Analysis of the Sand Drop Defect to Reduce the Rejection Level of Cylinder Block Casting-A Case Study

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Abstract

This paper deals with the procedure to analyse and minimise sand drop casting defect in automobile cylinder block of grey cast iron in foundry. The primary tools used in this investigation process were the check sheet, cause-and-effect diagram, cause-and-effect matrix, and why-why analysis.Casting production involves various processes which include pattern making, moulding, core making, melting, pouring, shell breaking, shot blasting etc. A cylinder block having an integrated structure comprising the cylinders of an engine. Since casting of cylinder block is having some intricate parts. 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. This paper represents the defect reduction by why-why analysis of non measurable rejection causes. Outcome of the validation trials showed substantial reduction in rejection of cyl.block castings due to sand drop defect minimization and rejection level from 37.17% to 16.3% is achieved.

Keywords-Casting Defect, Sand Drop, Why-Why Analysis, Root- Cause Analysis, Rejection Reduction

"1. Introduction"

A Sand Drop is a casting defect due to the loss of a portion of sand from the core or other overhanging section. In appearance, the defect resembles a sticker. The same has shown in figure1.

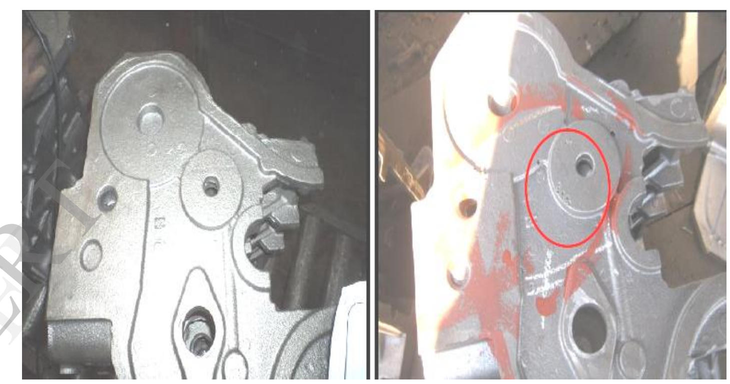

Fig.1: Sand Drop in Cyl. Block

It is an irregularly shaped projection on the cope surface of a casting. This defect is caused by the break-away of a part of mould sand as a result of weak packing of the mould, low strength of the molding sand, malfunctioning of molding equipment, strong jolts and strikes at the flask when assembling the mould. The loose sand that falls into the cavity will also cause a dirty casting surface, either on the top or bottom surface of the casting, depending upon the relative densities of the sand and the liquid.

"2. Methodology"

Problem solving should follow a logical, systematic method. This will place emphasis on locating and eliminating the root or real cause of the problem. Other, less systematic attempts at problem solving run the risk of attempting to eliminate the symptoms associated with the problem at its cause. Organized problem solving efforts utilized a variety of quality tools for problem analysis.
The basic tools of quality includes,

- Check sheet
- Pareto chart
- Ishikawa diagram
- cause and effect matrix
- Why -why analysis
- Histogram

2.1 Check Sheet

The check sheet is a simple document that is used for collecting data in real-time and at the location where the data is generated .The document is typically a blank form that is designed for the quick, easy, and efficient recording of the desired information, which can be either quantitative or qualitative. Rejection check sheets are generally large data sheets showing the total information about rejected items. Following is the five months data of the total pouring per month. Rejection of total cylinder block is given in the following table no.1.

Month	Pouring	Total Rejection	Sand Drop	Cold Shut	Broken Casting
April	7253	1167	431.80	163.38	128.37
May	7835	1032	381.84	144.48	113.52
June	6975	1797	664.90	251.58	197.67
July	8277	1039	384.43	145.46	114.29
August	7689	1153	426.61	161.42	126.83

Table-1: Rejection Data Sheet

2.2 Pareto Chart

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

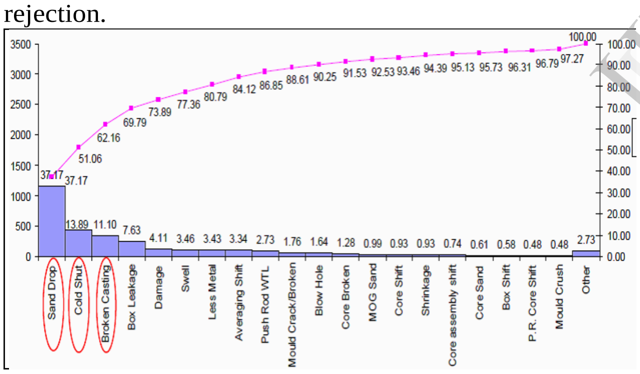

Fig.2: Defect Pareto Chart of Cylinder Block for last five months

Sand Drop is identified as one of the three major defects. It was necessary to find out the actual reasons behind the Sand Drop defect, to find the reasons behind the defect use of Ishikawa diagram was made which is also called as root- cause analysis. The quality control tools are proven scientific management tools, which are basic and easy to understand for all problem solving. Defects Cold Shut and Broken Casting were not selected for the analysis as they were already in the process.

2.3 Root- Cause Analysis for Sand Drop.

Root cause analysis is the process of identifying causal factors using a structured approach with techniques designed to provide a focus for identifying and resolving problems.

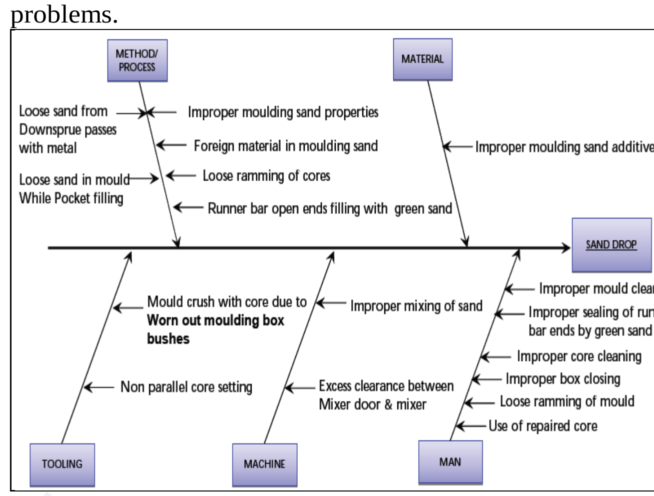

Fig.3: Cause and Effect Diagram for Sand Drop

2.4. Cause Effect Matrix for Sand Drop

The brainstorming session was held for finding different causes behind the Sand Drop defect and identifying the main causes those are responsible for the maximum damage. It consists of the group of members working in foundry. There are members in brainstorming session from different foundry departments which includes Lab In-charge, Quality manager, Furnace supervisor, Worker. We started with Cause and Effect Analysis to find generalized reasons for Sand Drop defect. After that we have shortlist the critical causes (X's) that potentially given impact to Project Y proceeded to generate Cause and Effect Matrix (C & E Matrix) as shown in table 2.The Cause and Effect Matrix is a tool which is used to prioritize potential causes by examining their relationship with the critical to quality (CTQs). Causes are place along the left side. Causes are ranked in terms of importance. Cause with the highest rank should be addressed first because they will have the largest impact on the CTQs. Cause effect matrix for sand drop is tabulated as shown in table – 2

Input / Process Indicator	Output	Output Indicators
Loose sand from down sprue passes with metal	5	50
Loose sand in mould while pocket filling	5	50
Improper moulding sand properties	8	80
Foreign material in moulding sand	4	40
Loose ramming of cores	4	40
Runner bar open ends filling with green sand	9	90
Improper moulding sand additives	5	50
Improper mould cleaning	5	50
Improper sealing of runner bar ends by green sand	9	90
Improper core cleaning	5	50
Improper box closing	5	50
Loose ramming of mould	8	80
Use of repaired core	5	50
Improper mixing of sand	5	50
Excess clearance between mixer door & mixer	9	90
Non parallel core setting	5	50
Mould crush with core due to worn out molding box bushes	5	50

Table 2: Cause-Effect Matrix for Sand Drop
Scale: 0=None, 1=Low, 5=Moderate 9=Strong

"3.Why-Why Analysis Method"

Different tools and techniques were employed to find correlation between'X's and project 'Y' in order to reduce the number of variables and select the 'vital few' for further analysis. Here, statistical tool why-why analysis is used for carrying out the analysis. It is a method of questioning that leads to the identification of the root cause(s) of a problem. An important component of root cause analysis is a thorough understanding of "what happened". The team begins by reviewing an "initial understanding" of the event and identifying unanswered questions and information gaps. The Information-gathering process includes interviews with staffs and workers who were directly and indirectly involved with the physical environment where the event and other relevant processes took place, along with observation of usual work processes. This information is synthesized into a "final understanding", which is further used by the team to begin the "why" portion of the analysis in a logical sequence to find a logical solution to the problem. It is one of the many brainstorming methodology of asking "why" five times repeatedly to help in identifying the root cause of a problem. If a problem is repeatedly questioned, each time an alternative solution comes out which is linked to the root cause. However, asking why may be continued till getting an agreeable solution. Five is an arbitrary figure. The theory is that after asking "why" five times one is likely to arrive at the root cause. Rather than taking actions that are merely band-aids, a why-why helps you identify how to really prevent the issue from happening again. It is useful for analysis of non measurable causes as listed in table 4.

Sr.No	Non measurable causes
1	Mixing of dry sand with prepared sand
2	Sand in runner bar

Table-3: Non measurable Causes

The why -why analysis for sand drop is shown in figure-4 below.

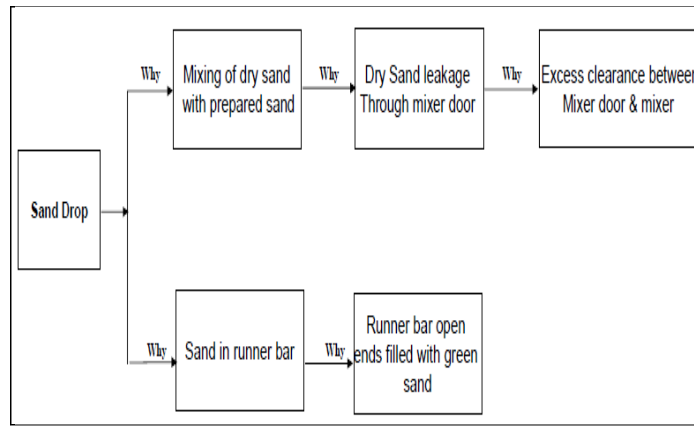

Fig.4: Why-Why Analysis for Non Measurable Causes of sand drop (X's)

"4.Observations from Why-Why Analysis"

1. Excess clearance between mixer door & mixer. The same is shown in figure 5 below.

Fig.5: Dry Sand on Belt Due to Excess & Mixer Door Clearance between Mixer Door & Mixer

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 9, September - 2013

2. Improper sealing of runner bar ends and shown in figure-6.

Fig.6: Improperly Sealed Runner Bar End

"5. Summary of Validated Non Measurable Causes"

1) Validated Causes (Xs) identified are tabulated as table-4 below

Sr. No.	Xs identified as important from Cause –Effect Matrix	Validated (Y/N)	Tool Used	Remarks
1	Excess clearance between mixer and mixer door	Yes	Why Why anlysis	Analysis attached above
2	Runner bar open ends filled with green sand	Yes	Why Why anlysis	Analysis attached above

Table -4: Summary of Validated Xs

As we know, which are critical inputs and affect the outputs then, there is need to run trials to find and confirm the changes in old processes or procedure of these vital inputs and start implementing new processes by implementing following steps.

"6. Criteria for Selecting Solutions"

A Solutions Selection Matrix helps to identify the best solution from the several solutions by weighting the impact of each solution on the Critical to Quality and cost-benefit, hence measuring the effectiveness of solving the problem. Where in each solution is evaluated against impact factors namely, sigma impact, time impact and cost benefit impact if evidenced. This tool helps to remove any subjectivity and bring in objectivity in the solution selection process. Then weighting for each evaluation criteria was done based on 1 to 10 scales, where in 1 for least weightage & 10 stands for high weightage. Upon discussion with our project champion the weightage to three criteria was given as follows. Sigma impact -10 (Since our main target is reduction rejection) Time impact -8 (Time was important, since six months was given to our team for this project) Cost impact -6 (Cost for implementation is considered .Solution selection matrix is constructed in table-5 as below.

Sr .No.	Xs validated	Possible Solutions	Sigma impact (A)	Time Impact (B)	Cost Impact C)	Total score
		Weightage	**10**	**8**	**6**	**(A*10) + (B*8) +(C*6)**
1	Excess clearance between mixer and mixer door.	1.1) Mixer door adjustment to reduce excess clearance between mixer and mixer door.	9	8	6	190
		1.2) Mixer design modification to increase overlap.	8	8	7	186
2	Runner bar open ends filled with green sand and improper sealing of runner bar open ends by operator.	1.1) Plugging and sealing of runner bar open ends by cold box core piece.	7	7	6	162
		1.2) Plugging sealing of runner bar open ends by shell core piece.	8	7	6	172
		1.3) Molding line expansion to increase no of molding boxes to give sufficient cooling time.	7	8	9	188

Table-5: Solution Selection Matrix

"7. Final Solution Selected"

After examine the scores of solution selection matrix final solutions are tabulated as shown in table-6 below.

No	Causes	Possible Solutions
1	Excess clearance between mixer and mixer door.	Mixer door adjustment to reduce excess clearance between mixer and mixer door.
2	Runner bar open ends filled with green sand and improper sealing of runner bar open ends by operator.	Plugging and sealing of runner bar open ends by cold box core piece.

Table-6: Final Solution

“8. Solutions Implemented”

1)Mixer door adjustment done to reduce excess clearence between mixer door & mixer.Same is shown in figure7 below.

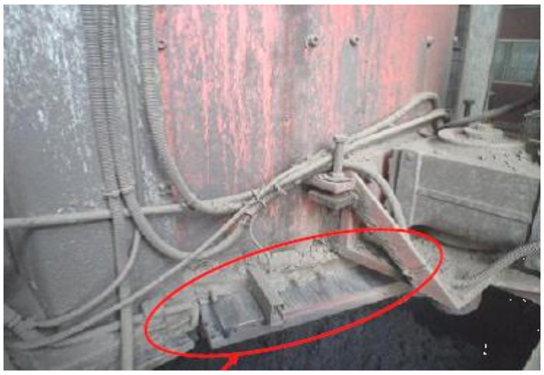

Fig.7: Door Adjustment

2) Poka yoke done to remove dry sand from belt.

Fig.8: Remove Dry Sand from Belt

3) Plugging and sealing of runner bar open ends by cold box core piece shown in figure 9 below.

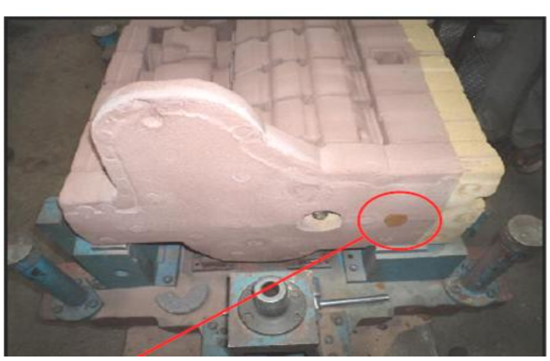

Fig.9: Runner Bar ends Sealing

“9. Results after Pilot Implementation”

After applying solutions the following results are obtained from pilot run and tabulated in table-7 as below. Rejection status is shown in following figure-10

Sr No.	Quantity Produced	Defects (Nos) Sand Drop	Rejection %
1	40	7	17.5
2	52	8	15.38
Total	92	15	16.30

Table-7: Results of Pilot Run

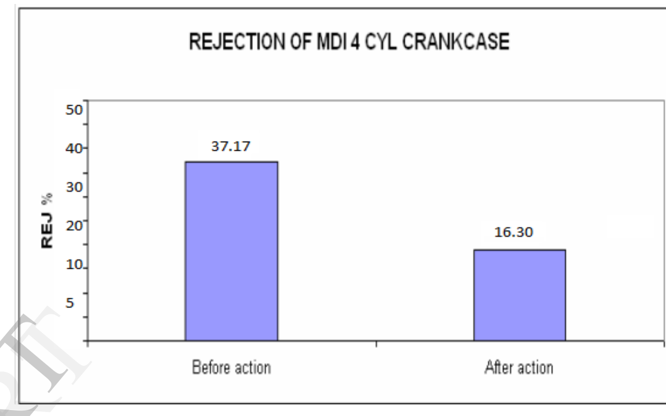

Fig.10: Cylinder Crankcase Rejection % due to Sand Drop defect

“10. Conclusion”

The above work was a systematic approach towards quality control through reduced rejection level. In nutshell it is concluded from the analysis that, the quality can be improved by minimizing rejection percentage of cyl.block due to sand drop and rejection level from 37.17% to 16.3% is reduced. The work showed that the quality tools are an effective way of investing and minimising rejections due to non measurable causes.

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