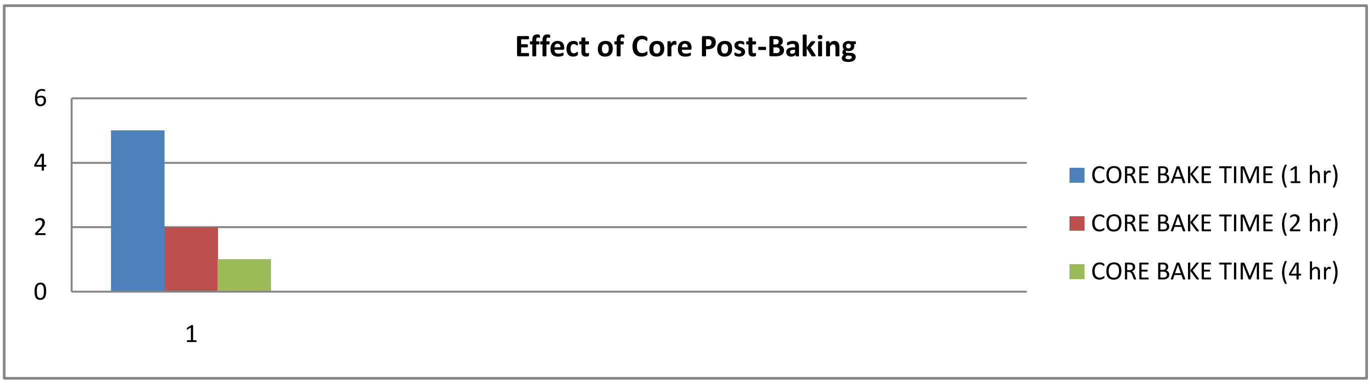
Table 3-

Binder Level	Binder Ratio	Temperature	Time	Porosity Extent
1.50%	35:65	232^0 C	1 hr.	Severe
1.50%	35:65	232^0 C	2 hr.	Nil to trace
1.50%	35:65	232^0 C	4 hr.	none

Test Conditions- PUNB binders on W/D silica sands;
4.3 CE iron; Pouring Temperature- 1482^0 C for all tests.

Table shown above gives on porosity extent as a result of core post baking time and temperature along with its binder ratio.

Graph-2- (On Y-Axis- Porosity Extent and on X-Axis- Baking Time)



The above experimentally obtained graph gives effect of core post baking time on the porosity extent. Hence castings made with test cores baked at 232^0C, but for only one hour, contained severe porosity defects. Intermediate times of two hours significantly reduced the extent of porosity. Baking for four hours at 232^0C produced distinctive core colour change to chocolate brown, and had a significant effect on porosity elimination.

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RESULT ANALYSIS:

The experiments were conducted with reference to the sand, core and mould parameters and optimum results are tabulated as follows. Hence the results were obtained regarding porosity occurrence are shown in the following table-

Table 4-

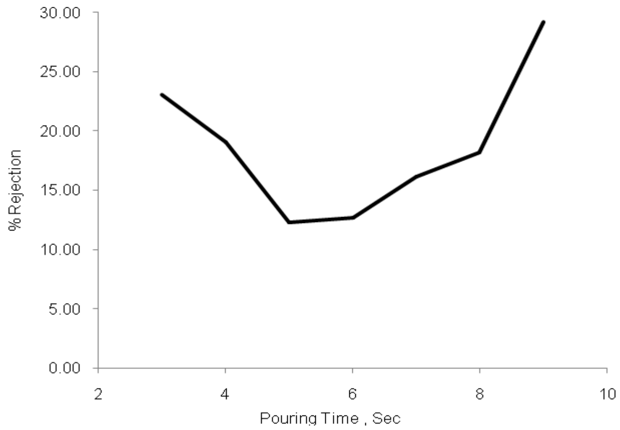
Experiment No.	Binder Ratio	Addition of Hematite	Binder Level	Post Baking Time	Post Baking Temperature	% reduction in casting over existing % of rejection
1	35:65	0.25%	1.2	1	232^0C	1%
2	40:60	0.50%	1.5	2	232^0C	13.4%
3	50:50	2.00%	1.25	4	232^0C	68.23%
4	65:35	3.00%	1.25 – 1.8	2	232^0C	23.56%

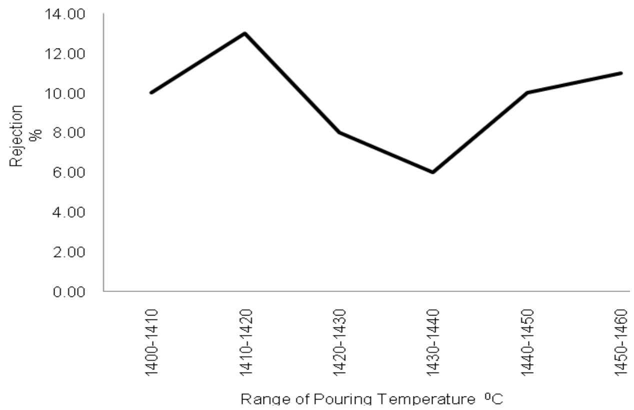
C. PHYSICAL PARAMETERS–

The physical parameters we considered for the experimental analysis are as under-

- Holding Temperature
- Pouring Temperature and Time
- Melting Temperature

All the temperature ranges considered are specially FG 260 Material which is used for casting of Brake Disc.





Graph 3- Pouring time v/s % Rejection for Brake Disc

Graph 4-Pouring temperature v/s % Rejection for BrakeDisc

The graph-3 obtained during experiment showing the effect of pouring time on % rejection of castings whereas graph-4 shows range of pouring temperature in ^{0}C during test cast pouring and corresponding % of rejection of brake disc castings.

V. RESULT DISCUSSION

All the above discussed experiments and results are achieved at foundry by pouring the test castings. Results of previous castings were path director for the next experiment. Each and every experiment is based upon previous result of experiments; hence there were no chance for deviation of research and final agenda of porosity reduction.

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Another important aspect of our research is inspection of microstructure at each stage of experiments. That was really helpful to decide the material behaviour and its composition. The powerful tool we used for our research is "Spectrometer" which we utilised for checking the correct composition of material. Hence by summarising the entire results conclusion can be made as mentioned below.

VI. CONCLUSION

I. Addition of Titanium and Zirconium are effective in eliminating the porosity defects up to the great extent.

II. The standard composition is; 0.3 to 2.5% Ti, 0.5 to 2.5% Zr in strontium based inoculant.

III. The addition of small amounts of red iron (Fe_2O_3) oxide (82% minimum purity) to silica sand mixes was extremely effective in eliminating the porosity defect.

IV. The temperature of the molten iron, as it contacted the core surface, was found to have a significant effect on porosity formation when castings were poured under conditions favouring their formation. Severe porosity defects were formed at 1482^0 C and higher. As the temperature was reduced, these defects became fewer in number and intensity until none formed at 1371^0 C.

VII. ACKNOWLEDGMENTS

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VIII. REFERENCES

[1] Rajesh Rajkolhe, J.G.Khan, "Defects, causes and their remedies in casting process: a review", IJRAT, Vol-2, No- 3. March2014
[2] Malcolm Blair, Raymond Monroe, Christoph Beckermann, Richard Hardin, Kent Carlson, and Charles Monroe "Predicting the Occurrence and Effects of Defects in Castings" Journal of materials, Vol. 2 29-34, May-2014.
[3] C.Umezurike, W.O.Onche, "Experimental Analysis of porosity in grey iron castings" GJRE, vol-10, issue-7, Pg-65-70, December-2010.
[4] A.P. More, Dr. R. N. Baxi, Dr.S.B.Jaju, "Review of Casting Defect Analysis to initiate theImprovement Process" Mechanical Engineering Department, G.H.Raisoni College of Engineering, Nagpur.440016 (India), International Conference, Dec.-2009
[5] Mills, K., 1985. Metals Handbook, vol. 9, ASM International, pp.320-325.
[6] PSG Design Data Book, PSG Engg. College, Coimbatore.
[7] Rukadikar M C, Reddy G P. "Influence of chemical composition and microstructure on thermal conductivity ofalloyed pearlite flake graphite Cast irons". *J. Mater. Sci*., Vol-3 Issue- 21(12): Pg.-4403-4410.May-1986
[8] R.L.Naro, "Porosity defects in iron castings from mould metal interface reactions" silver anniversary paper, Div-5
[9] R.L.Naro, "Formation and control of lustrous carbon surface defects" AFS transactions, vol-81, pg. 280, Sep 1961
[10]Monroe. R." Porosity in casting", steel founder's research journal, Vol-3, Pg. - 1-2 Apr-2005.
[11]Bates, C.E., "Binder decomposition and its relation to gas defects in castings", AFS Casting congress, 1980.
[12] Test Results provided by foundry" Zanvar Group of Industry's Ashta Liners Pvt.Ltd.Ashta"
[13] Image courtesy – "Zanvar Group of Industry's Ashta Liners Pvt.Ltd.Ashta".

BIOGRAPHY

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