Implementation of Statistical Quality Control Techniques to Minimize the Casting Defects

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Abstract – *Metal casting is complex process which contains several sub processes such as mold making, melting, pouring, heat treatment, cleaning and finishing. Many methodologies have been attempted in foundries to minimize the casting defects occurred during these processes. Still wastage in production process is rapidly growing due to inefficient process planning and changes in the customer requirement. This leads to increase in production cost of the product being manufactured. In order to reduce these defects and improve the process efficiency, statistical quality control (SQC) techniques can be used. This research paper deals with analyzing the root causes of defects and suggesting the necessary improvements in order to minimize the occurrence of defects. For analysis of defects statistical quality control tools such as cause and effect diagram, Why-Why analysis is utilized and necessary improvements have been suggested. Implementation of SQC techniques result in overall productivity improvement of the manufacturing firm through reduction of resource consumption.*

Key Words: Foundry, Casting, defects, Statistical quality control, productivity,

1. INTRODUCTION

Casting industry favour referring to the deviation in less-than-perfect castings as discontinuities, these imperfections are more commonly referred to as casting defect. Some casting defects may have no effect on the function or the service life of the cast component, but it will give an unsatisfactory appearance or will make further processing, such as machining more costly. Many such defects can be easily corrected by using simple steps such as hot blast cleaning or grinding. Other defects that may be more difficult to remove can be acceptable in some circumstances. It is most critical that the casting designer understand the differences and that he writes specifications that meet the true design needs.

It is suggested that the foundries follow the low cost methodology with the exception that a process optimization is used instead of the conventional trial and error method.

1.1 Casting Process

Casting is the process in which metal in the molten state is poured into mould cavity and allowed to solidify in to a shape. The mould may be expendable or permanent. Founding has been shaping the metals since earliest day of civilization. A wide variety of sizes and shape of sample and intricate nature can be produced in different metals. Casting is the process of producing metals and alloy component part of required design shapes by pouring the molten metal/alloy into a prepared mould and then allowing cooling and solidifying. The solidified piece of metal/alloy is known as casting.

The whole process of producing castings may be classified into 5 stages -

1. Pattern making-

In pattern making section, the patterns are designed and prepared as per the drawing of casting received from the planning section and according to the moulding process be applied. The material of the pattern may be selected from wide range of alternatives available, the selection depending on factors such as no. of casting required, the possibility of repeat orders, and the surface finish desired in the casting. Core boxes needed for the making cores and all other auxiliary tooling items are also manufactured in the pattern making section.

2. Moulding and core making-

After the patterns are prepared, they are sent to the moulding section. The moulds are prepared in either sand or a similar material with the help of the patterns so that the cavity of the desired shape is produced. For obtaining hollow portions, cores are prepared separately in the core boxes. The moulds and cores are then baked to import strength and finally assembled for pouring. The moulding work may be carried out either by hand or with the help of machines, depending on the output required. Proper mould design and arrangement for flow of molten metal is very important for the production of sound castings.

3. Melting and casting-

The metal of correct composition is melted in a suitable furnace. When molten, it is take into ladles and poured into moulds. The moulds are then allowed to cool down so that the metal solidifies. The castings are finally extracted by breaking the moulds and are then send to the cleaning section.

4. Fettling-

The castings as obtained from the moulds are not fit for immediate use or for work in the machine shop as they carry unwanted metal attached in the form of gates and risers. Sand particle also tends to adhere to the surface of the castings. The castings are therefore send to the fettling section where the unnecessary projection cut off, the adhering sand removed, and the entire surface made clean and uniform. The castings may also needs heat treatment depending on the required specific properties.

5. Testing and inspection-

Finally, before the casting is dispatched from the foundry, it is tested and inspected to ensure that it is flawless and conform to the desired to the specification. In case any defects or short coming are observed during inspection which may render to the casting unfit, analysis is necessary to the determine causes of this defect, so as to prevent their recurrence. Production process then has to be corrected accordingly. Statistically quality control has been applied in order to achieve consistent quality of manufactured product with minimum cost. Foundry mechanization and modernization are also of considerable importance today when foundry has evolved from an ancient art into a modern. Computers have entered in all industrial applications, and more so in foundry technology as well. Foundry Technology also includes the use of CAD/CAM for design optimization and simulation, and process control at various stages of production.

1.2 Defects-

Foundry industry suffers from poor quality and productivity due to the large number of process parameters, combined with lower penetration of manufacturing automation and shortage of skilled workers compared to other industries. Global buyers demand defect-free castings and strict delivery schedule, which foundries are finding it very difficult to meet.

Casting defects result in increased unit cost and lower morale of shop floor personnel. The defect need to be diagnosed correctly for appropriate remedial measures, otherwise new defect may introduce. Unfortunately, this is not an easy task, since casting process involves complex interactions among various parameters and operations related to metal composition, metal design, moulding, melting, pouring, shake-out, fettling and machining. For example, if shrinkage porosity is identified as gas porosity, and the pouring temperature is lowered to reduce the same, it may lead to another defect, namely cold shut.

So far, casting defect analysis has been carried out using technique like cause effects diagram, design of experiment, if-then rules (expert systems), and artificial neural networks. Most of the previous work is focused on finding process-related causes for individual defects, and optimizing the parameter values to reduce the defects. This is not sufficient for completely eliminating the defects, since parameters related to part, tooling and method design also affect casting quality, and these are not considered in conventional defect analysis approaches.

In this work, we present 2 step approach to casting defect identification, analysis and rectification. The defects are classified in terms of their appearance, size, location, consistency, discovery stage and inspection method. This helps in correct identification of the defects. For defect analysis, the possible causes grouped into design, material and process parameters. The effect of suspected cause parameters on casting quality is ascertained through simulation. Based on the results and their interpretation, the optimal values of the parameters are determined to eliminate the defects.

Types of defects:

1. Shift

A shift results in a mismatch of the sections of a casting usually at a parting line. This defect is usually easy to identify. Unless the error cause due to mismatching is within the allowable variation on the casting, it cannot be rectified and the casting has to be scrapped.

2. Warpage

Warpage is an undesirable deformation in a casting which occurs during or after solidification. Large and flat sections or intersecting sections are particularly prone to warpage. A proper casing design can go a long way in reducing the warpage of the casting. A judicious use of ribs can be prevent the warping tendency, but an incorrect placed ribs may worsen defect.

3. Swell

A swell is an enlargement of the mould cavity by metal pressure, resulting in localised or overall enlargement of the casting. It may be caused by insufficient ramming of the sand. If molten metal is poured too rapidly, a swell may occur. Insufficient weighing of the moulds during pouring may also cause to cope to lift, giving a swell.

4. Fin

A thin projection of metal, not intended as a part of casting is called as fin. Fins usually occurs at the parting of the moulds or the core sections. A 'run-out' of a molten metal may be considered as extreme type of fin. Moulds and cores incorrectly assembled will cause fins.

5. Blowhole-

Blowholes are smooth and round holes clearly perceptible on surface of casting. They may be either in the form of a cluster of a large number of small hole having diameter of about 3 mm or less or in the form of one large and smooth depression.

6. Pin hole-

Pinholes are numerous holes of small diameter, usually less than 2 mm, visible on the surface of the casting. They are caused by the absorption of hydrogen or carbon monoxide when the moisture content of sand is high or when steel is poured from wet ladles or is not sufficiently degasified.

7. Gas holes-

Gas holes are those holes that appear when surface of casting is machined or when the casting is cut into sections. If the core prints are of inadequate size, gas cannot escape from the mould as fast as it is generated in cores

8. Shrinkage cavity-

Shrinkage cavity is a void or depression in casting caused mainly by uncontrolled and haphazard solidification of the metal. It may due to wrong location or improperly size gating system, inadequate risers, or poor design of casting involving abrupt changes of sectional thickness.

9. Porosity-

Porosity is also due to gas formation and gas absorption by the metal while it is poured. The metal may dissolve some gas or air from the mould or core faces. This gases are liberated later when the metal cools, living behind porosity in the casting.

10. Drops-

Drop occurs when the upper surface of the mould cracks and pieces of sand fall into the molten metal. Sand having too low green strength, soft ramming or insufficient reinforcement of mould may cause this defect.

11. Metal penetration and Rough surfaces - This defect appears as an uneven or rough external surface of casting. It may cause when the sand has too high permeability, large grain size, and low strength. Soft ramming may also cause metal penetration.

12. Scabs-

Scabs are a sort of projection on the casting which occur when a portion of mould face or core lifts and metal flows beneath in a thin layer. Scabs can be recognized as rough, irregular projections on the surface containing embedded sand.

13. Cold Cracks-

Cold cracks are similar in appearance and formation to hot tears except that the breaks are less ragged and cracks occur at temperature below 430$^{\theta}$C.

14. Cold shut and Mis-run

A cold shut is a defect in which discontinuity is formed due to the imperfect fusion of two streams of metal in the mould cavity. The defect may appear like a crack or seam with smooth rounded edges. Mis-run casting is one that remains incomplete due to the failure of metal to fill entire mould cavity

1.2 Inspection & Testing of Casting –

Two basic objectives of inspection are to reject castings that fail to meet the customer's requirements and to serve as a means of maintaining the quality of workmanship and materials used in foundry. Inspection of casting broadly covers a large number of methods and techniques used to check the quality of castings. These methods may be classified into categories:

1) Visual Inspection

2) Dimensional Inspection

3) Mechanical and Chemical Testing

4) Flaw detection by non-destructive methods

5) Metallurgical Inspection

2. STATISTICAL QUALITY CONTROL

There are seven basic tools employed for SQC. The seven basic tools of quality is a designation given to a fixed set of graphical techniques identified as being most helpful in trouble shooting 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. These seven basic tools are as below.

1. Check Sheet
2. Histogram
3. Pareto Analysis
4. Control Charts
5. Cause and Effect Analysis Diagram
6. Flow Chart
7. Scatter Diagram

3. PROBLEM STATEMENT-

Higher level of rejection of casting due to defects is a matter of concern for any foundry industry. The quality of casting is influenced by various process parameters. Influence of different process parameters causing rejection needs to be identified and further be analysed, for purpose of establishing control over the process and optimizing the process in foundry.

4. OBJECTIVES-

1. To identify the defects and find root causes.

2. To analyse causes of defect and find solution.

3. To minimize scrap.

4. To reduce overall cost of production.

5. To suggest and implement corrective and preventive measure and evaluate their effectiveness.

8. To create implementation plan to establish and control standard parameters in order to reduce rejection.

5. STEPS INVOLVED IN METHODOLOGY-

Data collection –

The rejection data for a month period were collected and drawn as line graph. The total rejection percentage for this casting varies from 8% to as high as 20%. The rejections were distributed to all the days of the production.

Study of all the defects –

The next step in the analysis is to study all the casting defects occurred during the castings process thoroughly through various data representation techniques.

Identify major defect

A Pareto chart can be drawn using the rejection data of the casting to identify the major defects.

Detailed analysis of the major defect

The detailed analysis of this major defect is made in this step. It is essential to know whether the defect was occurring in particular days of production or it was distributed to all the days of production in the study period. A bar chart can be made for this major defect for all the days of production

Determine all causes –

The porosity defect appears due to entrapped gases on the surface of casting, during solidification. Also it might be the result of irregular refinement of the grains of material during solidification. The possible causes for this defect due to various parameters and processes are found out with the help of Cause- Effect diagram. In this way root cause for the formation of porosity defect is determined.

Selection of Root cause –

The detailed examination of rejected castings is required to identify the root cause for this major porosity defect. For reducing this defect, the proper analysis of the component is required. There are various software's are available for this purpose. The analyzed component is then simulated to get the exact location of this porosity defect. So further we found that the porosity is occurring only at the surface of the casting.

This major porosity defect can be reduced only by many ways as follows:

- By changing the material composition
- By changing the inoculation material
- By checking the mould and gating design
- By focusing on physical parameters like pouring as well as holding temperature, pouring time etc.

Selection of the best solution –

The best solution can be selected according to the available resources. This is one of the general methods to analyse the cast component which helps for finding the exact causes behind the defect. This further helps to find the corrective action to be taken to minimize the same defect.

Table-1: Defects and Rejected Quantity

DEFECTS	Gas porosity	Cold shut	Sand inclusion	Shift	Fusion
REJECTED QUANTITY	171	155	152	85	25

Core damage	Damage	Leak	Ex metal	SK	MD	Slag
23	21	21	18	11	5	5

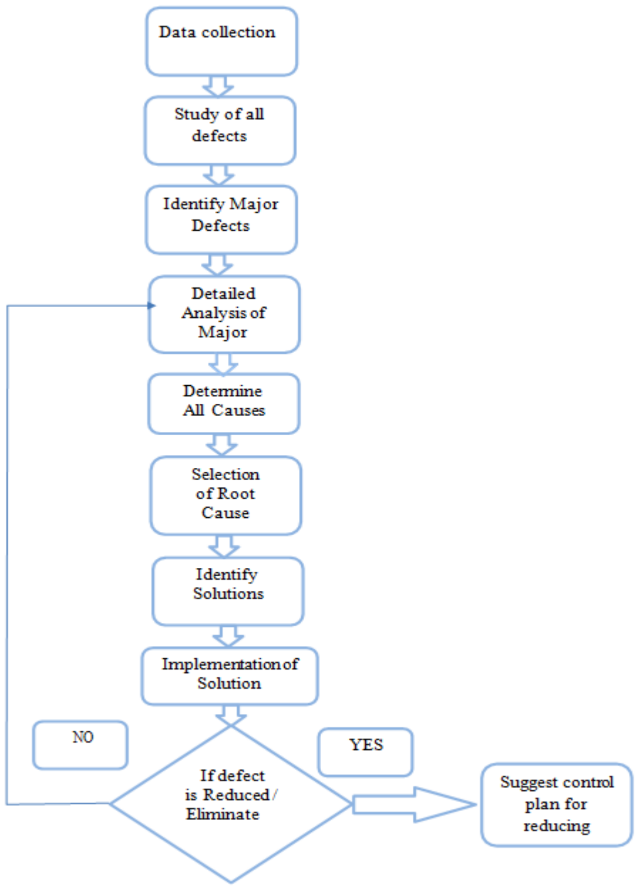

Fig -1: Methodology

6. DATA COLLECTION AND SELECTION OF DEFECTS –

Selection of casting defect is second step after selection of components for study. The foundry unit under consideration has variety of casting defects. Broadly they can classified as defect due to sand, defect due to gases, defects due to pattern, defects due to temperature, defect due to cores, defects due to gating system.

The defects recurring at the foundry can be listed as sand drop, sand inclusion, fusion, slag inclusion, cold shut, crack, blow holes, gas holes, scrap, leak and shift.

For Pareto analysis, first step is to record the defect wise data for every 3 months with their quantities. The rejection quantity will be composition of both casting rejection as well as machine rejection. The monthly poured quantity and its weight along with rejection quantity and its weight is required. Next step is to tabulate all the collected data. Table will have defect name, month, poured quantity, rejected quantity and rejection percentage. With all these, tabulated data construct a graph. For simpler representation of graph, needs defect name with its quantity. To select major defect Pareto analysis is carried out

Table-2: Major defects

Months	Poured Qty.	Rejected Qty.	Rejected %	Sand Inclusion
Sept.	1224	134	10.9	25
Oct.	1250	139	11.1	22
Nov.	1908	181	9.48	22

Months	Shift	Gas Porosity	Cold shut
Sept.	4	64	25
Oct.	24	11	46
Nov.	25	36	74

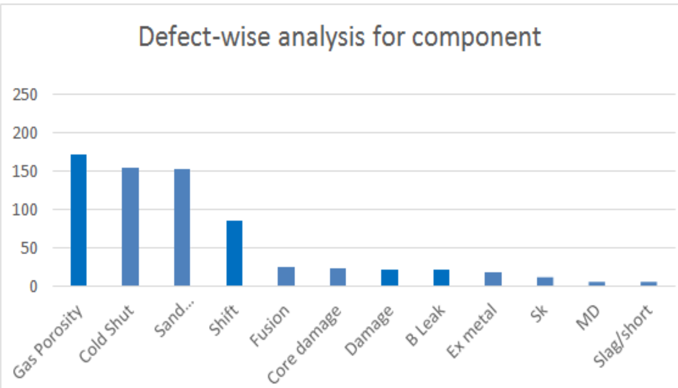

Fig -2: Defect wise analysis for component

Pareto analysis shows that Gas porosity, Cold shut, Sand inclusion, Shift constitute for higher proportion of rejected quantity than other defects. Other defects are less in quantity but they also have the cumulative impact on overall rejection percentage. They will have less focus but main focus will be on defects which are having higher percentage.

The other defects can be simultaneously controlled by taking corrective actions or preventive measures. After selecting different processes, parameters as a cause of major defects, we can group all the major and minor defects to control their rejection percentage.

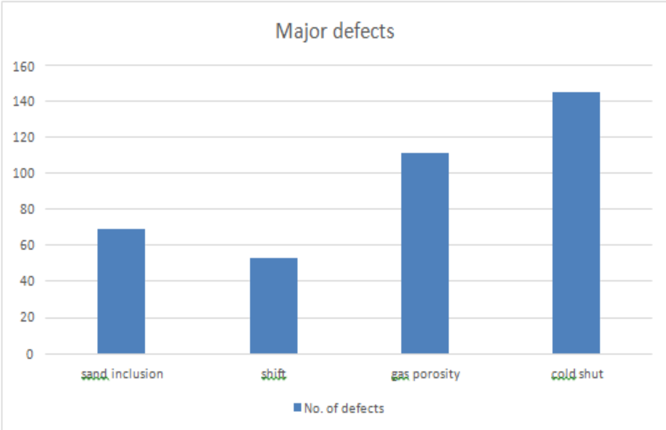

Fig -3: Major Defects Bar graph

6.1 WHY-WHY Analysis

"Why-Why" analysis is used to structure the ideas during brainstorming process to explore the possible root causes.

The technique was originally developed by Sakichi Toyoda and was later used within Toyota Motor Corp during the evolution of their manufacturing methodologies.

The following steps will be used in Why-Why analysis for identifying the root cause of the problem.

Ask "Why" that is what are the first level of causes of the problem. Then write each cause on the Diagram.

For Each Cause, ask "Why" again and write the answers in the next column, linked to the previous answer.

Keep asking "Why" until no more answers can be suggested.

Use the Causes listed, especially those on the last level of the diagram, to generate possible solutions.

Review data for evidence along with causes which are most important; gather fresh data if necessary.

6.2 Shift–

This mould defect is because of the shifting of cope and drag from its original position. It causes the dislocation at the parting line.

Fig -4: Shift

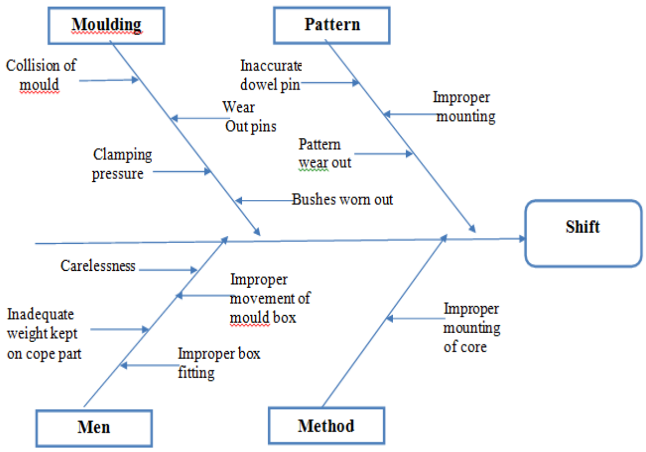

Fig -5: Ishikawa Diagram for Shift

Fig shows the possible causes of shift defect. Shift is variation in concentricity of all diameters of the component. The parting line is perpendicular to the axis of bush and the pins are used for aligning the two halves of pattern. The Ishikawa diagram suggests, there is imbalance at the match plate. After research we found that, there are number of possible causes for shift defect, which are divided into main causes and they are again sub-divided into sub-causes or they are also called as root causes. The main four causes are Moulding, Pattern, Men and Method. Then it gives sub-causes like carelessness, Improper mounting of core, Wear out pins. It will help to find out root cause and then applying remedial actions for that causes. Following table shows the summery of causes and remedial actions.

SR.NO.	MAIN CAUSES	SUB CAUSES	REMEDIAL ACTION
1	Pattern	Improper pattern mounting	Mounting of pattern at exact place
		Inaccurate dowel pin	Checking dowel pins periodically or replacing it if necessary.
2	Moulding	Wear out pins	Replacement of weared out pins.
		Clamping Pressure is uneven.	Adequate clamping pressure on both sides.
3	Men	Inadequate weight kept on cope part.	Use of adequate and enough weight.
		Improper Movement of mould box.	Careful and proper handling of mould box.
4	Method	Improper mounting of core.	Proper mounting of core

Table-3: Causes and remedies

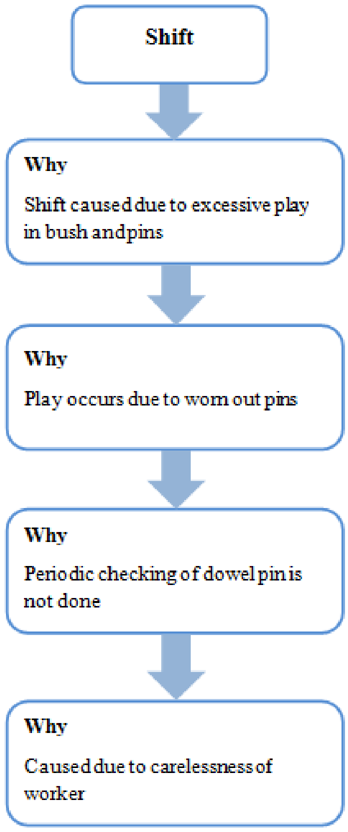

Fig -6: Why-Why analysis

6.3 Cold shut –

Cold shut is a crack with round edges. Cold shut is because of low melting temperature or poor gating system

Fig -7: Cold Shut Defect

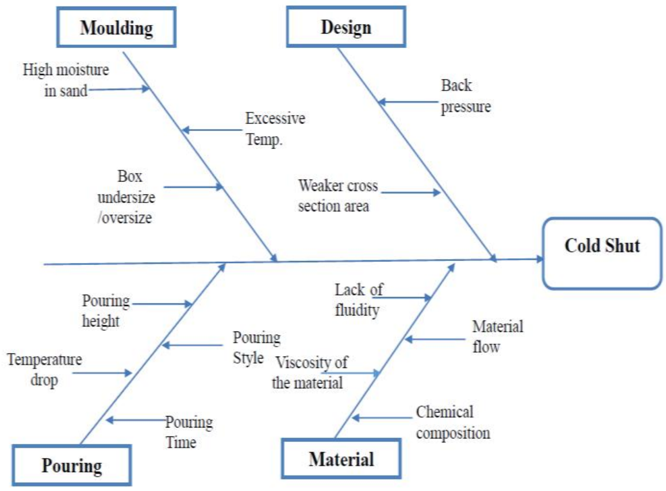

Fig -8: Ishikawa Diagram for Cold Shut

Fig shows the possible causes of cold shut defect. Cold shut is a crack with round edges. Cold shut is because of low melting temperature or poor gating system. The Ishikawa diagram suggests, more time is taken for poring. After research we found that, there are number of possible causes for cold shut defect, which are divided into main causes and they are again sub-divided into sub-causes or they are also called as root causes. The main four causes are Moulding, Design, pouring and Material. Then it gives sub-causes like Temperature drop, lack of fluidity, High moisture in sand. It will help to find out root cause and then applying remedial actions for that causes.

Following table shows the summery of causes and remedial actions.

SR.NO.	MAIN CAUSES	SUB CAUSES	REMEDIAL ACTION
1	Material	Lack of fluidity	Increasing the fluidity by the use of additives.
		Chemical composition	Maintaining pro per compositions.
2	Moulding	High moisture in sand	Removal of moisture in sand.
		Clamping pressure is	Adequate clamping pressure on both sides.
3	Pouring	High pouring time	Reducing time required to pour.
		Temperature drop	Use of insulation to avoid heat loss

Table-4: Causes and Remedies

Cause- Remedies

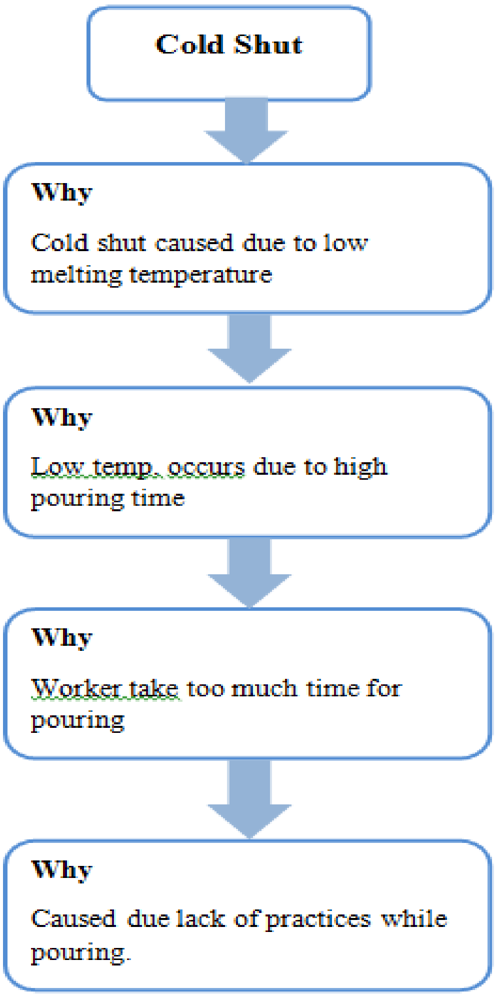

Fig -9: Why-Why analysis

6.4 Sand Inclusion-

In sand inclusion areas of sand are often wash away by the metal stream and then float to the surface of the casting

Fig -10: Sand Inclusion Defect

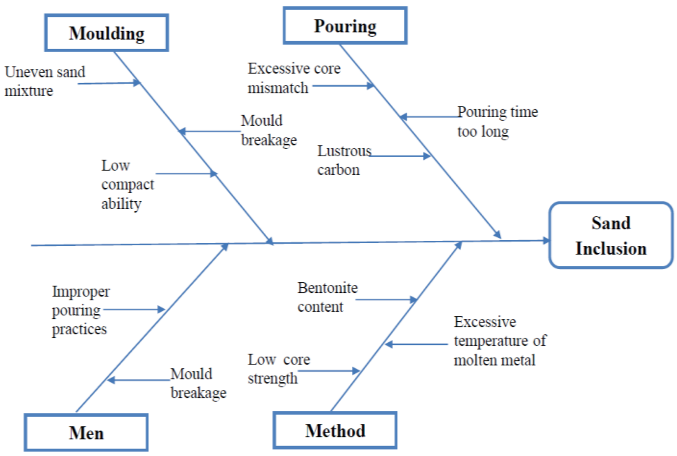

Fig-11: Ishikawa Diagram for Sand Inclusion

Fig shows the possible causes of Sand inclusion defect. In sand inclusion areas of sand are often wash away by the metal stream and then float to the surface of the casting. The Ishikawa diagram suggests, there Bentonite content and quality is low or poor. After research we found that, there are number of possible causes for sand inclusion defect, which are divided into main causes and they are again sub-divided into sub-causes or they are also called as root causes. The main four causes are Moulding, Men, pouring and Method. Then it gives sub-causes Lustrous carbon, mould breakage, Bentonite content and quality. It will help to find out root cause and then applying remedial actions for that causes. Following table shows the summery of causes and remedial actions.

SR.NO.	MAIN CAUSES	SUB CAUSES	REMEDIAL ACTION
1	Men	Improper pouring practices	Provide proper training
		Mould breakage	Proper handling of mould while assembly
2	Moulding	Uneven sand mixture	Use of proportionate additives
3	Pouring	Excessive core mismatch	Proper core placing in mould
		Less percentage of lustrous carbon	Increasing percentage of lustrous carbon
4	Method	Bentonite content to low	Increasing of Bentonite percentage.

Table-5: Causes and Remedies

Why-Why Analysis

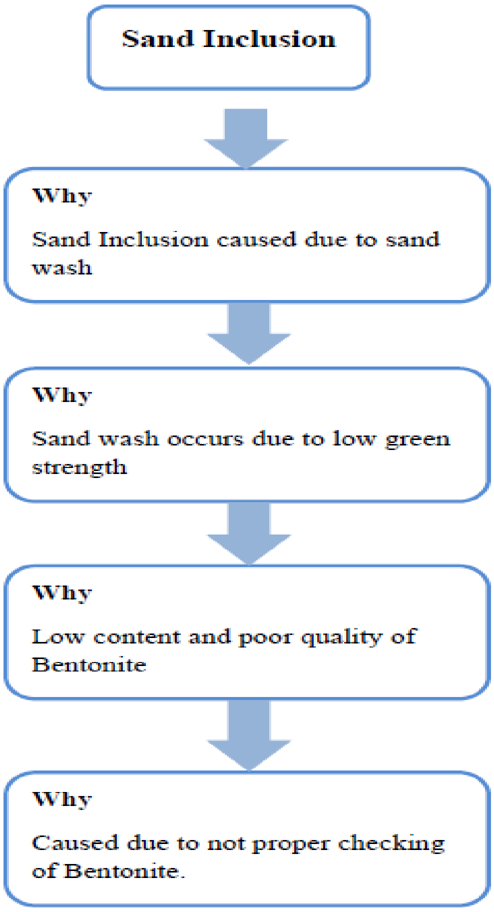

Fig -12: Why-Why analysis

6.4 Gas Porosity-

Air is present in the cavity before the pouring. It can easily be trapped as the metal starts to fill the cavity. The air is then compressed as more and more metal streams into the cavity and the pressure rises. When the cavity is full it becomes dispersed as small spheres of high pressure air. The swirling flow can cause them to become elo

Fig -13: Gas Porosity Defect

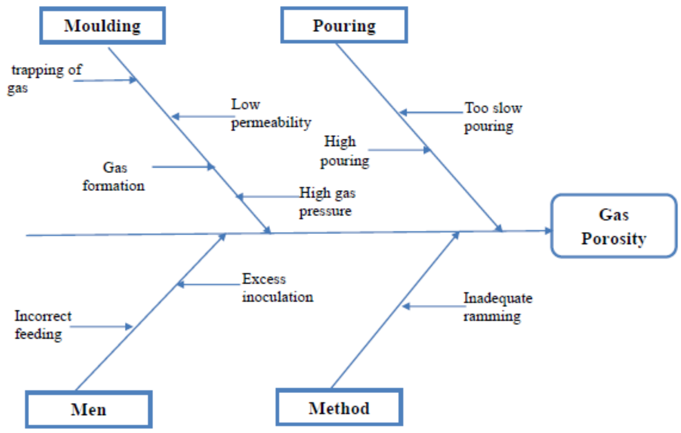

Fig -14: Why-Why analysis

Fig shows the possible causes of Gas porosity defect. In Gas porosity gas is trapped inside the mould cavity and cavities are produced on casting. The Ishikawa diagram suggests, improper venting causes trapping of gas. After research we found that, there are number of possible causes for gas porosity defect, which are divided into main causes and they are again sub-divided into sub-causes or they are also called as root causes. The main four causes are Moulding, Men, pouring and Method. Then it gives sub-causes trapping of gas, too slow pouring, low permeability. It will help to find out root cause and then applying remedial actions for that causes. Following table shows the summery of causes and remedial actions.

SR.NO.	MAIN CAUSES	SUB CAUSES	REMEDIAL ACTION
1	Men	Incorrect feeding	Continuous pouring.
2	Moulding	Trapping of gas.	Provide sufficient vents.
3	Pouring	Too slow pouring.	Moderate pouring speed.
4	Method	Inadequate ramming	Ramming with moderate pressure.

Table-6: Causes and Remedies

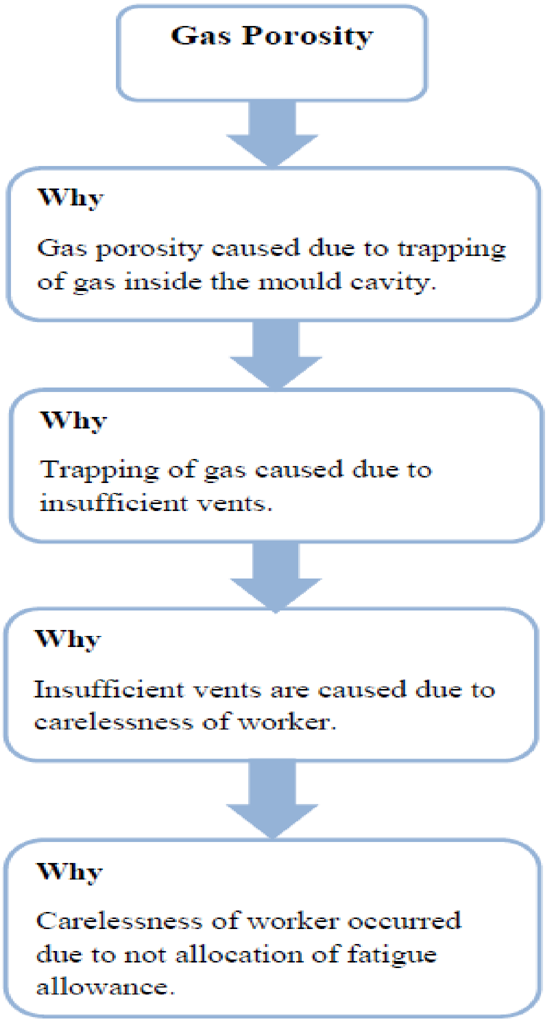

Fig -15: Why-Why analysis

7. SUGGESTION

1) As mention above, Shift is caused due to worn out pins, so we suggest that to replace mould pins. To check the pins in regular interval and replace pins if required. Instructions were given to the operators for ensuring the proper checking of pins.

2) Proper mounting patterns on match plate is necessary. If pattern is not placed properly or lifted or tilted from any one side shift can occur. After pouring moulds can lift, to avoid this some weights are kept on it or clamping is done. We suggest that weights kept on boxes are distributed equally and clamping should be firm while applying equal pressure on both side so it will not lift and shift doesn't occur.

3) We suggest that workers should handle mould boxes with care and movement of boxes should proper which will avoid collision of mould boxes. It will reduce shift defect.

4) As mention above, cold shut caused due to various reasons one of those is pouring time which is important to reduce. So we suggest reducing the pouring time

By Calculation,

Pouring Time (t) =

$T = K^* [1.41 + T/14.59] \sqrt{w}$ sec.

K = Fluidity of iron in inches / 40.

T = average section thickness, mm.

W = Mass of casting, kg

$T = 28/40 * [1.41 + 28/14.59] * \sqrt{12.5}$

T = 8.23 sec.

Time required for pouring right now is around 20 second and by calculation or theoretically it is around 8 second. But it is difficult to achieve 8 second, so we suggest that time reduce up to around 14 second which will reduce pouring time as well as possibility of causing cold shut.

5) Sometime cold shut is caused due to temperature drop while pouring. To reduce temperature drop we suggest using insulation to avoid heat loss. Cold shut is also caused due to lack of fluidity to remove this we suggest to use additives to increase the fluidity. Maintain chemical composition in sand

6) As mention above, sand inclusion is caused due to poor quality of Bentonite. So we suggest to take a sand test and check the quality of Bentonite and also to increase the quantity of Bentonite as per required green strength.

7) Sand inclusion is also caused due to less percentage of lustrous carbon. Lustrous carbon forms a thin film /layer of carbon between casting and sand which provide gap between sand and casting which doesn't allow sand to stick over casting. So we suggest increasing the percentage of lustrous carbon.

8) Also we suggest removing sharp edges on pattern if any.

9) Also due to Excessive temperature of molten metal (more than required) sand wash can be occur. So we suggest that not to increase the temp. of molten metal than required and maintain the temperature of molten metal across whole moulding line.

10) Due to improper pouring practices or carelessness of worker cold shut occur. So we suggest giving proper training.

11) As mentioned earlier, gas porosity is mainly caused due to trapping of gas inside mould, to remove this we suggest to provide extra vents. Also due to improper feeding gas porosity can occur so we suggest doing continuous feeding with moderate rate and improving pouring practices. Also due to improper ramming it can happen so we instructed to do proper ramming.

8. RESULTS

SR. NO.	DEFECTS	POURED QTY BEFORE RM	REJECTION QTY BEFORE RM	POURED QTY AFTER RM	REJECTION QTY AFTER RM	REDUCTION IN REJECTION
1.	SHIFT	1460	15 (147)	1030	6 (121)	51.48
2.	COLD SHUT	1396	23 (142)	1230	14 (140)	38.24
3.	SAND INCLUSION	1389	27 (143)	862	10 (94)	43.7
4.	GAS POROSITY	1146	32(128)	552	14 (63)	11.12

Table-7: Comparison Table

Above table shows the difference/ comparison table of defects reduction before and after remedial measure or after implementation of suggestion. This table contains types of defects, quantity of poured casting before remedial measure. In next column it shows quantity of rejected components before remedial measure and bracket value indicate the total no. of defects and outside value is of that particular defect quantity

Next column shows poured quantity of casting after apply remedial measure. Second last column shows rejected quantity after remedial measure. Last column shows percentage of reduction in rejection in casting.

As we see in above table, Shift defects is reduced by 51.48 % as previous statistics is 15 defects was of shift out of 147 but after remedial measure it is down to 6 defects in 121 overall defects.

Cold shut defect is reduced by 38.24% as previously 23 defects were of cold shut out of 142 but after remedial measure it goes down to 14 defects in 140 overall defects

Sand Inclusion defect is reduced by 43.7% as previously 27 defects were of Sand inclusion out of 143 but after remedial measure it is further reduced to 10 defects in 94 overall defects. Gas Porosity defect is also reduced by 11.12% as previous stat is 32 defects was of Gas porosity out of 128 but after remedial measure it is down to 14 defects in 63 overall defects.

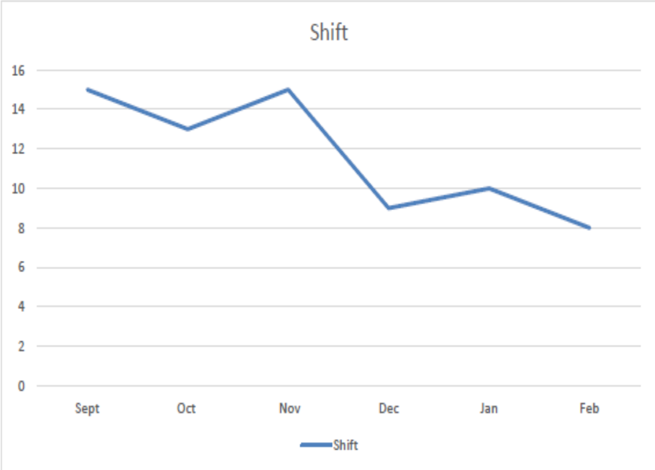

Fig -16: Reduction in Shift defect

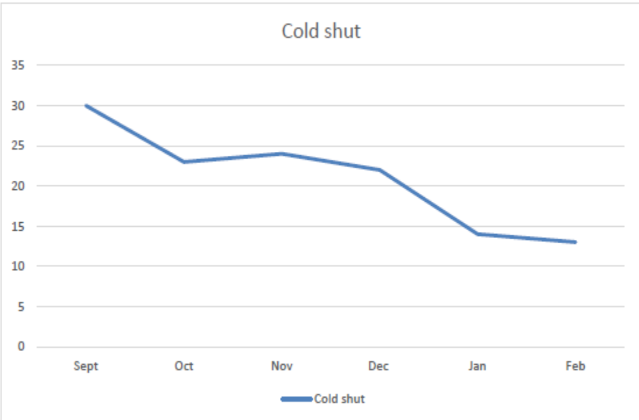

Fig -17: Reduction in Cold Shut defect

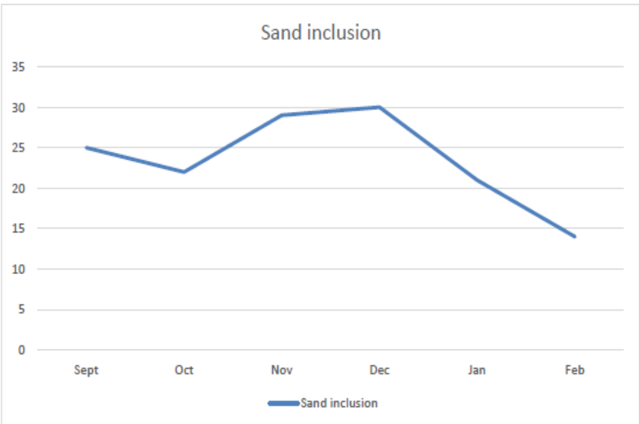

Fig -18: Reduction in Sand Inclusion defect

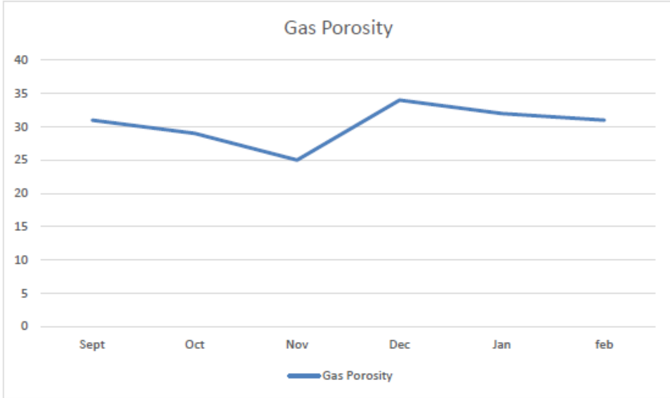

Fig -19: Reduction in Gas Porosity defect

Above all graphs shows the reduction in defects. All charts are of type of control charts used as Statistical Quality Control tool. First graph shows the reduction in rejection percentage of shift defect. Second graph shows the reduction in rejection percentage of Cold shut defect. Third graph shows the reduction in rejection percentage of Cols shut defect. Last graph shows the reduction in rejection percentage of Gas porosity defect.

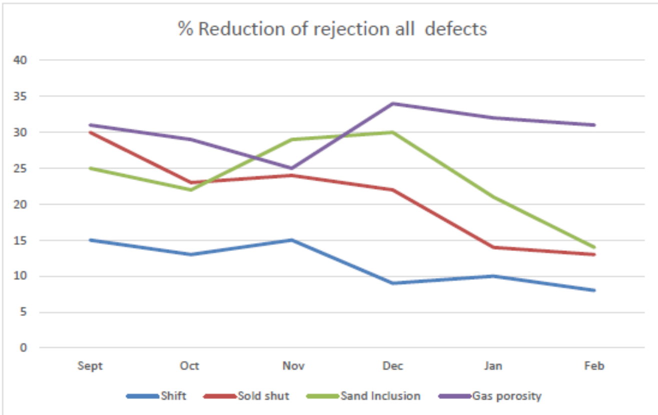

Fig -20: Percentage Reduction in all defects

Comparison pictures

Fig -21: Defects Comparison

9. CONCLUSIONS

The quality of casting depends on different process parameters of whole casting process. Pouring temperature, pouring time, quality of parameters are identified.

To identify root cause, three quality control tools Ishikawa Diagram, why-why analysis and brain storming are used in work.

Diagnostic study carried out on castings revealed that the contribution of the four prominent defects in casting rejections are Shift, Cold shut, Sand inclusion and Gas porosity.

Production trials were carried out in the foundry for three months period by incorporating the remedial measures and validated. Outcome of the results showed substantial reduction in rejection of castings. Company has accepted and adopted the remedial measures suggested in the production methods, also suitably modified the standard operating procedure.

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