Review Analysis of Casting Defects with Respect to Indian Standards in Cast Iron Foundry

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ABSTRACT

Foundry industries need to produce quality castings (Prasan Kinagi, 2014) with minimum number of rejections (Sunil Chaudhari, 2014; Jadhav, 2013) to meet the customer requirements in the global market. The growth of the foundries depends on the state of the art techniques and also due to knowledgeable and experienced people. Some foundries are working with trial and error method and most of the foundries have very less control on rejections. Majority of the foundries have failed to maintain a satisfactory quality control level as they have to meet customer urgency. Defect free castings with minimum production cost have become the need of the foundries. The return in terms of good castings is less in comparison with the inputs in terms of capital investment, manpower, raw materials and power utilization.

This study compares the defects with Indian Standard Guide Lines. The entire process of casting manufacture is to be reviewed aiming for minimizing casting defects (Rejesh, 2014; Kassie, 2013; Shivappa, 2012; More, 2011; Rajesh, 2014; Blair, 2005). The Indian Standard guide lines (BIS, 1990) specify the common defects, their causes and remedies in an attempt to reduce foundry rejection for Indian foundries.

KEY WORDS: foundry, Castings, defects, rejections, Causes, Remedies, Quality.

1. INTRODUCTION

Foundry industries with poor quality suffer in the market due to involvement of number of process parameters (Patil, 2014; Kumar, 2014; Uday, 2013; Rasik, 2012) in casting process. There are so many factors that influence the production of castings. The cause is often a combination of several factors. The nature and the extent of the defects are decided on the basis of the end use of the product. The causes for the casting defect are identified in an attempt to eliminate the defect by taking appropriate remedies necessary for quality enhancement. In case of increase in rejections, A B C analysis can be done on the cause of rejection. Suitable remedial techniques, such as welding, brazing etc., along with pre- and post – salvaging treatments also contribute towards bringing down the rejection.

Indian Standard Guide Lines: The standard lays down the guide lines towards controlling and saving rejections in foundry. The Indian Standards IS 210: 1978 Grey Iron Castings (third revision) and IS 6331: 1987 Automotive Grey Iron Castings are necessary adjuncts to IS 12880: 1989 (Reaffirmed 2000) Standard.

The grey iron castings may confirm to IS 210: 1978 and high duty castings may confirm to IS 6331: 1987 having simple shape with no core or simple cores. The attainable foundry rejection is in the order of 3% (max). If the castings are having complicated outer as well as inner profiles such as automobile castings, then the foundry rejection can be in the order of 5% (max).

Basis of Rejection Reporting: Castings of repetitive nature in weight range of up to 500 kg may be accounted for the determination of rejection percentage on number basis, that is, the number of castings inspected and the number of castings rejected. Castings of jobbing nature may be accounted for the rejection percentage on weight basis.

Rejection Reporting System: The daily inspection report can indicate casting – wise numbers inspected and rejected. The rejection may be classified into different defects group and each casting of these groups can be identified by the date of cast, serial number and shift when it has been produced.

The weekly and monthly inspection report indicating the rejections can be reported as percentage of the total rejection as well as the break-ups under individual categories and defects. The report should have the cumulative status in the week as well as in the month comparing rejection of the previous week and month.

The master chart should indicate item-wise rejection of the day, cumulative till date of the month, previous month, cumulative till date of the year, previous year and all-time best achieved.

Master Card: Once a casting drawing is finalized for production, the mould scheme/core setting/core assembly system must be indicated in a card. The card may have a rough sketch of the casting indicating gating system and core setting arrangement, vent positions. Information should also be available regarding the type of moulding machine, boxes to be used, grade of metal, sand pouring temperature, pouring time, composition for mould and cores, wash practice etc., during early stage of trials, relevant data regarding rejection, physical properties and chemical composition should be recorded against each trial. Changes even seemingly insignificant ones at any stage of production should be recorded and incorporated with the knowledge of all the concerned departments.

The result obtained from the production trials vis-à-vis practices adopted should be discussed and the target of rejection, method of manufacture for the particular casting should be finally recorded in the method card.

The final method card should be released to all the concerned that is, production, process control, inspection and quality control departments.

Rejection Meeting: Depending on the production rate of the foundry, a shop floor meeting should be held daily or as required to examine the defective castings.

The meeting should be conducted by either the chief of quality control or trouble shooting unit who should properly identify the defects decided on the status i.e rejected castings, good castings and repairable castings. The method of rectification should also be decided in the meeting.

The meeting should be attended by heads/supervisors of all the production shops, process control and quality control departments regularly. Moulding shop group leader from the workmen's side should also attend the meeting.

At least once in a week, the foundry head should meet his managers and supervisors to discuss the rejection and to decide the line of action.

Feedback System: The copies of rejection report should be forwarded to the foundry head, in turn should be passed on, with his comments to the concerned departments.

The display boards indicating daily rejections on individual items produced and their break- ups should be kept on a place or places where the work men and concerned supervisors should see and discuss among themselves for corrective actions.

The result achieved on any trial / action should be recorded in the form of report received from the concerned department initiating the action and copies be circulated among all concerned departments. Work men of the concerned department should also be explained in simple language by their supervisor about the result of trial. The master chart should be made use of, for the weekly rejection meeting.

Training of Personnel: The workmen, supervisors and managers should be required to undergo suitable technical and managerial courses to keep them up to date on the subject. Such courses may be either organized within the organization or different educational / professional bodies.

Suggestion Scheme: The problems which are not getting solved easily should be put for suggestion through proper information system and the suggestion received should be scrutinized on priority and actions should be taken accordingly.

Statistical Quality Control: For maintaining and analyzing technical data, suitable statistical methods, such as control chart, etc., can be utilized.

Defects, Causes and Remedies: The Table 1 indicates list of 14 defects that normally occurred in iron castings and their causes and remedies as per Indian standard IS 12880:1989 (2000). The photo graphs for some of the casting defects are listed in the Figures 1 to 8.

Table.1. Diagnosis Chart as per Indian Standard

Appearance	Causes	Remedies
1. Cold shut / Cold Lap		
Hole in the thinner section rounding of edges with s smooth and shiny appearance	Low pouring temperature, slow or interrupted pouring	Adjust pouring temperature and use ladle cover
	Low fluidity	Increase phosphorus, if permitted
May appear as a line where two forwarding fronts have not fused. Casting surface closer to the defect may be smooth and shiny	Core shift causing uneven wall thickness	Avoid core shift by proper print or use chaplet wherever possible
	Very hard mould or low permeability	Avoid excess ramming
	High moisture	Increase vents Adjust moisture as per sand GFN and clay content
2. Cold Shut		
Gas hole having shiny surface with embedded shot	Turbulent flow of metal causing iron shots separating out of metal stream, interrupted pouring	Streamline and uninterrupted flow of metal is desirable
3. Shrinkage and Draw		
Rough cavities entering casting on heavy sections or at the joint of change of sections	Incorrect feeding	Design correct gating and feeding system
	Weak mould	Improve mould hardness/density
	Carbon equivalent unsuitable for the casting design	Select proper composition
	Excess inoculation	Adjust inoculation suiting melting practice and casting design
	High pouring temperature	Adjust gating system properly

4. Slag		
Not so rough to smooth cavities generally in the vicinity of gates	Unclean metal/ladle	Remove slag from the furnace prior to tapping into the ladle Use coagulant for better removal of slag from the ladle
	Gating system unable to trap the slag	Design gating system properly
	Faulty pouring practice	Keep pouring basin full during pouring the casting
	Very high sulphur or manganese or both	Use correct type of scrap and select proper composition to avoid Mn-S slag
5. Micro Porosity		
Machined surface shows localized spongy surface, may leak under fluid pressure	Incorrect feeding	Design correct gating and feeding system
	Weak mould	Improve mould hardness/density
	Carbon equivalent unsuitable for the casting design	Select proper composition
	Excess inoculation	Adjust inoculation suiting melting practice and casting design
	High Pouring Temperature	Reduce Temperature wherever possible
	Core and Mould having poor thermal stability	Avoid Core / Mould dilation
	High Phosphorus content	Adjust suitable charge to avoid Phosphorus level
6. Chilled Edges and Hard Spot		
Bright areas on the edges after machining, fractured surface shows white or mottled surface white shining spots after machining	Incorrect type of metal composition	Adjust composition for correct carbon equivalent percentage
	Presence of excess carbide stabilizing elements	Avoid excess chromium, etc
	Insufficient inoculation	Use correct type and quantity of inoculants
	Sulphur not balanced with manganese	Balance Sulphur with Manganese (1.7 x S) + 0.3 = Mn
7. Scab		
Rough sand/metal fused layer connected to the casting by a thin strip of metal and on removal, may show a depression on the casting surface	Expansion of silica not compensated by clay	Balance clay/sand water proportions in the sand mix. Avoid excess free water
	Erosion of the mould surface in front of the gates and its deposition in adjacent areas	Increase clay, reduce water reduce metal velocity, as far as possible
	Condensation of high moisture layer in cope specially flat surface due to prolonged radiant heat	Increase clay, reduce water reduce metal velocity, as far as possible and reduce pouring time/temperature as far as practicable Incorporate cellulose in the sand mix
	Inadequate combustible in sand mix	Use adequate combustible
8. Rough Surface		
Casting surface rough	Metal penetration	Use finer sand or use coating, if Permitted
	Insufficient coal dust to generate adequate lustrous carbon	Use proper quality/quantity of coal dust
	Very hard mould surface	Avoid hard ramming or adjust the sand composition of suit hard ramming condition
	Base sand too coarse or distribution too wide producing open grain Surface	Select proper sand grading
	Sand fusion	Increase refractoriness in the mix Reduce metal temperature if Possible

9. Warpage		
Casting shows warpage on cooling or after machining	High Section Sensitivity	Ensure correct inoculation
10. Distortion		
Casting shows swelling or growth on surface	Too soft a mould to withstand ferrostatic pressure	Ram evenly and firmly
	Inadequate counter weight on the mould	Increase weight mould/or mould ensure proper clamping
11. Cracks		
Hairline crack seen on casting surface and discolouration indicates crack generation at high temperature otherwise it is cold crack	High dry strength of the mould or poor collapsibility of the core	Adjust ramming and clay content reduce oil, improve baking or use combustible filler material
	Improper handling	Ensure proper handling
	Incorrect loading during storage or transportation	Avoid stacking of thin walled castings. Load flat castings standing on the thicker section
	Incorrect tool pressure during machining	Use proper tool and clamping during machining
12. Dirt		
Rough cavities and pits in casting surface before cleaning, sand grains may be seen visually or under magnification	Weak mould surface	Ensure proper ramming
	Weak sand	Maintain correct compression strength of sand
	Core print too tight	Design proper prints
	Pattern liner low	Adjust liner height to reduce pressure at the drag/cope mould cavity edges
	Poor pattern finish or undercut	Ensure proper pattern condition.
	Handling of moulds after closing Friable sand	Avoid manual handling of closed mould
13. Blow Holes		
Smooth, nearly round shaped cavity may be on the surface or found after shot blasting or machining. Surface of the cavity may be dull or shiny depending on the nature of the gas causing the defect. In severe cases, section of the casting may be hollow.	Insufficient permeability of moulding or core sand	Avoid fines in the sand system
	Hard ramming	Avoid excess ramming
	High moisture content of mould	Minimize free water content in the sand mix
	Rusty or damp chills and chaplets	Use coating in the chills and dry them. Ensure chaplets are clean and rust free
	Very hard core	Reduce organic binder content as much as possible
	Inadequate venting in the core and mould	Vent sufficiently Optimize baking/curing of core
	Unbaked core causing high gas content	Optimize baking / curing of core
	Damp pouring ladle, spout and launder	Ensure proper drying before tapping of metal
	Too low a pouring temperature	Increase pouring temperature if possible
14. Pin Holes		
Tiny subsurface round cavity normally having shiny surface. May be isolated or can be found in clusters. Generally found in the cope portion of the casting	High moisture in the sand associated with high aluminium content of the metal	Cut down source of hydrogen which ***is*** normally water, optimize quantity of inoculation. Control aluminium content of FeSi below 1.5 percent
	High nitrogen content of the core or mould	Optimize use of nitrogen bearing binder and hardener
	High manganese or sulphur content	Balance sulphur with manganese. Control both to an optimum level

Figure.1. Blow hole

Figure.2. Body cracks

Figure.3. Cold shut

Figure.4. Distortion

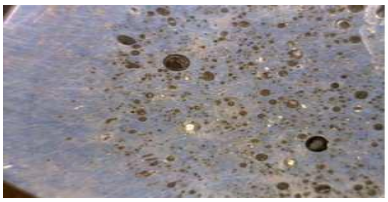

Figure.5.Porosity

Figure.6. Miss run

Figure.7. Sand inclusion

Figure.8. Shrinkage

Table.2. Percentage of Rejection

Month / Year	FRD	SRD	TD	DBA	Total Rejection
April'14	5.14	3.08	2.53	3.50	14.42
May'14	5.80	3.15	2.65	3.41	15.01
June'14	5.10	3.60	2.60	3.48	14.78
July'14	4.98	3.24	2.52	3.21	13.95
Aug'14	5.14	3.10	2.57	3.18	13.39
Sep'14	4.47	2.90	2.50	2.99	12.86
Oct'14	4.31	3.03	2.53	3.00	12.87
Nov'14	2.29	2.38	2.54	2.87	13.08
Dec'14	5.10	2.96	2.53	3.05	13.64
Jan'15	3.36	3.11	2.53	3.31	14.31
Feb'15	5.72	3.13	2.64	3.36	14.85
Mar'15	5.00	3.42	2.62	3.44	14.48

FRD – Filling Defects, SRD – Shape Related Defects, TD – Thermal Defects, DBA – Defects by Appearance.

Table.3. Review of Literature

Author & Year	Techniques used	Result
Sunil Chaudhari (2014)	Casting defects like gas defects, moulding material defects and metallurgical defects are studied	Concluded that process parameters should be decided based on the quality of the sand.
Jadhav (2013)	Investigation of cold shut defect in automotive cylinder block and analysis carried out using seven quality tools.	Parameters like temperature, phosporous, and silica percentage are recommended to reduce the cold shut defects.
Rajesh Rajkothe (2014)	Casting defects due to various factors are studied	The study will help for analysis and improving the productivity and yield of casting.
Uday A.dabade (2013)	DOE (Taguchi method) for analysing sand and mould related defects	Optimised parameters are obtained. Percentage rejection of castings due to sand related defects is reduced from 10% to 3.59%.
Rashik upadhye (2012)	Optimize sand casting process parameter (Taguchi method)	Optimised parameters obtained. Percentage rejection of castings is reduced from 6.16% to 3.84%

Review of Casting Defects: A study on various casting defects are carried out for one year from April 2014 to March 2015 in Ammarun Foundries, Coimbatore and the details are listed in Table 2. The defects are categorized like filling related defects (FRD), shape related defects (SRD), Thermal defects (TD) and defects by Appearance. The monthly percentage of rejection due to these defects are varying from 12.86 % to 15.01 %

The filling related defects are categorized are further classified as sand inclusion, rough surface, scabbing, blow holes, chill blow, clay ball hole, sand fusion, and pin holes. Sand related defects are also further classified as mould lift, mould broken, and shift, leakage. The defects by appearance are categorized as DBS blast core missing, swelling, and no core. Out of these defects the filling related defects are to be given importance for the analysis and

it is mainly due to the quality of sand. The shape related defects, defects by appearance and thermal defects are due to various factors in mould making process and melting process.

Some of the research papers of Indian authors have considered for review in comparison with Indian Standard for the various casting defects and the outcome are listed in Table 3.

4. CONCLUSION

The guide lines of Indian Standard clearly indicate the achievable percentage rejection in a foundry. The diagnosis chart in Table 1 also clearly indicates some of the common defects in castings, their causes and remedies. Using the modern method and suitable techniques, it is really a boon for the foundry sector to produce quality casting to satisfy the customer requirement. The guide lines and diagnosis chart are definitely helpful in improving the quality and yield of the casting. If castings are inspected with technologically advanced way, it keeps foundry men to alert condition for control of rejections and it will be within limit specified by the Indian standard.

Many researchers have conducted experiments on sand process parameters and proved that they have successfully reduced the casting defects due to sand process up to 6% and it will vary in each case. The quality of castings depends on quality of sand, method of operation, quality of molten metal and environmental conditions etc., Rejection of the casting due to casting defects should be reduced for better quality. With continuous improvement and monitoring of foundry process as specified in the Indian Standard, it is possible to achieve the overall foundry rejection percentage of less than five percentages.

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