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Optimization of Casting Defects in Modern Alloy Wheel Casting With Quality Control Estimation

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***Abstract*— With the increasing use of aluminum wheels in automotive industry, the aluminum foundry industry had to focus on the quality and reliability of the products. To produce good quality aluminum cast wheels, defects must be minimized.**

Aim of the current study is to study defects of an aluminum alloy casting and to improve the quality of casting using quality control tools. This study shows the systematic approach to find the root cause of major defects in aluminum castings using defect diagnostic approach as well as cause and effect diagram. Casting defect analysis is carried out using techniques like historical data analysis, cause-effect diagrams, design of experiments and root cause analysis. Data from X-ray inspection (Radiographic Inspection) have been collected along with the production parameter data. Using Pareto chart major defects in the aluminum castings were noted. The major defects for the rejections during production were identified as shrinkages, inclusions, porosity/gas holes and cracks. Each defect is studied thoroughly and the possible causes for the defects are shown in Fishbone Diagrams (Cause Effect Diagrams). As the shrinkages mainly occur due to lack of feed ability during the fluid flow the stalk changing frequency is noted along with the shrinkages defects and a relation is drawn between them. As hydrogen forms gas holes and porosity in the aluminum castings the amount of hydrogen present in the molten metal is studied by finding specific gravity of the samples collected. The molten metal temperature affects the amount of the hydrogen absorbed by it. .So the effect of molten metal temperature on the specific gravity of the sample collected have been shown in a graph and the optimum value for molten metal temperature was found out.

***Index Terms*— Alloy wheel, molten matel, Fishbone Diagrame.**

I. Introduction

The use of aluminum castings in the automotive industry has increased incredibly over the past two decades. The driving force for this increased use is vehicle weight reduction for improved performance, particularly fuel efficiency. In many cases, the mechanical properties of the cast aluminum parts are superior to those of the cast iron or wrought steel parts being replaced. For the production of aluminum alloy wheel, Al-Si casting alloys are mostly used as the raw material. Because of their good casting properties, this type of alloys provides the alloy wheel to have good corrosion resistance and strength so that the vehicle can adapt to the road and weather conditions.

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The main alloying elements of Al-Si castings are silicon, magnesium, iron, manganese, beryllium, zinc, strontium and titanium. Each element gives some special features to the casting alloy so that the alloy can be produced with desired properties.

Aluminum casting alloy wheels are generally produced using low-pressure die-casting. For the application of this casting method, Al-Si casting alloys should be chosen owing to their high adaptation capability to the permanent metal molds. By the help of alloying elements, it is possible to achieve effective and efficient aluminum alloy wheel production. However, in production of wheels, defects in the cast microstructure undermine performance characteristics.

Quality improvement of aluminum alloy wheel production facilitates understanding the process parameters and their influences on the defect formation. To decrease the amount of scrap and rework, satisfactory quality of the production has to be achieved. This can be done using quality improvement tools. Controlling process parameters can decrease defects on aluminum alloy wheel and the amount of scrap produced. In this study, defects on aluminum alloy wheel were investigated by means of real time radioscopic method and minimize using quality control tools.

II. Methodology : CoQ framework

Defect analysis in casting is carried out using techniques like
1. Historical data analysis

2. Cause-effect diagrams

3. Design of experiments and

4. Root cause analysis

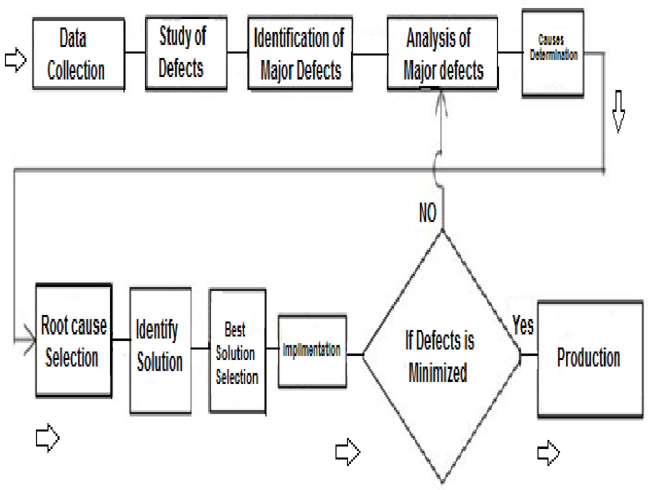
- Identifying the casting defect correctly is the first step in the defect analysis [9]

- Then the identification of the sources of the defect is to be made

- By taking the necessary corrective remedial actions defects can be controlled

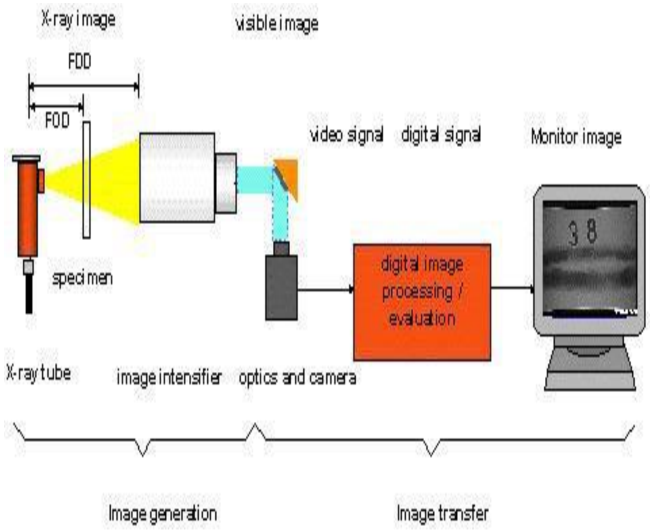
- Implementation of wrong remedial actions makes the problem complicated and severe

- The major rejected aluminum alloy wheel castings were analyzed using “Defect Diagnostic Approach” as shown in Figure.



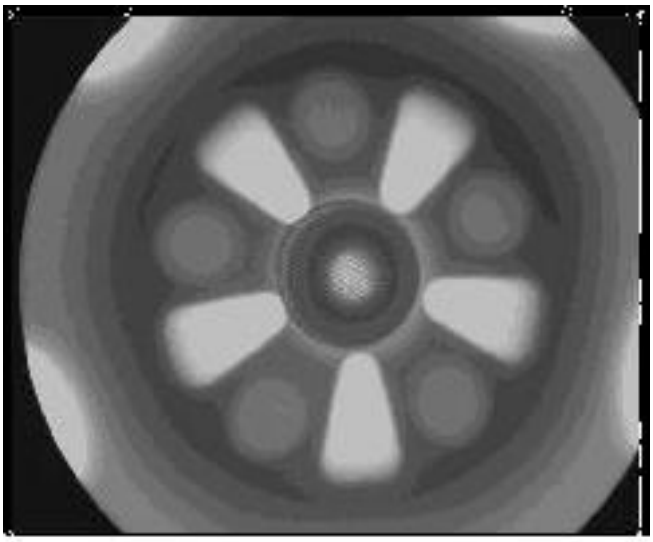
III. SINGLE INSPECTION

The real time radiographic inspection (RTR) is a technique to detect the micro defects is in aluminum alloy wheel manufacturing. In this arrangement X-ray is used to detect the faults. The arrangement for RTR is shown in figure.



RTR inspection is especially applied for the casting materials, which are produced for automotive, and airplane industry, acceptable defect type and defect size is so a few. Real time radioscopic method has been developed for the last few years and it is widely used in Al wheel production lines.

In this method, a feeding line from the casting machines to the RTR system transports the wheels and then, they pass through the inspection unit. In the system, the robotic manipulator, controlled by an operator or an automatic system, assists the operator to inspect all territories of the wheels effectively and to see clearly the defects on the monitor. As a result, the operator of the RTR system agrees to choose the accept or reject criteria for the inspected wheel. The typical image of Al wheel, which is obtained by means of real time radioscopic inspection system, is shown in Figure.



IV. CONCLUSION

In this study, casting of an Al alloy was investigated. Aim was to minimization of casting defects using 7 quality control tools. This study shows the systematic approach to find the root cause of major defects in aluminum castings using defect diagnostic approach as well as cause and effect diagram. To obtain more detailed and effective feedback control during casting of Al-alloy wheel, a process model for the production line was constructed. By help of this diagram the causes of defects and remedies can be pointed.

The results obtained in this present study have allowed the following conclusions to be made:

- Pareto diagram for defects have been drawn. The major rejections are due to shrinkages, cracks, inclusions.
- Cause effect diagrams have been drawn for shrinkages, cracks, inclusions.
- Data has been collected using check sheets and the no. of rejections due to various shrinkages has been noted. Using histogram it was noted that the hub shrinkages were more compared to rim and spoke shrinkages.
- With the use of histograms it was noted that the shrinkage percentage decreases with the increase in stalk change frequency. A proper riser prevents shrinkage formation by maintaining a path for liquid flow. Therefore the feeding in the die is achieved by the effective riser.
- The hydrogen content change is stable, between 700oC and 720oC temperature of molten metal. Between these temperature limits, the specific gravity values are in the range of change between 2.645 and 2.658. In this range, there is stability in the hydrogen content of molten metal.
- The relation between HF cleaning and inclusions was plotted and is concluded that there is a significant decrease in the inclusions with an increase in the HF cleaning frequency. Holding furnace cleaning and removal of dross would reduce inclusions. Metal filters can be placed in gate to filter incoming molten metal.

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