Analysis of Reduction in Shrinkage Defect in Reciprocating Piston

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Abstract— In this paper, we deal with the reduction and eliminating the occurrence of shrinkage in the component by a standard approach in design, experimentation and implementation phases systematically. Here, we are working to find the properties which will prevent shrinkage in the reciprocating piston. Thus by this analysis it would help the company to improve the quality of the product and thereby decreases the rejection level of the product.

Key words: Experimentation, Reciprocating Piston

I. INTRODUCTION

Manufacturing Ductile Iron, Grey Iron, SG Iron (Vermicular graphite Iron), ADI, Ni Resist & Steel Castings using shell moulding, has a history of continuous improvement.

A concept that has given it a past that it can be proud of and a future it can look forward to with confidence. The Surface finish and dimensional accuracy of the shell-moulded casting is superior to the conventional green sand mould castings [1].

Semi-Automatic 4 station shell moulding (PLC controlled) machines are capable of producing 15000 moulds everyday which finds its application in casting intricate shaped hydraulic and automobile components ranging from 0.05 Kg's to 15.0 Kg's [2].

It has a strong metallurgical base and experience. Its metallurgical quality of SG Iron is very much acclaimed by their domestic & overseas customers.

Home grown machines developed for producing parts with weight range of 5-50kgs with surface finish comparable to shell molded castings. Semi-automatic PLC controlled shooters capable of producing intricate cores with close dimensional accuracy.

II. METHODOLOGY

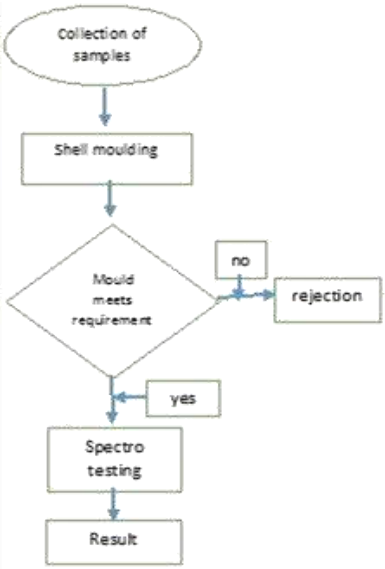

Fig. 1: Flowchart for the process

The detailed study of component was done, including the application of the component. The method of production including, the preparation of the shell mould, melting the molten metal and the dimensional data of the component were studied. The reciprocating piston has been sectioned in the sides and checked for the internal defects, shrinkage. The cause and effect diagram was prepared for shrinkage and the major root cause was isolated [2].

The major causes like pouring temperature, pouring charge details chemical compositions and the cooling curves are studied. Chemical composition vs. number of defects due to shrinkage scatter plot diagrams is drawn.

III. SAMPLE PROPERTIES

Depending upon the matrix phases, SG iron can be classified into four groups.

1) Ferritic
2) Pearlitic
3) Martensitic
4) Austentic

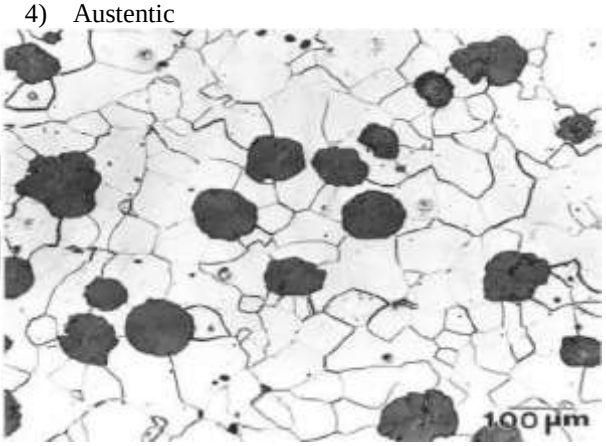

Fig. 2: Ferritic Ductile Iron Microstructure

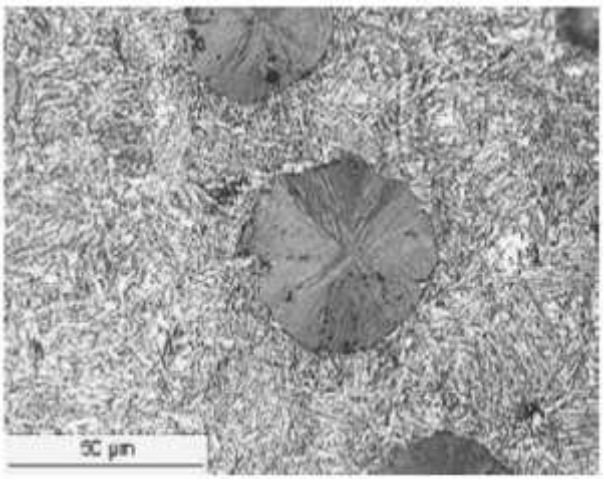

Fig. 3: Pearlitic Ductile Iron Microstructure

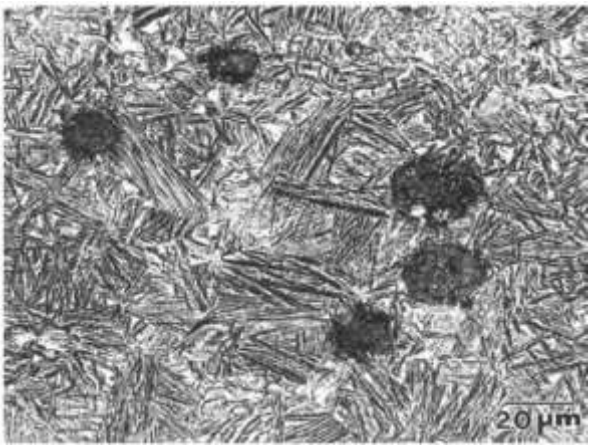

Fig. 4: Austempered Ductile Iron Microstructure

SG irons are generally ferritic type. But low yield strength and high ductility makes it difficult to be used in certain applications. Thus if some carbon is left intentionally in cementite form, property gets enhanced. Such type of SG iron is referred as pearlitic SG iron. If the rate of cooling is very high then the matrix will get converted into martensite. Due to its ductile nature it has limited applications. Thus the matrix may vary from a soft ductile ferritic structure through a hard and higher strength pearlitic structure to an austentic structure [3].The above classified sample properties are shown in figure (2),(3),(4).

IV. EXPERIMENTAL ANALYSIS

The specifications of a reciprocating piston which The chemical composition of some pistons are we have analyzed is shown in table1.

Component name	PISTON
Materials of pattern	SGIRON
Number of reciprocating piston in one shell	4
Number of reciprocating piston per heat	520
Material grade	SG IRON 600/3 as per BS 2789 STD
Pouring temperature	1440°C-1360°C
Casting weight	.850gms
Shell weight	7 kg
Casting yield	45.4%
Pouring time	600sec

Table 1: Process Parameter

A. The Typical Chemical Composition Of A Component

- Iron
- Carbon 3 to 4%
- Silicon 1.9 to 3.5%
- Manganese 0.1 to 0.5%
- Magnesium 0.03 to 0.05%
- Phosphorus 0.025 to 0.06%
- Sulphur 0.005 to 0.02%

Other elements such as copper or tin may be added to increase tensile and yield strength while simultaneously reducing elongation. Improved corrosion resistance can be achieved by replacing 15% to 30% of the iron in the alloy with varying amounts of nickel, copper, or chromium [4].

S.No	C	Si	Mn	Mg	S	P	Shrinkage
1	3.797	2.495	0.349	0.03	0.013	0.036	0
2	3.495	2.707	0.356	0.021	0.01	0.036	1
3	3.44	2.573	0.434	0.032	0.014	0.03	1
4	3.56	2.488	0.388	0.036	0.008	0.043	1
5	3.561	2.563	0.335	0.013	0.008	0.036	1
6	3.727	2.69	0.348	0.03	0.007	0.037	0
7	3.365	2.721	0.354	0.05	0.011	0.035	1
8	3.681	2.429	0.386	0.027	0.013	0.039	1
9	3.285	2.432	0.385	0.016	0.01	0.038	1
10	3.753	2.651	0.356	0.012	0.02	0.035	0
11	3.685	2.54	0.32	0.014	0.008	0.037	0
12	3.721	2.631	0.365	0.014	0.002	0.039	0
13	3.34	2.42	0.352	0.016	0.003	0.038	1
14	3.45	2.78	0.365	0.016	0.006	0.039	1
15	3.78	2.634	0.342	0.035	0.007	0.038	0

Table 2: Chemical properties and shrinkage

*0-No shrinkage
*1-Shrinkage

V. ANALYSIS OF SHRINKAGE USING MINITAB SOFTWARE

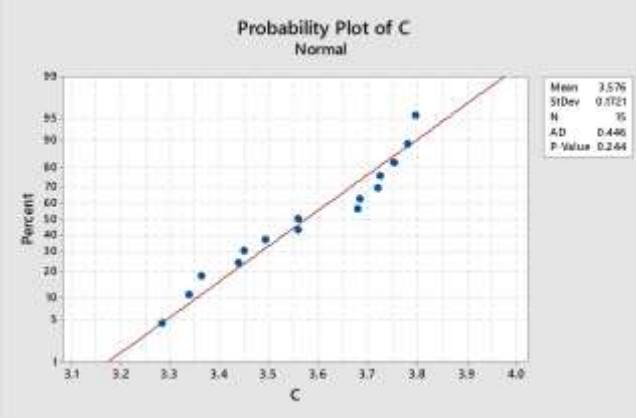

Fig: 5: Probability plot of Carbon

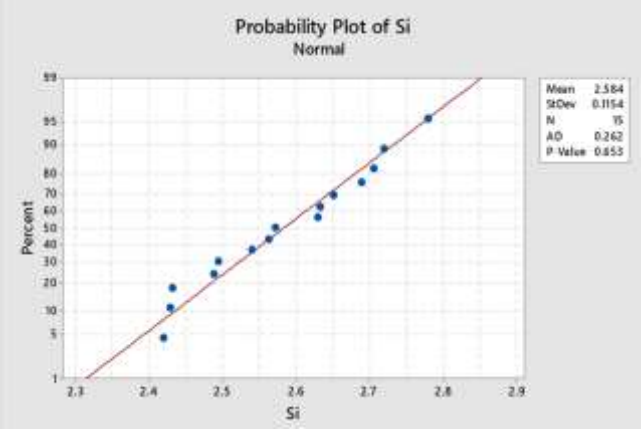

Fig. 6: Probability plot of Silicon

The analysis of shrinkage in MINITAB software is to check for the shrinkage is due to the possibility of the chemical compositions.With this software graphical representation of the data are plotted and taken for analysis.The types of plot are Probability plot,Main effect plot and scatter plot [5].

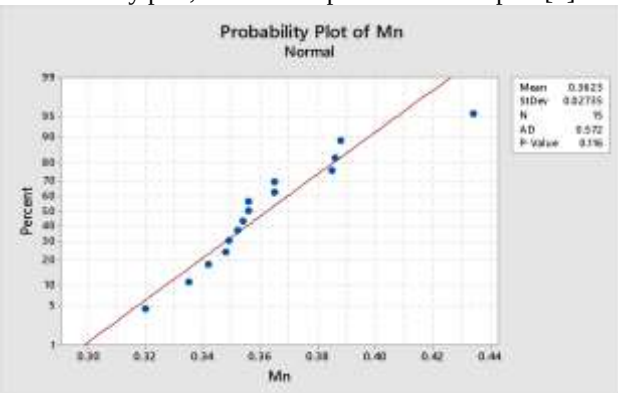

Fig. 7: Probability plot of Manganese

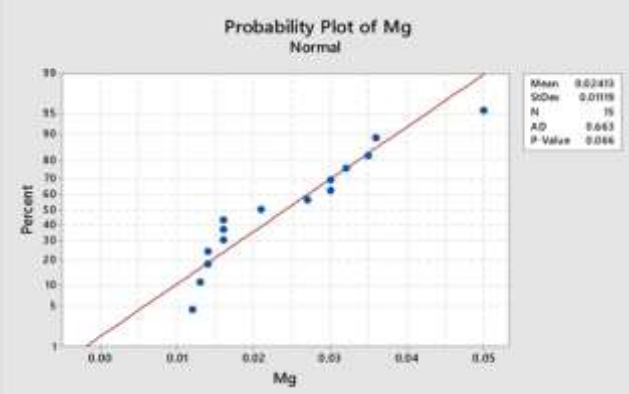

Fig. 8: Probability Plot of Magnesium

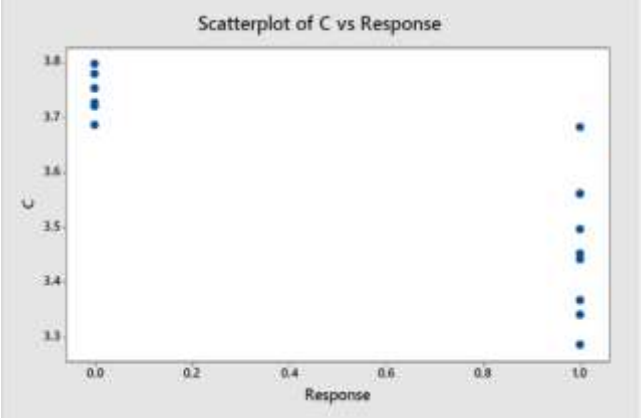

Fig. 9: Scatterplot of Carbon

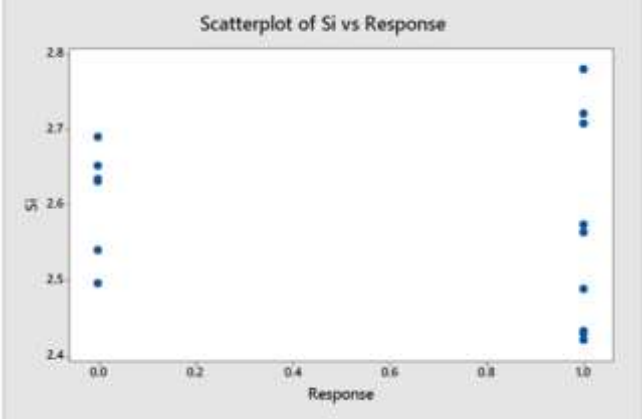

Fig. 10: Scatterplot of Carbon

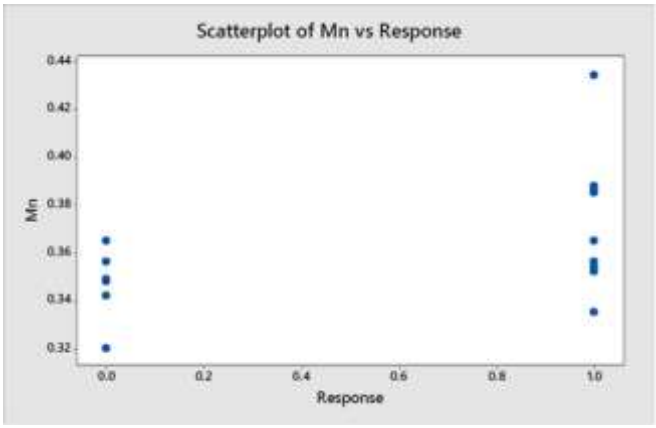

Fig. 11: Scatterplot of manganese

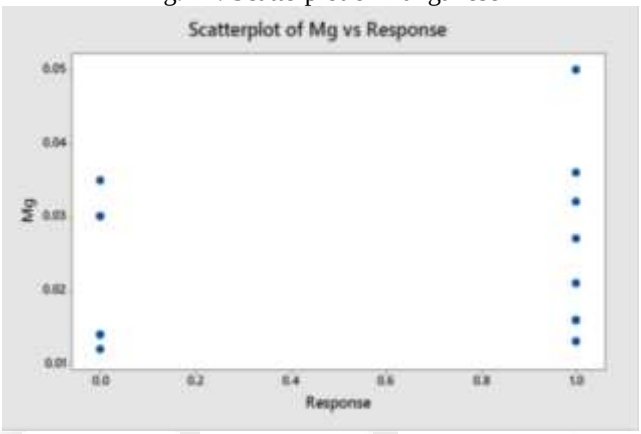

Fig. 12: Scatterplot of magnesium

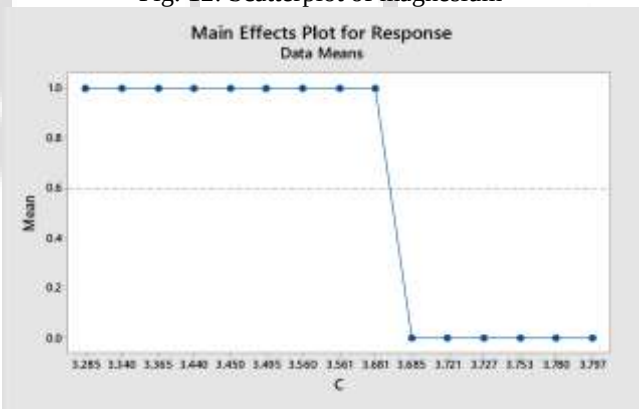

Fig. 13: Main Effect Plot of Carbon

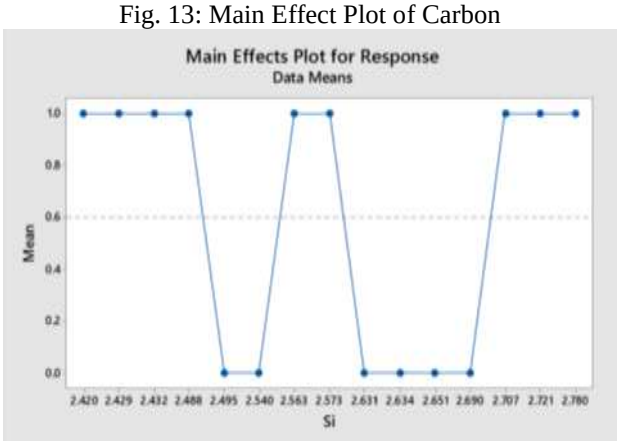

Fig. 14: Main effect plot of silicon

Carbon is playing a vital role in getting shrinkage. If % carbon is more than 3.6% no shrinkage was found. No shrinkage was noticed if Carbon Equivalent is found more than 4.5%.% Mg between 0.034% and 0.04% shows ideal for

getting sound casting. Maintaining Mn less than 0.38 shows good in order to get shrinkage free casting. Maintaining % Si between 2.5 and 2.7 shows good in order to get shrinkage free casting. This study clearly demarcates that it is the chemical composition7s and the charge materials that play a major role contributing for shrinkage [6]. Thus if the above inference were made in perfect manner then the percentage of shrinkage could be brought down. These inferences are shown with the help of figures (5)-(14).

VI. CONCLUSION

By the given inference the chemical compositions were made perfect and then verified for the occurrence for the shrinkage. Thus by this software it is found that there is no occurrence of the shrinkage and the pouring velocity and the pouring temperature were also maintained in order to get bring the shrinkage level as low as possible.By the analysis the causes for the shrinkage was found out and the major contribution for the shrinkage was the chemical compositions. Thus the charge material compositions were made to final proportions such that the shrinkage level due to the chemical compositions is brought down. Also the changed compositions is been verified and it helped in bringing the rejection level of the reciprocating piston down[7].

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