Reduction of Rejections in Modine Top Tank Manufacturing Process by Using Statistical Process Control

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Abstract – Foundry industries in developing countries experience the ill effects of low quality and profitability because of contribution of number of process parameters. Indeed, even in totally controlled process, deformity in castings are observed and henceforth casting process is otherwise called procedure of vulnerability which challenges clarification about the reason for casting abandons. This will be useful in improving the yield of casting. This investigation expects to perform deformity examination on castings and furnish cures with their causes and to diminish the in plant dismissals and to boost the plant operational productivity by limiting misfortunes. The main aim of the present study is to analyze the production line of aluminum automobile parts of a manufacturing industry and to improve the quality of production. This examination demonstrates the efficient way to deal with diminishment of dismissals in Modine Top Tank manufacturing process by utilizing Statistical Process Control.

Index Terms – Modine Top Tank Process, Casting Process, Productivity, Statistical Process Control.

1. INTRODUCTION

Casting is a procedure which conveys danger of disappointment event amid all the procedure of achievement of the completed item. Thus important move ought to be made while assembling of cast item with the goal that imperfection free parts are acquired. For the most part throwing surrenders are worried about process parameters. Henceforth one needs to control the procedure parameters to accomplish zero deformity parts. For controlling procedure parameters one must know about impact of process parameters on throwing and their effect on absconds. To acquire this, all information about throwing deformity, their causes, and imperfection cures one needs to break down casting surrenders. Casting deformity investigation is the way toward discovering underlying drivers of event of imperfections in the dismissal of castings and finding a way to diminish the deformities and to enhance the throwing yield. In this survey paper an endeavor has been made to furnish all casting related imperfections with their causes and cures. Amid the way toward casting, there is dependably a shot where imperfection will happen. Minor deformity can be balanced effectively however high rejected rates could prompt noteworthy change at high cost. In this way it is basic for bite the dust caster to have learning on the kind of deformity and have the capacity to recognize the correct main driver and their cures.

Joshi and Jugulkar Used Pareto principle and cause effect diagram to identify and evaluate different defects and causes for these defects responsible for rejection of components at different stages of manual casting operations[1]. Mane V.V et al carried out casting defect analysis by using techniques like cause-effect diagrams, design of experiments, if-then rules and artificial neural network. Researcher describes 3-step approach to casting defect identification, analysis and rectification[2]. Ved Parkash et.al described about the SPC, its advantages, limitation, applications and information regarding the control charts[3].Gasper Skulj et.al in their Illustrated a service approach of SPC and discussed through an industrial case study. They clearly explained the successful development and implementation of SPC as a service[4]. Rungasamy, S., Antony, SPC considers process variability, and is an essential tool for continuously enhancing product quality [5]. Chakraborty, states Clearly, SPC has become a popular tool for improvement of quality in manufacturing [6]. Prof B.R. Jadhav, S.J. Jadhav, Investigation And Analysis Of Cold Shut Casting Defect And Defect Reduction By Using 7 Quality Control Tools[7].

The casting defects can be broadly classified as follows:

- Filling related defect
- Shape related defect

- Thermal defect
- Defect by appearance

1.2 Modine Top Tank

Figure 1 shoes the schematic view of Modine Top Tank radiator. The top tank receives the hot water from the engine block just after it goes through the thermostat.

Figure 1 Modine Top Tank Radiator

The Modine top tank is mainly used in the radiators. Aluminum Modine Top Tank process is involved in three sections

1. Shell core process
2. Casting Process
3. Machining Process

1.3 Objectives of the Present Work

In this paper a contextual investigation is considered to lessening of dismissals in Modine Top Tank fabricating process by utilizing Statistical Process Control in M/s. SIBAR Auto parts restricted at Industrial Estate, Renigunta Road, Tirupathi.

2. METHODOLOGY

Statistical Process Control (SPC) is a strategy for quality control which utilizes factual techniques to screen and control a procedure. This guarantees the procedure works productively, creating more determination adjusting items with less waste (modify or scrap). SPC can be connected to any procedure where the "acclimating item" (item meeting determinations) yield can be estimated. Enter instruments are utilized as a part of SPC incorporate circumstances and end results outlines, control diagrams, Pareto graph investigation, an emphasis on nonstop change, and the plan of examinations. The establishment for Statistical Process Control was laid by Dr. Walter Shewart working in the Bell Telephone Laboratories in the 1920s directing examination on techniques to enhance quality and lower costs.

2.1 Specific SPC Tools and Procedures

The preliminary periods of SPC include a few stages utilizing various distinctive apparatuses. These apparatuses are portrayed underneath and most are accessible in SPC. Eight quality instruments are accessible to help associations to better comprehend and enhance their procedures. The fundamental apparatuses for the disclosure procedure are:

- Process Flow Diagram
- Check Sheet
- Cause-and-Effect Sheet
- Pareto Chart
- Control Charts
- Action plan suggestion

3. PROBLEM DESCRIPTION AND ANALYSIS

A. Data collection

There are many quality related problems which were observed during the work in industry. Rejection data of materials due to defects occurred during the top tank manufacturing process of the production has been taken from “Product rejects Oct, 2017” reports for about one month and is presented in Table 1. It provides the total rejection data in the process.

Table 1 Rejection Data of Modine Top Tank Process

S. No.	Name of defects	Rejections
1	Unflow	114
2	Shrinkage	100
3	Bend	85
4	Leak	73
5	Casting damage	33
6	Core broken	32
7	Under cut	5
8	Inclusion	5
9	sand inclusion	3
10	Blow holes	2
11	Die coat build up	1
12	Miss match	1

B. Pareto Chart

Pareto chart is a special type of chart where the plotted values are arranged from largest to smallest. A Pareto chart is used to highlight the most frequently occurring defects, the most common causes of defects, or the most frequent causes of customer complaints. To identify the main problems which cause frequent defects of top tank manufacturing process. Table 2 and Figure 2 shows the percentage of rejections of Modine Tank Radiator process in October 2017.

Table 2.Categorization of Defects in Modine Top Tank during in Process and at Final Stage

S. No	Name of defects	Rejections	Cumulative rejections	Percentage
1	Unflow	114	114	25.11
2	Shrinkage	100	214	47.13
3	Bend	85	299	65.85
4	Leak	73	372	81.93
5	Casting damage	33	405	89.20
6	Core broken	32	437	96.27
7	Under cut	5	442	97.35
8	Inclusion	5	447	98.45
9	sand inclusion	3	450	99.11
10	Blow holes	2	452	99.55
11	Die coat build up	1	453	99.77
12	Miss match	1	454	100

Based on the Pareto principle the "vital few" factors which have significant effect in the quality of the products are identified. Pareto chart was constructed based upon data collected (Tables 1a and 2a) and to identify the most common defect. The Pareto chart revealed that unflows / misrun defect-25.11%, shrinkage defect-22.02%, bend defect-18.72%, leakage defect-16.07% and casting defect-7.26%. These five major defects contributed 89.20% of the overall rejection. Only the major defects identified are chosen for the case study. Therefore at this stage, it is obvious that most of all rejections (defects) will decrease, if the causes for these major defects are reduced.

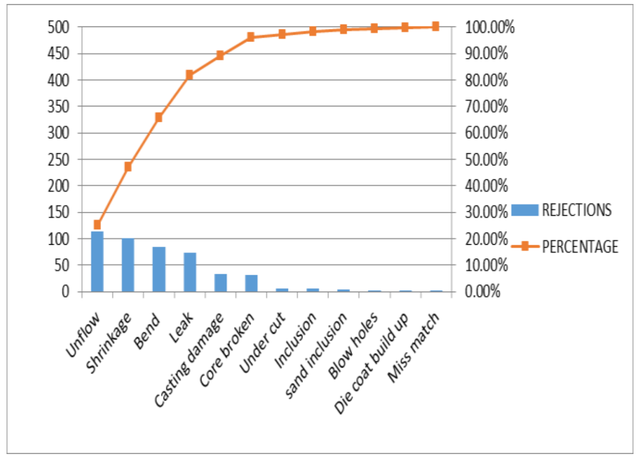

Figure 2 Pareto Chart

C. Cause and Effect Diagram

Cause and Effect Diagram is one of the approaches to enumerate the possible causes. Following section shows all cause effect diagram for all defects occurred in organization All below figures shows the cause and effect diagrams for each defect. This determines the potential cause which causes defects. These defects after the particular cause has been identified, remedies are suggested to eliminate these defects such as Unflow defect, Shrinkage defect, Bending defect, Leakage defect, and Casting damage. Figure 3, 4, 5, 6, 7 shows the cause and effect diagrams at various defects.

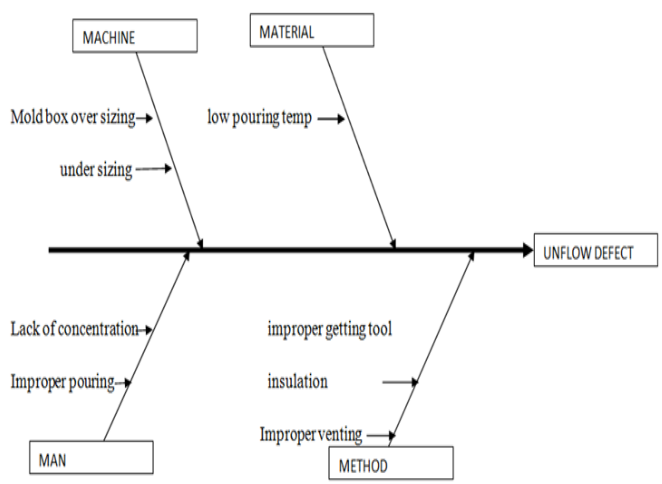

Figure 3 Cause and Effect Diagram For Unflow Defect

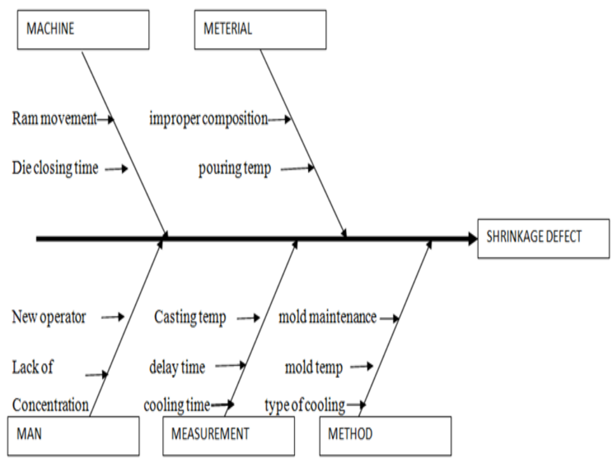

Figure 4 Cause and Effect Diagram For Shrinkage Defect

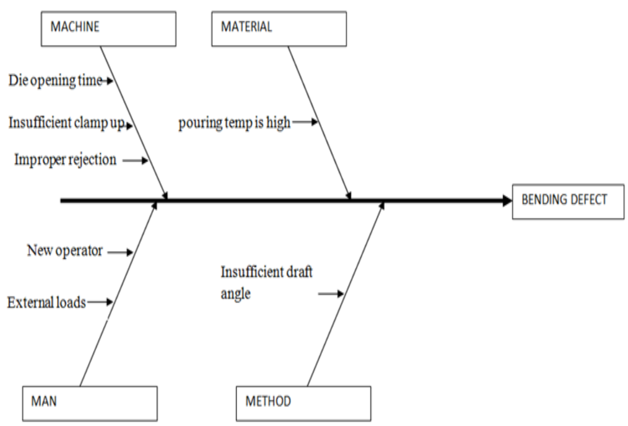

Figure 5 Cause and Effect Diagram For Bending Defect

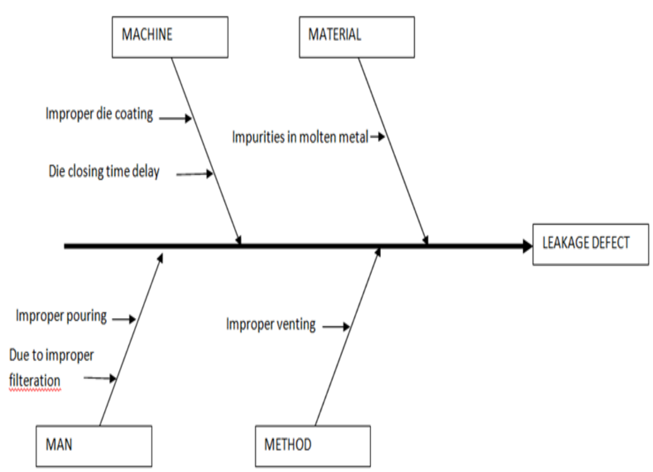

Figure 6 Cause and Effect Diagram For Leakage Defect

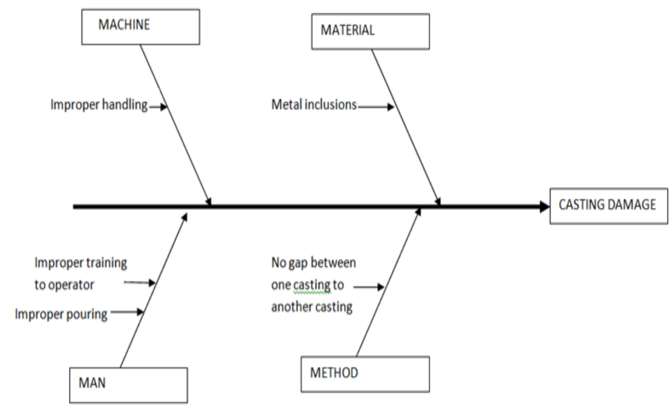

Figure 7 Cause and Effect Diagram For Casting Damage

D. Control chart

Table 3 Computing fraction defective for October 2017

Day	Prod.	Total	P	Day	Prod.	Total	P
1	77	2	0.0259	15	171	35	0.2046
2	73	9	0.1232	16	160	11	0.0687
3	138	32	0.2318	17	64	8	0.1250
4	137	24	0.1751	18	135	8	0.0592
5	178	35	0.1966	19	41	15	0.3658
6	42	15	0.3571	20	155	10	0.0645
7	168	7	0.0416	21	61	5	0.0819
8	155	29	0.1870	22	73	3	0.0410
9	82	16	0.1951	23	167	3	0.0179
10	164	30	0.1829	24	127	26	0.2047
11	84	11	0.1309	25	82	30	0.3658
12	131	15	0.1145		2862	395	
13	48	4	0.0833				
14	149	12	0.0805				

In the present examination the information has been gathered in October, 2017 from creation line and for every subgroup the part damaged is ascertained. According to SPC systems for better investigation and translation of information, the base size of the subgroup is 25 taken (ISO 8258:1991-E). To construct trait control diagram (p-graph) with consistent subgroup (ISO 8258:1991-E). P-graph is built up to control the division faulty for a gathering of value attributes visual deformities (Unflow, Shrinkage, Bend, Leak, Casting harm, Core broken, Inclusion, sand consideration, under cut and so on.). Table 3 shows the Computing fraction defective for October 2017.

Figure 8 shows P-chart and it has been constructed with control limits (UCL = 0.234, CL = 0.138, and LCL = 0.0413) shown on upper right side of the chart

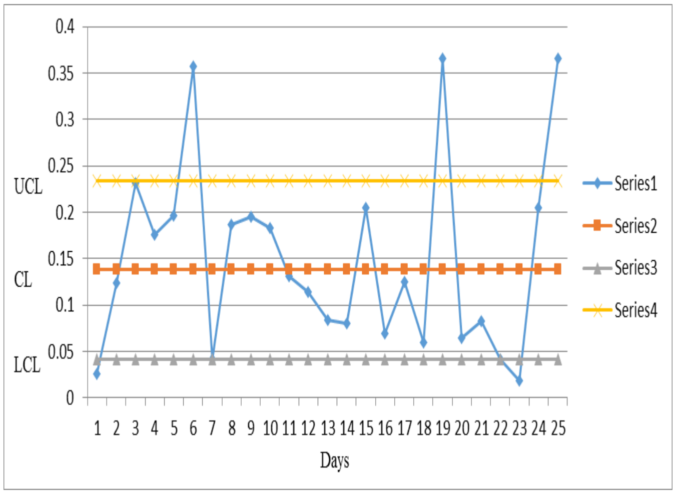

Figure 8 P-chart to illustrate process condition for October, 2017

From the process control graph, p-diagram built for October, 2017 it has been discovered that quality attributes in the assembling forms tended not to be in factual control (subgroup number 3 and 9 wild). Henceforth, the procedure must be brought into condition of factual control by finding the main driver and dispensing with from the procedure. Meeting to generate new ideas has been completed to discover main drivers and cures have been distinguished. In view of these cures recognized, change activity design proposal has been made and given to the organization's quality controlling division.

E. Action plan suggestion

Action plan suggestion for the top defects such as Unflow, Shrinkage, Bend, Leak, and Casting damage

- Unflow:

Type	• Action plan suggestion for unflow defect
Man	• Pay full attention • Must have good attitude toward quality improvement • Pouring time should be maintained at 4-6 seconds to reduce the defects
Machine	• Should maintain correct mold box size • Die coat should apply and air vents should maintain
	• Temperature probe should fix
Material	• Should maintain pouring temp • Should be Maintain metal temp. 710 to 740°c & die temp. 220 to 320°
Method	• Maintain proper tool insertion • Maintain proper venting

- Shrinkage

Type	• Action plan suggestion for shrinkage defect
Man	• Must have skill in identifying causes of defects before it occurs/provide training. • Must have attention • Must have good attitude toward quality improvement
Machine	• Should maintain good ram movement in the machine • Should be maintain die closing time • Apply sufficient die coat
Material	• Proper composition should be maintained • The total temperature of die and molten metal should between 1050-1100°C
Measurement	• Working time should be maintained between 4-6secs • Ingot and returns ratio should be 3:2 ratio
Method	• Maintain proper mold temperature • Mold maintenance should be maintained

- Bend

Type	• Action plan suggestion for bending
Man	• Pay full attention • maintaining proper pressure loads
Machine	• Maintain sufficient machine clamp up • Die opening time should be maintain to reduce the defects
Material	• Maintaining proper pouring temp
Method	• Maintain the sufficient draft angle

- Leak

Type	• Action plan suggestion for leakage defect
Man	• Pay full attention while pouring to reduce the defects • Provide every machine work instruction to worker to avoid mistake • Maintain proper filtration in the molten metal
Machine	• Proper die coating should be maintain • Should maintain die closing time properly
Material	• Should avoid the impurities in the molten metal • Degassing should maintain between 10-15min • Metal purification should be maintain
Method	• Should be maintain proper venting

- Casting Damage

Type	• Action plan suggestion for Casting Damage
Man	• Should avoid the impurities in the molten metal • Degassing should maintain between 10-15min • Metal purification should be maintain
Machine	• Maintain proper handling of machine parts
Material	• Maintaining proper pouring temp
Method	• should be no gap between one casting to another casting

After implementing the action suggestion plans for the top defects, considerable improvement was observed. The *p*-chart was constructed to analyze the process and help to determine how to yield further improvement. The *p*-chart was constructed before and after the action suggestion plans implementation. To plot control chart, data has been collected again for the month of December 2017 (Table 4 & 5).

Table 4 Pareto Analysis for Number of Physical Defectives (Top Tank)

S. No	Name of defects	Rejections	Cumulative rejections	Percentage
1	Unflow	59	59	30.42
2	Shrinkage	37	96	49.5
3	Core broken	31	127	65.46
4	Leak	31	158	81.44
5	Casting damage	13	171	88.14
6	Bend	13	184	94.85
7	Sand inclusions	5	189	97.43
8	Inclusion	2	191	98.45
9	Under cut	2	193	99.48
10	Miss match	1	194	100

CONTROL CHARTS

Table 5 Computing fraction defective for December, 2017

Day	Prod.	Defectives	P	Day	Prod.	Defectives	P
1	46	6	0.1304	15	40	4	0.1000
2	128	8	0.0625	16	80	11	0.1375
3	129	3	0.0232	17	115	7	0.0608
4	112	10	0.0892	18	119	4	0.0336
5	124	3	0.0241	19	82	9	0.1097
6	132	4	0.0303	20	72	2	0.0277
7	128	2	0.0156	21	63	6	0.0952
8	178	1	0.0056	22	98	6	0.0612
9	96	7	0.0729	23	95	11	0.1157
10	159	8	0.0503	24	92	7	0.0760
11	190	9	0.0473	25	79	9	0.1139
12	176	6	0.0340		2825	194	
13	90	10	0.1111				
14	136	18	0.1323				

Figure 9 shows the p-chart and it has been constructed with control limits (*UCL*=0.139, *CL*=0.0686, and *LCL*= 0) shown on upper right side of the chart

After slight improvement in defects the revised control charts (*p*-chart) indicate that the process is in-control.

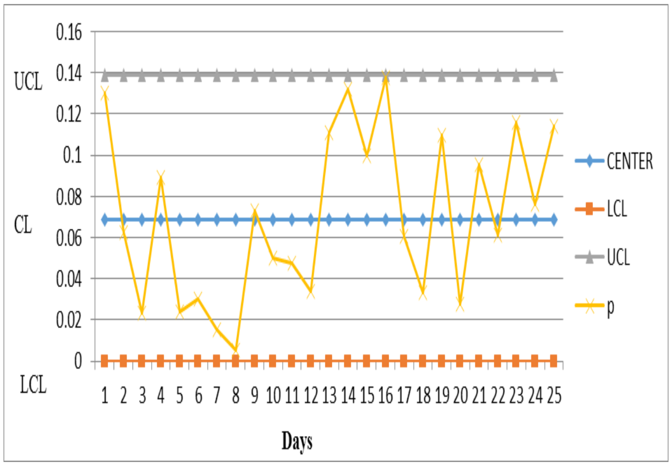

Figure 9 P-chart to illustrate process condition for December, 2017

4. RESULTS AND DISCUSSIONS

Based on the collected data of Modine Top Tank Radiators, the SPC analysis is carried out for before and after implementing the suggested plans and found that the revised control charts indicate that the process is in control with suggested plans. Based on solution on that problem effect on production is changed as increase in productivity or reduction of rejection rates which is provided as below table 6.

Table 6 Comparison of SPC results after implementation of suggested plans

Methodology	**Production per month**	**Rejections per month**	**Rejection percentage**
Before SPC	2862	454	15.86%
After SPC	2500	194	7.76%

This process is continued until for zero rejections.

5. CONCLUSION

Quality prompts change in efficiency and it additionally upgrade the consumer loyalty. Study has been directed to execute SPC instruments and procedures in assembling industry. The fundamental objective of this investigation is distinguish the deformity and recommend a superior answer for enhance the generation line execution on usage of SPC instruments in assembling process with a specific end goal to limit the dismissal and improve.

Quality apparatuses i.e. Pareto graph, Cause and impact outline and control diagrams are utilized to recognize and assess distinctive deformities and reasons for these imperfections in charge of dismissal/adjust of materials at various stages (In process, Final Stage).

Quality Control Tools could enhance process execution by diminishing item changeability and enhances creation productivity by diminishing piece and adjust.

ACKNOWLEDGEMENTS

Authors are thankful to S.V.U. School of Engineering and M/s. Seibar Auto Parts Limited, Tirupati for doing the task and supply of fundamental instruments and information for finish of this work.

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