Research Paper

INVESTIGATION AND ANALYSIS OF COLD SHUT CASTING DEFECT AND DEFECT REDUCTION BY USING 7 QUALITY CONTROL TOOLS

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ABSTRACT

Casting production involves various processes which include pattern making, moulding, core making, melting pouring, shell breaking, shot blasting etc. It is almost impossible to produce defect free castings. Occurrence of the defect may involve single or multiple causes. These causes can be minimised through systematic procedure. The paper represents procedure to analyse and minimise casting defect Cold shut in automobile cylinder block of grey cast iron Grade FG150. Gaiting systems are not always responsible for the defect occurrence; this paper represents the defect reduction by controlling alloy composition and pouring temperature. The seven quality control methodology is used to analyse and reduce defects which includes check sheet, pareto analysis, cause effect diagram, flow chart, scatter diagram, histogram and control chart.

KEYWORDS- Seven quality control tools, Grey cast iron, Cold shut, Casting defect.

1. INTRODUCTION

Fig.1 Cold shut in automotive cylinder block

A cold shut is a visual and structural discontinuity caused by separate metal flows or where two or more metal streams have come together and fused. A dividing like can be visually seen of the discontinuity. This can occur especially in thin flat sections of the casting e.g. fins of a automobile cylinder block.

A cold shut casting is one in which the casting detail is incomplete due to a unable to fill the mold cavity. A portion of the casting may be missing, and/or necessary sharp corners may be rounded. Since this defect is related to casting design and also pouring practice, all casting methods (green sand, chemically bonded sand, permanent and semi-permanent mold) can be responsible. Here main focus is on improving the pouring practices and alloy composition for improving the flowability of the molten metal

Cold shuts generally occur on wide casting surfaces in thin, difficult to fill sections which are farthest from the pouring cup, or where two streams of metal come together in the mold during filling.

2. METHODOLOGY

The Seven Basic Tools of Quality is a designation given to a fixed set of graphical techniques identified as being most helpful in troubleshooting issues related to quality. They are called basic because they are suitable for people with little formal training in statistics and because they can be used to solve the vast majority of quality-related issues.

The Seven Basic Tools of Quality includes:

- Check sheet
- Pareto chart
- Ishikawa diagram
- Flowchart
- Control chart
- Scatter diagram
- Histogram

2.1 Check sheet

The rejection data was obtained from the foundry and placed in a tabulated form for the convenience to use and understand. Rejection check sheets are generally large data sheets showing the total information about rejected items.

2.2 Check Sheet-

Simplified data from the total rejection sheet is represented in the following table. Data shows the total pouring per month and the data is of three months. Rejection of total Hero moto-corp cylinder block is given in the following table.

Table 1 rejection data sheet

Month	Pouring	Total rejection	Slag	Sand	Cold shut	Porosity	Shrinkage
June	88560	11227	2560	1853	1412	1235	1059
July	89800	10506	2873	1885	1973	987	1116
August	72530	8776	2248	1595	1087	942	870

2.3 Pareto chart

Following is the pareto analysis made to identify the major defects those are contributing in major percentage.

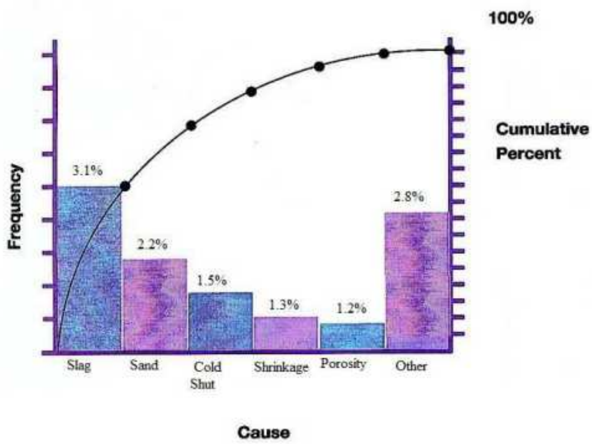

Fig2 Pareto analysis

Cold Shut identified as one of the five Major defects. It was necessary to find out the actual reasons behind the cold shut defect, to find the reasons behind the defect use of Ishikawa diagram was made which is also called as root- cause analysis. Defects slag and sand were not selected for the analysis as they were already in the process.

2.4 Root- Cause analysis for Cold shut.

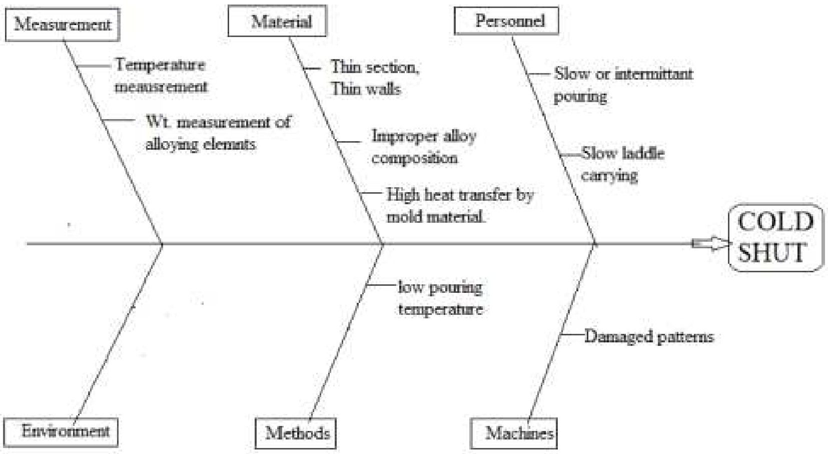

Fig.3 Root cause analysis

2.5 Brain storming

The brainstorming session was held for finding different causes behind the defects and identifying the main causes those are responsible for the maximum damage. It consists of the group of members working in foundry. There are five members in brainstorming session from different foundry departments which includes Lab In-charge, Quality manager, Furnace supervisor, Worker working at furnace and mould checking supervisor. It involves higher management members and shop floor members.

As shown in Fig.2 causes and effect diagram helps in analysing different causes Cold shut problem. Results obtained are placed in tabulated form .Rating is from 0 to 5 , higher is the number in rating more is the severity.

Table 2 Brainstorming result in tabulated form for cold shut

Sr. No.	Causes	Lab Incharge	Quality Manager	Furnace Supervisor	Worker at Furnace	Mould supervisor	Rating	Rank
1.	Lower pouring temperature	Yes	Yes	No	No	Yes	5	1
2.	Low % of Si and P	Yes	Yes	Yes	Yes	Yes	4	2
3.	Slow or intermittent Pouring	Yes	Yes	No	No	No	3	3
4.	Slow ladder carrying	Yes	Yes	No	No	No	2	2
5.	Damaged patterns	No	No	Yes	No	No	1	1

After brain storming session it was concluded that Lower percentage of Si and P were one of the reasons for cold shut, Silicon are Phosphorous are mainly important for the improving the flowability, lower pouring temperature was also the another major cause for cold shut. The Recommended % Si range for the Cylinder block is 1.75 to 2.20 % and the % P is 0.3 % Maximum. The recommended pouring temperature is 1380^0C to 1440^0C.

2.6 Control charts

Control chart of Silicon percentage, the recommended range of Si in alloy was 1.75 to 2.20 %. The observed final percentage of the Si was mainly from 1.80 to 1.85 % after addition of the inoculants. It was necessary to control the % Si in the upper range in a recommended range. The other fact to consider was extreme higher percentage of Si in a recommended range may be responsible for other defects like porosity and lowering the hardness. Silicon is mainly added for the de-oxidation process so that the carbon content added does not get oxidized to the iron carbides. Silicon acts as the stabilizing element for the graphite in the Grey Cast Iron. Percentage of P also plays an important role in flowability of molten metal but the excess percentage may lead to other defects like shrinkage. The recommended percentage of Phosphorous is 3% maximum. Observed range of the Phosphorous was in between 0.11 to 0.15 %. Trials were conducted increasing % Si and % P in a recommended range. Pouring temperature is another main factor of consideration in cold shut defect the recommended pouring range is 1380 to 1440^0C.

Trials were conducted on 120 (60x2) castings in two levels on 350kg capacity induction furnace. Trials are shown below in the table. First two rows in the table represent the random readings taken

Table 3 Trials table

Reading	Temp. ^{0}C	%P	%Si	Sample size	Good	bad	Cold shut
1.	i)1435 ii)1437	i)0.12 ii)0.11	i)1.80 ii)1.81	120	102	18	4
2.	i)1432 ii)1430	i)0.15 ii)0.13	i)1.83 ii)1.85	120	105	15	5
3. Trial 1	i)1422 ii)1420	i)0.10 ii)0.12	i)1.84 ii)1.84	120	108	12	4
4. Trial 2	i)1412 ii)1405	i)0.12 ii)0.14	i)1.82 ii)1.86	120	110	10	5
5. Trial 3	i)1428 ii)1425	i)0.22 ii)0.18	i)2.1 ii)1.95	120	113	7	2
6. Trial 4	i)1434 ii)1430	i)0.22 ii)0.23	i)2.0 ii)1.98	120	113	7	1

Following are the control charts for Temperature, %P and %Si (X-bar)

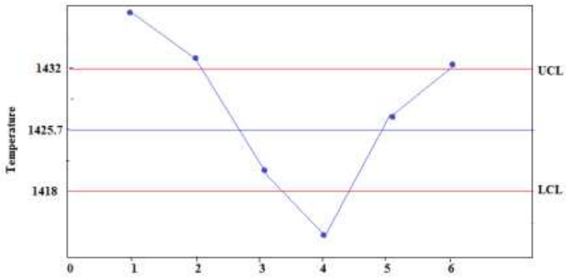

Fig.4 control chart X-bar for Temperature

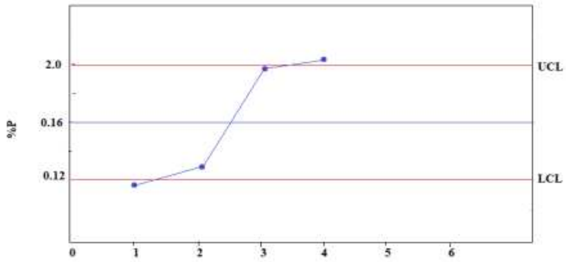

Fig.5 control chart X-bar for %P

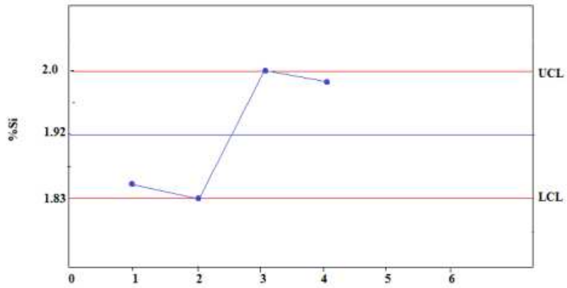

Fig.6 Control chart X-bar for %Si

2.7 Histogram

Following are the histograms showing the effect of pouring temperature, %Si and %P on rejection as per the results of trials conducted. Only trials results considered in plotting.

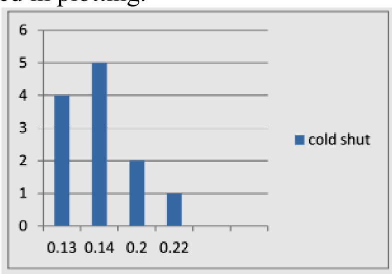

Fig.7 No. of defects Vs %P

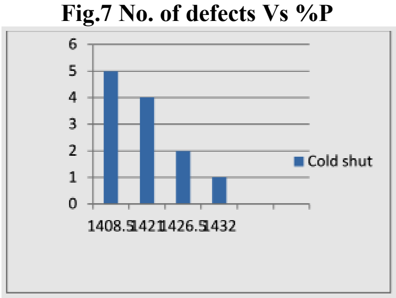

Fig8 No, of rejections Vs Temp.

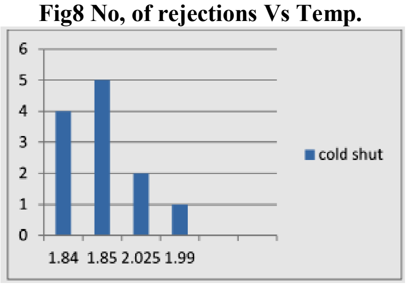

Fig.9 No rejections Vs % Si

3. RESULT AND DISCUSSIONS

- As the defect sand , porosity and shrinkage requires lower pouring temperature in the recommended range and cold shut requires higher pouring temperature so temperature range observed which can be useful to reduce cold shut considering the other defects is 1418 to 1432^0C.
- Phosphorous percentage is recommended to be 0.12 to 0.2%. as Prosperous increases the flowability it is recommended that to keep its percentage level towards upper control limit i.e. 0.2%. Higher than this may cause shrinkage porosity in castings.
- Silicon percentage is recommended to be 1.83 to 2.0 %. Above 2% mainly responsible for porosity in casting and lower percentage may reduce the flowability causing cold shut.

4. CONCLUSION

The correct identification of the casting defect at the initial stage is essential for taking remedial actions .This paper presents the systematic approach to find the root cause of one of the major defect (Cold shut) in an automobile casting produced in a medium scale foundry. The origin of the Cold shut defect was identified by means of Seven Quality control tools. Finally, it was found that the alloy composition and pouring temperature was the root cause for this major defect. The necessary remedial action was made in production of Cylinder block. The major Cold shut defect was reduced by up to 50%. The total rejection from cold shut was reduced to 6.6% from 12.3%. This systematic study proves that by means of effective analysis of tools and processes, it is possible to eliminate/control the casting defect.

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