iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VIII **Month of publication:** August 2021

DOI: https://doi.org/10.22214/ijraset.2021.37636

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VIII Aug 2021- Available at www.ijraset.com

Minimization of Casting Defects using SQC Tool

Abhijit M. Mane[1], Rhaul A. Pasale[2]
[1, 2]*Department of Mechanical Engineering, Ashokrao Mane Group of Institutions, Vathar tarf Vadgaon, Maharashtra*

Abstract: ***Casting is most widely used manufacturing technique. During casting process, number of defects in the casting takes place. In this research, Statistical Quality Control tool is used to minimize the defects. Paretro analysis technique is used to find out the defects in the castings. Recommendations are implemented in the casting line. Improved quality of casting and reduction of defects are found after the implementation of SQC tool.***
Keywords: Casting, Defect, Why-Why analysis, Shift, Manifold

I. INTRODUCTION

A. Casting

Metal casting is a complicated process which include various sub processes for example pattern making, mold & core making, melting & pouring, heat treatment, cleaning & finishing. Various methodologies are tried in foundries to minimize casting defect & improve profitability. Another important concern that, Indian companies already taken measure for improving their ability to face the global competition and reduce the rejection. Now days wastage in production process is increasing rapidly because of change in need of costumer. It results into increasing the production cost, especially foundry business in India is yet trying hard to meet customers demand at lower process cost.

In the casting industry, discontinuities are used to describe deviations in less-than-perfect castings; nevertheless, these imperfections are more often referred to as casting defects. Some casting defects have no impact on the cast component's function or service life, but It can also result in an undesirable appearance or require more processing, such as more expensive machining. Generally few defects can usually be easily repaired with only common sense, such as grinding or hot blast cleaning. Few defects may be more difficult for removal but it can be acceptable at some locations. The casting designer must be aware of the discrepancies and produce specifications that reflect the genuine design requirements.

Many factors are accountable for casting defects; hence statistical approach is not necessarily the optimum. For metal casting-related challenges, it is necessary to find out alternative and more elegant pattern recognition approach. The foundries should follow the low-cost methodology, with the exception that instead of the traditional trial-and-error method, process optimization should be applied.

B. History

Casting or founding is one of the oldest manufacturing process that goes back to around 4000 B.C. The manufacture and use of casting can be tress both in ancient and medieval history. The earliest axe heads of copper were cast in open (stone) moulds about 5000 years ago. Earlier castings were most likely composed of silver, gold, copper, bronze, etc. one existing life-sized portrait head of cast bronze from Mesopotamia antidates about 2250 B.C.

Decorated bronze casting could be seen in the European church and domestic life by the end of mediveal period. Cannon shots and grave slabs may have been among the first cast iron items. The 1st foundry come into existence in era of the Shang dynasty (1766-1122 B.C.) in china. Greek and roman history reveals use of metal bells & decorated ornaments.

In about 1540, Bringuccio wrote about metal founding. Previously founding was considered as art & craft and its secret limited with few families. Reaumur (1683-1757) experimenting with cast iron founding , produce malleable iron, and research the different elements that influence the manufacturing of Grey, White & Mottled irons. In 1709, Abraham Darby got succeeded in smelting in the coke blast furnace paving the way for the widespread usage of cast iron in construction. After the Industrial Revolution, a large number of foundries began using cast iron as a structural material (in Britain).

©IJRASET: All Rights are Reserved

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VIII Aug 2021- Available at www.ijraset.com

II. CASTING DEFECTS

Types of defects

A. Shift

A shift causes a mismatch between the sections of a casting, most commonly at the 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.

Mis-alignment of the flasks is the common reason for shift. The defect will be avoided by assuring accurate alignment of the pattern or die parts, moulding boxes, proper mounting of the patterns on the pattern plates, and pre-use inspection of pattern flasks, locating pins, and other items.

Like the shift of the two or more parts of the moulds, core shift may also occur due to misalignment of cores or core halves during assembly. It may also be the result of under sized or oversized core prints or the failure to use core sets, or if the chaplets are of the incorrect size. Core shift can be prevented by using prints and chaplets of the proper dimensions and design.

B. Warpage

Warpage is an unwanted distortion that occurs during or after the solidification of a casting. Large & flat sections or intersecting sections are particularly tends to warpage. Casting warpage can be reduced significantly with proper casing design. A judicious use of ribs can be preventing the warping tendency, but incorrect placed ribs may worsen defect.

Warpage may also be due to-

1) To small flask, which may cause rapid cooling of the edges or end of the casting
2) Weak flask, which may allow movement of the sand mould walls.
3) Inadequate gating system, which may prevent metal pouring from moving quickly.
4) Sand with too low green strength, which may cause it to move.
5) Non provision of camber allowance on the patterns, whenever necessary.

If warping cannot be altogether eliminated, extra warpage allowance may have to be provided along with the machining allowance so that it can be subsequently machined.

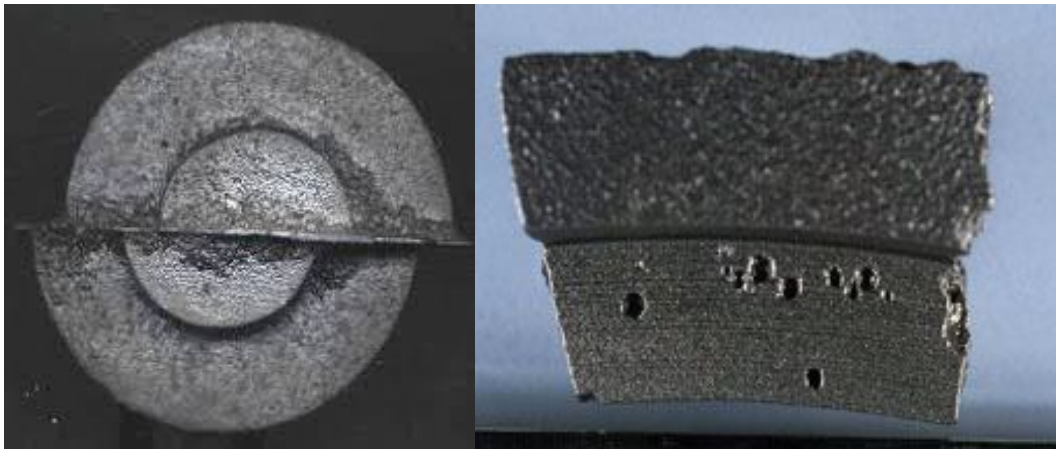


Fig. 1 Shift & Warpage

C. Swell

A swell is the result of metal pressure enlarging the mould cavity, resulting in localised or overall casting expansion. It may be result of insufficient ramming of the sand. If molten metal is poured too quickly, a swell may occur. Inadequate weighting of the moulds during the pouring process might potentially cause the coping to raise, resulting in a swell.

©IJRASET: All Rights are Reserved

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VIII Aug 2021- Available at www.ijraset.com

D. Fin

Fin is a thin projection of metal that is not meant to be a part of the casting. Fins are most commonly found near the separation of moulds or in the core sections.

A molten metal's 'run-out' could be regarded an extreme sort of fin. Moulds and cores incorrectly assembled will cause fins. 'Kiss cores' of shorter length than necessary may also give rise to fin. High metal pressures due to too long sprue insufficient weighing of the moulds, or inappropriate clamping of the flask may again generate the fin defect or, if the trouble is more critical, run-out may result.

Pattern which is too big for a given flask or kept too close to the flask edge may result in a weak spot and give rise to run-out. Improper sealing of moulding joints may also produce run-outs.

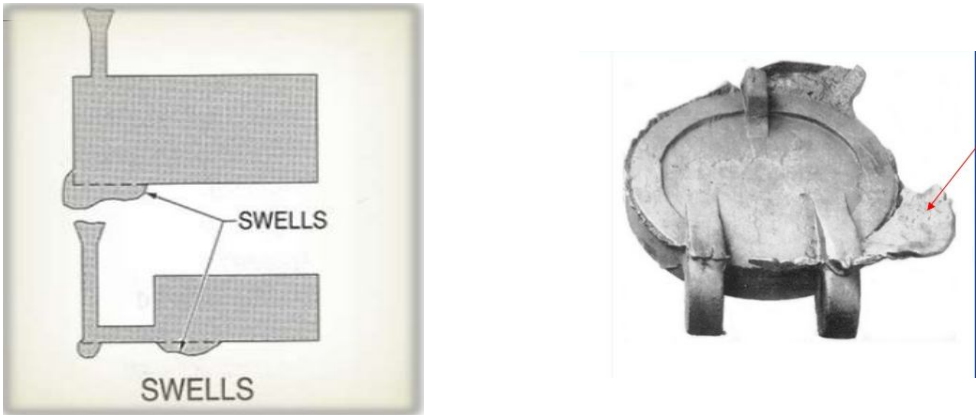


Fig. 2 Swell & Fin

E. Pin hole

Pinholes are small holes visible on the surface of the casting with a diameter of less than 2 mm. They are caused by carbon monoxide or hydrogen absorption when sand has a high moisture content, or steel is poured from wet ladles or is not fully degasified. By using good melting and fluxing procedures, reducing the moisture content of the moulding sand & increasing its permeability, and enabling a faster rate of solidification, the fault can be eliminated.

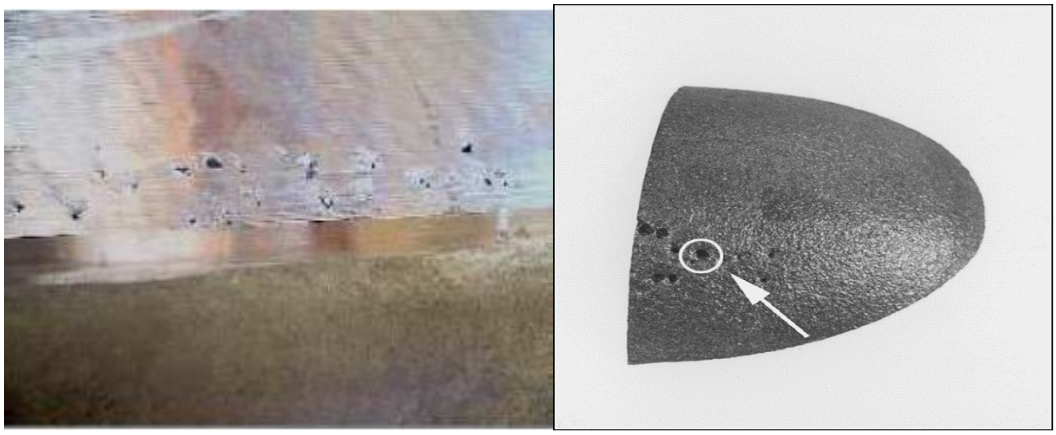


Fig. 3 Blow hole & Pin hole

F. 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. Accumulation gas from core may give rise to gas holes in casting. Faulty and poor quality of metal, the lack of control solidification, and excessively moist sand may also create gas hole.

©IJRASET: All Rights are Reserved

G. Shrinkage cavity

Shrinkage cavity is a void or depression in a casting created by unplanned and uncontrolled metal solidification. It may due to wrong location or improperly size gating system, inadequate risers, or improper design of casting involving abrupt changes of sectional thickness. Shrinkage may also be produced if the pouring temperature is too high. The defect can be minimized by using the directional solidification concept in mould design and using chilling, denseness, and cushioning sparingly.

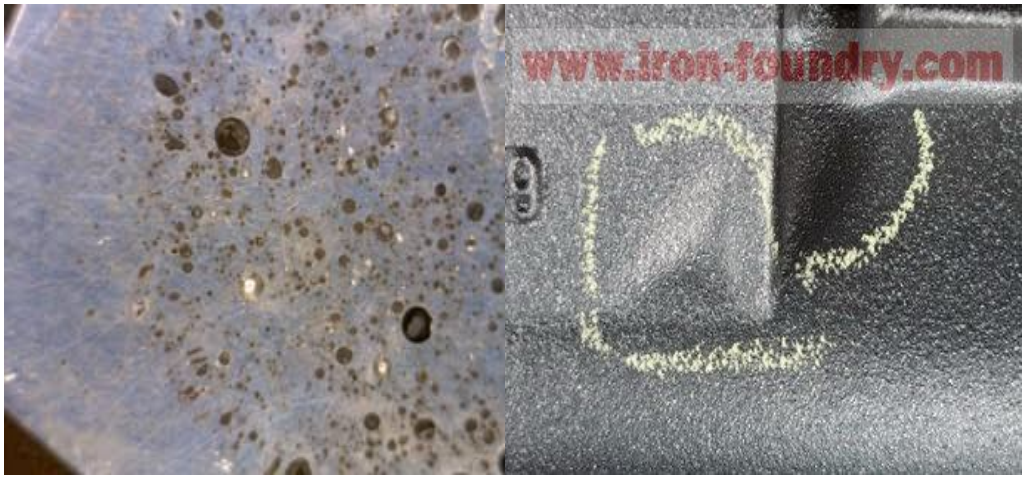


Fig. 4 Gas hole & Shrinkage cavity

H. Porosity

Porosity is also caused by gas formation and absorption by the metal during the pouring process. Some gas or air from the mould or core faces may be dissolved by the metal. When the metal cools, the gases that have been trapped behind the porosity in the casting are released. Obviously, the porosity defect may lead to leaking casting and reduce pressure tightness. Controlling the amount of gas-producing elements in the moulding and core-making sand mixes, as well as adequate metal fluxing, can help to minimise this defect.

III.INSPECTION AND TESTING

1) *Inspection & Testing of Casting*
2) *Inspection has two main goals:* to reject castings that do not satisfy the customer's specifications and to maintain the quality of workmanship & materials used in foundry. Inspection of castings encompasses a wide range of procedures and techniques for determining the quality of castings.

These techniques can be categorised into the following groups:

a) Visual Inspection
b) Dimensional Inspection
c) Mechanical and Chemical Testing
d) Flaw detection by non-destructive methods
e) Metallurgical Inspection

- *Visual Inspection:* All castings are visually inspected to guarantee that the surfaces meet the needs of both the client and the manufacturer. Visible faults that may be recognised are a good way to find out if there's a problem with the pattern equipment, the moulding or casting process, or both. The majority of defects can be identified with a thorough visual inspection. Visual inspection may be insufficient solely for detecting subsurface or internal defects, in that case more advanced approaches is required.
- *Dimensional Inspection:* All types of castings are frequently subjected to dimensional control. Generally it may not be critical, but sometime it may be vital. Dimensions must be carefully examined when precision castings are manufactured using procedures such as, investment casting, shell moulding, die casting. When castings are manufactured from a new pattern, a few sample castings are made first, then carefully examined against the designs to ensure that the sizes obtained adhere to the specifications & will be maintained within the prescribed tolerances in the production lot. Deviations from the blue print are corrected on pattern equipment during sample lot testing. When the castings are constantly within the tolerances then spot checks, along with regular check of patterns and dies being used. Each casting produced by a jobbing foundry may be unique, and as a result, each one may need to be rigorously inspected for dimensional variances based on the customer's specifications.

©IJRASET: All Rights are Reserved

- *Flaw Detection by non-destructive Methods:* Non-destructive testing is also necessary in foundries to inspect castings for any sub-surface or internal defects, surface faults that cannot be discovered by visual inspection, & overall soundness or pressure tightness, which may be required in service. These tests are useful for detecting or discovering casting faults in the interior of castings that could affect the machine member's performance when it is put into operation. Parts can also be checked while in service, allowing them to be replaced before they fail completely.
- *Magnetic Particle Inspection:* Test is used to pinpoint the place of cracks that extend to the surface of magnetic iron and steel castings. Initially casting is magnetised , & then iron particles are strewn over the magnetic field's path. The particles align themselves in the force line's direction. Their distribution is also proportional to the magnetic field's strength. If a perfect casting exists, the iron particles will jumble around the defect, however if a defect exists, the iron particles will be scattered evenly all over the surface. The reason for this is that when there is a discontinuity in the casting, the lines of force bypass it and concentrate around the defect's extremities. The depth at which the fault arises can also be determined by looking at the particle concentration. For an accurate evaluation of the flaw, however, substantial experience is required. Cracks longer than 1mm and a fraction of a millimetre deep can be defected with the right test procedure.

IV. COMPONENT DESCRIPTION



Fig. 5 Manifold

An inlet manifold, also known as an intake manifold in American English, is the component of an engine that delivers the fuel/air combination to the cylinders. The word manifold derives from the Old English word manigfeald' (from the Anglo-Saxon manig [many] and feald [repeatedly]), which means "to multiply into many." An exhaust manifold, on the other hand, gathers exhaust gases from several cylinders into a smaller number of pipes - generally only one. The primary function of the intake manifold is to supply a consistent amount of combustion mixture (or just air in a direct injection engine) to each cylinder head's intake port. To maximise the engine's efficiency and performance, even distribution is critical. The carburetor, fuel injectors, throttle body & other engine components could all benefit from it. Due to the downward movement of the pistons and the restriction imposed by the throttle valve, a partial vacuum (lower than atmospheric pressure) exists in the intake manifold of a reciprocating spark ignition piston engine. This manifold vacuum can be significant, and it can be utilised to power auxiliary systems such as windshield wipers, power assisted brakes, emission control devices, ignition advance, power windows, ventilation system valves, cruise control, and so on.

V. DATA COLLECTION

Selection of casting defect is second step after selection of components for study. The sponsor’s industry is having large number of different types of casting defects. Large variety of different types of casting defect can be found in a small scale foundry. 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 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 also rejection quantity and its weight is required. Next step to tabulate all the data achieved. Table will have defect name, month, poured quantity, rejected quantity and rejection percentage. With all these, tabulated data is unable to construct a graph. For simpler representation of graph, needs defect name with its quantity. To select major defect Pareto analysis is carried out

©IJRASET: All Rights are Reserved

Table I
Defects and rejected quantity

ECTS	Gas porosity	Cold shut	Sand inclusion	Shift	Fusion	Core damage	Damage	Leak	Ex metal	SK	MD	Slag
REJECTED QUANTITY	171	155	152	85	25	23	21	21	18	11	5	5

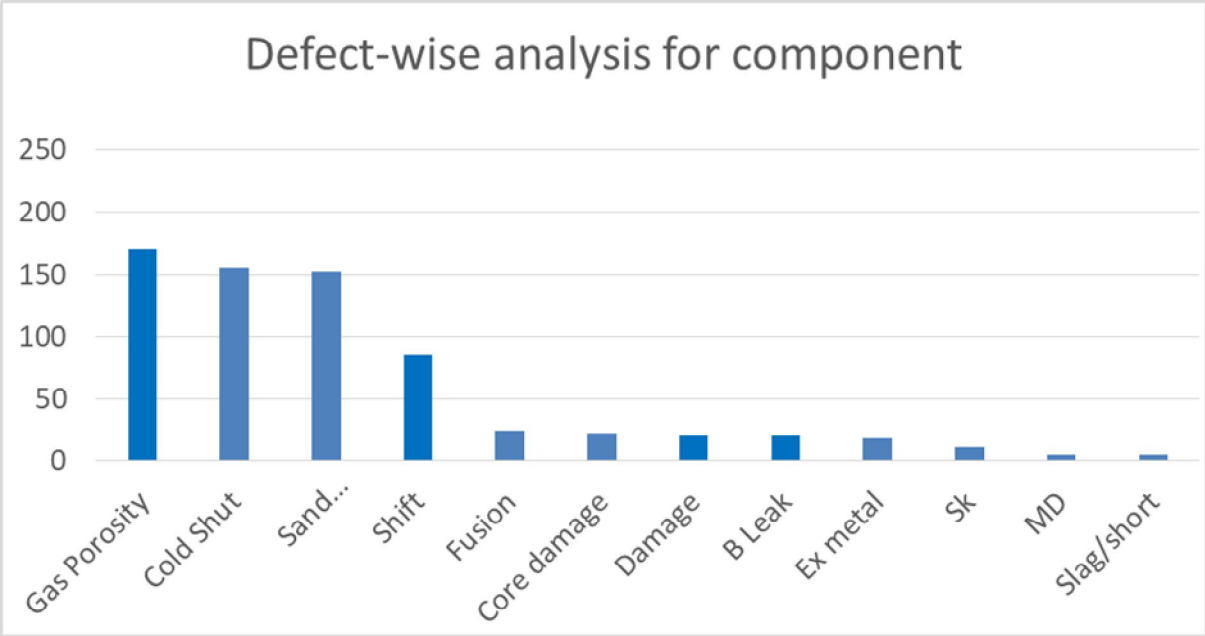


Fig. 6 Defect-wise analysis for components

Pareto analysis shows that Gas porosity, Cold shut, Sand inclusion, Shift indicates higher rejected quantity than other defects. Other defect shows less quantity but they also have the cumulative impact on overall rejection percentage. They will have less focus but main thrust will be on defects which are having higher percentage. The other defects can be simultaneously controlled by taking corrective actions or preventive measures for the major defects. After selecting different processes, parameters as a cause of major defects, we can group all the major or all the minor defects to control their rejection percentage.

VI. ANALYSIS

A. *Why-Why Analysis*

"Why-Why" analysis will be then done to structure brainstorm ideas to explore the possible root causes.
Sakichi Toyoda invented the technology, which was eventually adopted by Toyota Motor Corporation as part of their manufacturing methodology evolution. It is an important part of the problem-solving training provided as part of the Toyota Production System induction.

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

1) Ask "Why" i.e. What is the problem's initial level of causes?
2) Write each cause on the Diagram
3) For Each Cause, ask "Why" again and write the answers in the next column, linked to the previous answer.
4) Keep asking "Why" until no more answers can be suggested.
5) To come up with possible solutions, use the Causes given, especially those on the diagram's last level.
6) Examine the data for evidence of the most important causes; obtain further data if necessary.

©IJRASET: All Rights are Reserved

B. 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 7. Shift

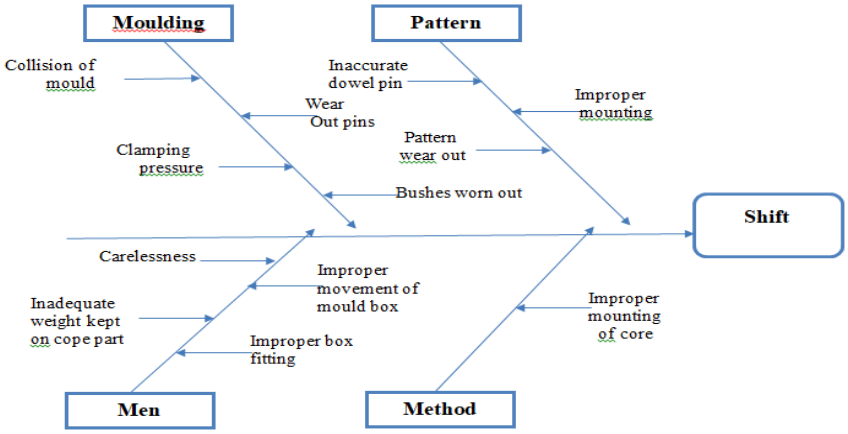


Fig. 8 Ishikawa Diagram for Shift

Fig. 8 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 mounting of pattern	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 wear 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

©IJRASET: All Rights are Reserved

VII. SUGGESSION

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. The operators were given instructions to ensure that the pins were checked properly.

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 suggests that weights kept on boxes are distributed equally and clamping should be firm and 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 to reduce the pouring time

By Calculation,

Pouring Time (t) =

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

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 to use 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 to increase the percentage of lustrous carbon.

8) Also we suggest to remove 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 to give proper training.

11) As mention above, 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 to do Continuous feeding with moderate rate and improve pouring practices. Also due to improper ramming it can happen so we instructed to do proper ramming.

VIII. RESULTS

Table II. List of Various Defects and Rejection Rate

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

©IJRASET: All Rights are Reserved

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 stat 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 previous stat is 23 defects was of cold shut out of 142 but after remedial measure it is down to 14 defects in 140 overall defects

Sand Inclusion defect is reduced by 43.7% as previous stat is 27 defects was of Sand inclusion out of 143 but after remedial measure it is down to 10 defects in 94 overall defects.

Gas Porosity defect is 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.

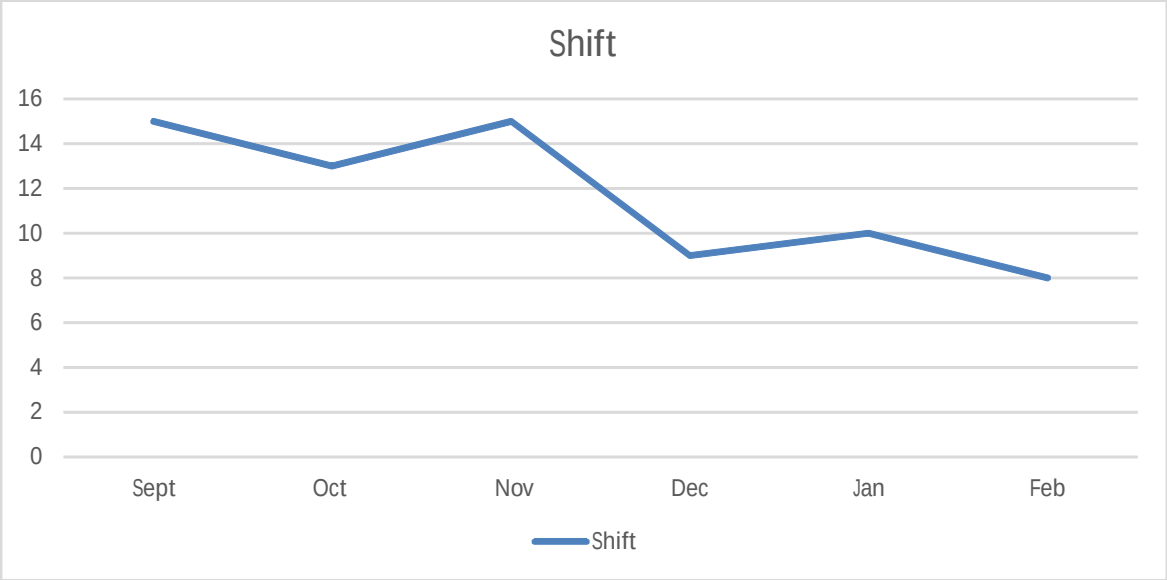


Fig. 9 Reduction in rejection %of shift

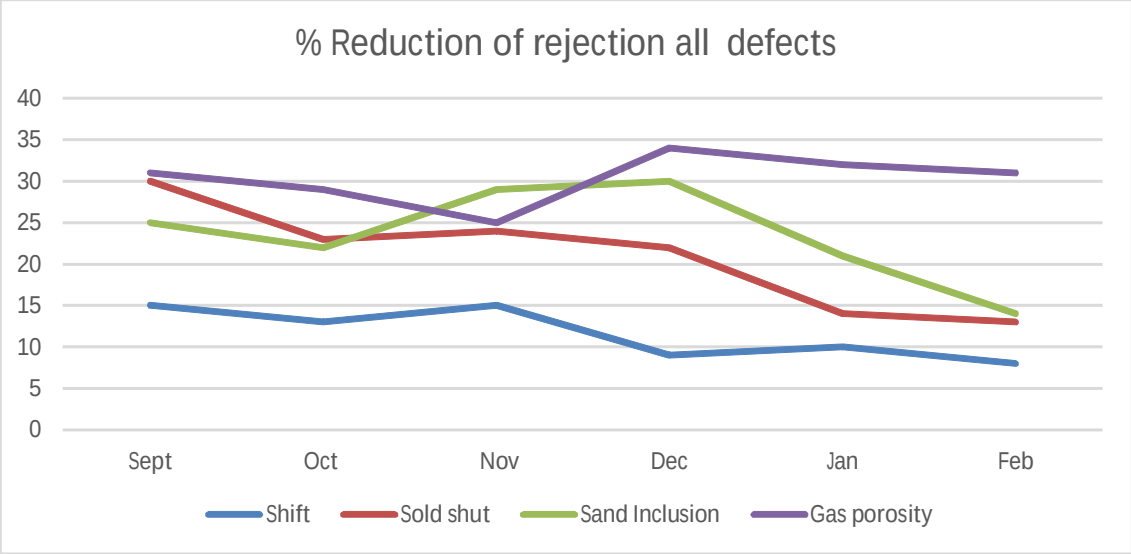


Fig. 10. Reduction in rejection %of all defects

©IJRASET: All Rights are Reserved

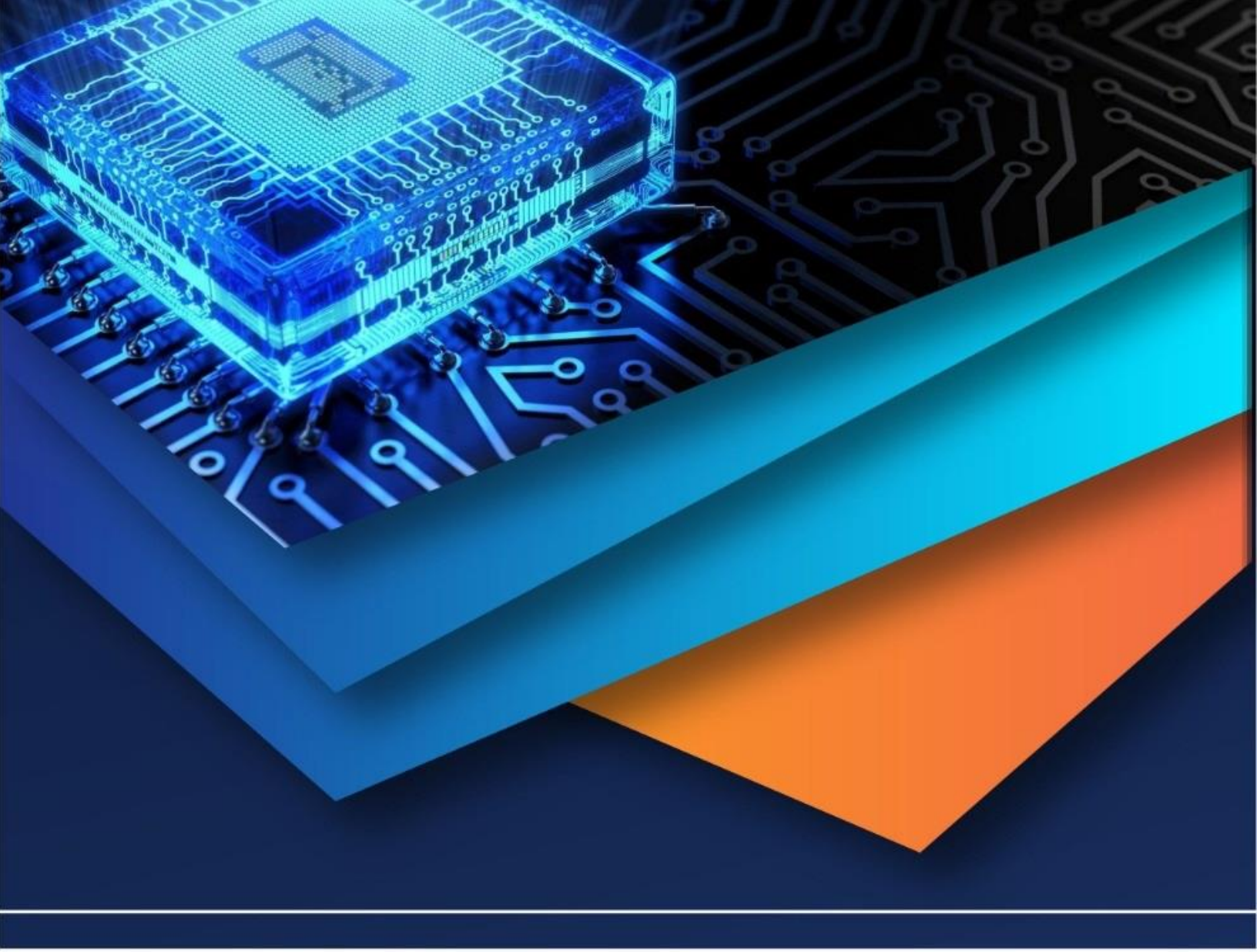
IX. CONCLUSION

The rejection analysis was conducted in Micro metal Ferrocast. The different quality tools were used to find root cause for major defects. 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. Shift, Cold shut, Sand inclusion, and Gas porosity are the four most common flaws found in casting rejections, according to a diagnostic research on castings. Production trials integrating the corrective measures were carried out in the foundry for three months and validated. The findings revealed a significant reduction in casting rejects. The company has accepted and implemented the remedial steps recommended in the production techniques, as well as making appropriate changes to the standard operating procedure.

REFERENCES

[1] B. Borowiecki, o. Borowiecka, e. Szkodzińka, casting defects analysis by the pareto, published by foundry commission of the polish academy of sciences, issn (1897-3310) volume 11 special issue 3/2011.
[2] Dr d.n. shivappa, mr.rohit, mr. Abhijit bhattacharya, analysis of casting defects and identification of remedial measures – a diagnostic study, international journal of engineering inventions, issn: 2278-7461, www.ijeijournal.com volume 1, issue 6 (october2012) pp: 01-05.
[3] Sunil chaudhari, hemant thakkar, review on analysis of foundry defects for quality improvement of sand casting, sunil chaudhari et al int. Journal of engineering research and applications, issn : 2248-9622, vol. 4, issue 3(version 1), march 2014, pp.615-618
[4] Rajesh rajkolhe, j. G. Khan, defects, causes and their remedies in casting process,international journal of research in advent technology, vol.2, no.3, march 2014 e-issn: 2321-9637
[5] Mr. Siddalingswami. S. Hiremath, advanced techniques in casting defects and rejection analysis a study in an industry,novateur publications international journal of innovations in engineering research and technology [ijiert] issn: 2394-3696 volume 2, issue 9, sep.-2015
[6] Avinashjuriani, casting defects analysis in foundry and their remedial, iosr journal of mechanical and civil engineering (iosr-jmce) e-issn: 2278-1684, p-issn: 2320-334x, volume 12, issue 6 ver. I (nov. - dec. 2015), pp 43-54
[7] R. Rajkolhe, j. G. Khan, defects, causes and their remedies in casting process a review, international journal of research in advent technology, vol.2, no.3, march 2014 e-issn: 2321-9637.
[8] S. Chaudhari, hemant thakkarreview on analysis of foundry defects for quality improvement of sand casting, , sunil chaudhari et al int. Journal of engineering research and applications issn : 2248-9622, vol. 4, issue 3(version 1), march 2014, pp.615-618
[9] .A, avinash.k.s, rejection analysis in piston manufacturing unit, issn(online): 2319 – 8753 issn (print):2347 – 6710 international journal of innovative research in science, engineering and technology (an iso 3297: 2007 certified organization) vol. 4, issue 3, march 2015
[10] V. Patil, mahesh sutar , quality control and statistical techniques used to improve productivity and to reduce rejections due to casting defects: a review, international journal of research in advent technology, vol.3, no 4, april 2015 e-issn: 2321-9637

©IJRASET: All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)