RESEARCH ARTICLE OPEN ACCESS

Review on Analysis of Foundry Defects for Quality Improvement of Sand Casting

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ABSTRACT
In the present global and competitive environment foundry industries needs to perform efficiently with minimum number of rejections. Also they have to develop casting components in very short lead time. Casting process is still state of art with experienced people, but these experience needs to be transformed in engineering knowledge for the better growth of the foundry industries. Some foundries are working with trial and error method and get their work done. Factually, most of the foundries have very less control on rejections, as they are always on the toes of production urgency; hence they ignore the rejections and salvage the castings. Majority foundries are failed to maintain a satisfactory quality control level. Defect free castings with minimum production cost have become the need of the foundries. This study is aimed to review the research work made by several researchers and an attempt to get technical solution for minimizing various casting defects and to improve the entire process of casting manufacturing.
Keywords –Casting defects, Defect Analysis, Quality improvement, Root Cause Analysis.

I. INTRODUCTION

Foundry industries in developing countries suffer from poor quality and productivity to involvement of number of process parameters in casting process. Even in a completely controlled process, defects in casting process is also known as process of uncertainty which challenges explanation about the cause of casting defect. There are so many variables in the production of a metal casting that the cause is often a combination of several factors rather than a single one. All pertinent data related to the production of the casting defect is identified an attempt to eliminate the defect by taking appropriate corrective action is necessary for quality enhancement.

1.1 VARIOUS CASTING DEFECT

Any irregularity in the molding process causes defects in castings which may sometime be tolerated, sometime eliminated with proper molding practice or repaired using method such as welding and metallization. The following are the major defects which are likely to occur in sand castings

1.1.1 GAS DEFECT

The defect in this category can be classified in to blow holes and open blows, air inclusion and pin hole porosity. The defect can appear in all regions of the casting.

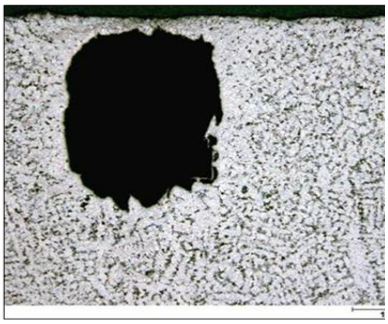

Fig.1 Air Inclusion

Possible causes:
All these defect are caused to a great extent by the lower gas passing tendency of the mould and/or improper design of the casting.
Remedies:
Adequate provision for evacuation of air and gas from the mold cavity.
Increase of permeability of mould and cores.

1.1.2 SHRINKAGE CAVITIES

Shrinkage defect occurring during the solidification of the casting.

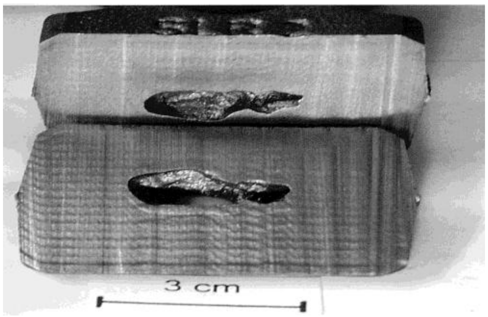

Fig.2 Shrinkage Cavities

Possible causes:
Volumetric contraction both in liquid and solid state.
Poor casting design.
Low strength at high temperature.
Remedies:
Proper feeding of liquid metal is required .
Proper casting design.

1.1.3 MOULDING MATERIAL DEFECTS

Under this category the defects which are caused because of the characteristics of the molding materials. The defect that can be put in this category are cuts and washes, metal penetration, fusion, run out, buckles, swell and drop.


Fig.3 Moulding cavities

Possible causes:
Erosion of molding sand by the flowing molten metal .
Molding sand not having enough strength.
Higher pouring temperatures.
Faulty mould making procedure .
Remedies:
Proper choice of molding sand and using appropriate molding method.
Choosing an appropriate type and amount of betonies.

1.1.4 POURING METAL DEFECT

In this category defects are miss run ,cold shuts and slug inclusions.


Fig.4 Mis run

Possible causes:
The metal is unable to fill the mould cavity completely.
Premature interruption of pouring due to workman's error
Remedies:
Have sufficient metal in the ladle to fill the mould
Proper gating system
proper use of pouring crew and supervise pouring practice.

1.1.5 METALLURGICAL DEFECT

The defects that can be grouped under this category are hot ears and hot spots.

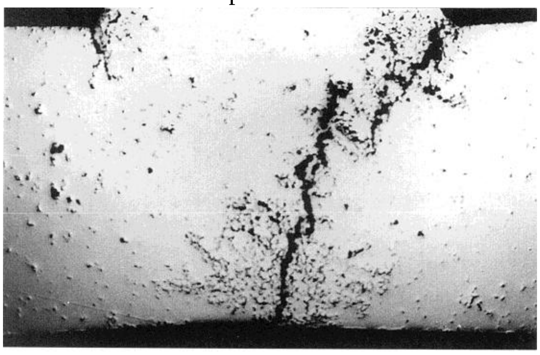
Fig.5 hot tears

***Possible causes*:**
Poor casting design
Damage to the casting while hot due to rough handling or excessive temperature at shakeout
Chilling of the casting
Remedies:
Improvement in casting design
Proper metallurgical control and chilling practices

II. REVIEW OF CASTING DEFECTS

K. Siekanski etal [1] have utilized various quality control tool for the analysis of casting defects to improve the quality of casting product. Ishikawa diagram and Pareto chart are used for data analysis. Analysis of various defects and their causes for accordance can be satisfied one with the help of Ishikawa diagram. Ishikawa diagram help us for analyzing failure analysis up to five different reasons. Pareto diagram shows separation of main nonconformance's casting defect like displacement, miss run, shaggy in homogeny, shrinkage depression, hot crack etc. On the base of this diagram it was concluded that the quantity of non-conformances in production process is influenced mainly by behaviour of employees connected with negligence, and noncompliance of technological process recommendations of procedures.

Uaday dabara etal. [2] have used two techniques are used for the analysis of the casting defects. In this study they have used a Design of Experiment (Taguchi method) for analysis of sand and mould related defects like as sand drop, bad mould, blow holes, cuts and washes, etc. and another method is computer aided casting simulation technique stem, which is used for meth ding, filling and solidification related defects such as shrinkage porosity, hot tears, etc. The

Authors have concluded that the optimized levels of selected process parameters obtained by Taguchi method are: moisture content (A): 4.7 %, green compression strength (B): 1400 gm/cm^2, permeability number (C): 140 and mould hardness number (D):85. With Taguchi optimization method the percentage rejection of castings due to sand related defects is reduced from 10 % to 3.59 %.

L.A. Dobrzański etal. [3] used the methodology of the automatic supervision for control of the technological process of manufacturing the elements from aluminium alloys. The methodology of the automatic quality assessment of these elements basing on analysis of images obtained with the X-ray defect detection, employing the artificial intelligence tools. The methodology is making it possible to determine the types and classes of defects developed during casting the elements from aluminium alloys, making use photos obtained with the flaw detection method with the X-ray radiation and also prepare the neural network data in the appropriate way, including their standardization, carrying out the proper image analysis and correct selection and calculation of the geometrical coefficients of flaws in the X-ray images. The correctly specified number of products enables such technological process control that the number of castings defects can be reduced by means of the proper correction of the process. Controlling the technological process on the basis of the computer generated information focused on the product quality, can enable the optimisation of this process and so the reduction of defective castings and in the result the reduction of expenses and environmental pollution.

Dr. D.N. Shivappa, and Mr Rohit, [4] found the four prominent defects in casting rejections. They are Sand drop, Blow hole, Mismatch, and Oversize in TSB Castings. The causes of the defects were due to improper cleaning of mould in the areas around chills and mould interface, sleeve, and breaker core, to connect flow off in the gating design., to lack of locators and improper setting of cores and due to mould lift and mould bulging. The remedial measures were identified to overcome the above defects and which are like proper cleaning of the mould before closing, ensure that sand do not enter into the sleeve, replace no-bake core with shell core, provide pads at bottom face, and modified the loose piece design to avoid core crushing. To be directly connected on top surface of long member, provided six locators for proper setting of cores - three are of metallic and three are self locators, clamp the moulds properly to withstand the pouring pressure – clamp centre channel with C - Clamps during metal pouring. The authors have identified various causes of casting defects.

Achamyeleh A. Kassie, Samuel B. Assfaw,[5] have used statistical analysis method for optimizing process parameters of casting process. There were 9 experiments conducted using Taguchi's DOE by changing the selected variables and different results were derived, from very bad to good, were shown up. Four process parameters were studied like sand – binder ratio, mould permeability, pouring temperature and de-oxidant amount in three levels. Factorial experiment was carried out. Finally it was concluded that the sand-binder ratio = 100:1, mould permeability = 250-300, pouring temperature = 1460-1490, and de-oxidant amount = 0.2 parameters are giving better and accurate castings.

Tapan Roy [6] studied the occurrence of different types of casting defects and its scientific analysis by computerised simulation techniques supported by industrial case studies. The main two categories of defects viz. solidification related defects like hot tear, shrinkage and porosity defects etc. and flow-related defects like sand burn in and rough surface/ metal penetration, air entrapment, cold shut etc. were discussed along with simulation results and practical case studies. The author has concluded that the defect analysis done by simulation helps to practical foundry men to take decision and corrective actions can be taken to eliminate these defects with lesser efforts.

Charnnarong Saikaew , Sermsak Wiengwiset [7] have studied to optimize the proportion of betonies and water added to a recycle sand mould for reducing iron casting waste using techniques like response surface methodology and mixture experimental design. The proposing of various components significantly influence the property's of moulding sand and quality surface of iron casting. The authors have concluded that the optimal proportion of the components was obtained at 93.3 mass % of one-time recycled moulding sand, 5 mass % of bentonite, and 1.7 mass % of water. This mixture yielded the optimal green compression strength of 53,090 N/m^2, the optimal permeability of 30 A.F.S. permeability numbers and the overall desirability of 72%. The aim of optimization was to obtain a good set of moulding sand mixtures that maximized the desirability function.

Xiaoli Li and SK Tso [8] used x-ray inspection processed by traditional method and wavelet technique to facilitate automatic detection of internal defects. Using x-ray inspection system the 2^{nd} order derivative and morphology operation, row by row adaptive thresholding and 2-D wavelet transformation defects of the castings can be determined very accurately. According to defects, subsequently process can be rectified to minimize the defects.

Rasik Upadhye [9] tried to optimize sand casting process parameters of the castings manufactured in iron foundries by maximizing signal to noise ratios and minimizing the noise factors using Taguchi method. His paper demonstrates the robust method for formulating a strategy to find optimum factors of process and interaction with a small number of experiments. Author has concluded that the optimum conditions for the factors computed are: Moisture (%) – Level 1 – minimum 3.5; Green compression strength (g/cm^2) – Level 1 – minimum 900; Permeability – Level 2 – minimum 185; Pouring temperature (deg. Celsius) – Level 3 – maximum 1420. The improvement expected in minimizing the variation is 37.66 % which means reduction of casting defects from present 6.16 percent to 3.84 percent of the total castings produced in the foundry.

LA Dobrzanski etal. [10] have proposed a methodology of computer aided relationship between chemical composition of aluminium alloy and casting quality. They have used ANN (Artificial Neural Network), to achieve better casting quality. Based on use of ANN inputs analysis one can determine which chemical elements are significant and contribute for better casting quality. The network does not disregard the main alloying element or modifiers which make changes in the crystallization process introduced in small quantity into the metal bath, improving the structure and property of the alloy.

III. CONCLUSIONS

Modern method of casting components using various software and simulation technique is really a boon for the industrial sector. It offers number of advantages and in the form of intelligent tool to enhance the quality of cast component. This will definitely helpful in improving the quality and yield of the casting. If castings are inspected with such technological way, it keeps foundry men to alert condition for control of rejections.

Many researchers have conducted experiments to find the sand process parameters to get better quality castings. They have successfully reduced the casting defects considerably up to 6% by proper selecting sand parameters. Now looking to their recommended process parameters, they vary in each case. So, we can conclude that the sand process parameters should be decided experimentally depending on quality of sand. We should not select these parameters directly from other manufacturers. This is called customization of process parameters depending on sand quality, and environmental conditions etc.

Rejection of the casting on the basis of the casting defects should be as minimum as possible for better quality. One can continuously strive for change in sand mixing process parameters until rejections are under control.

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