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Pareto Analysis Based Investigation And Reduction Of Welding-Defects In Automobile Ring Gear/Flex Plate Assembly

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Abstract

Welding is an important joining process in automotive industry. Any reduction in the welding defects directly translates into improved quality and reliability of welded auto structures. This paper showcases a Pareto based study on reducing welding defects in ring gear/flex plate assembly manufacturing. Analysis revealed that major welding defects, in the problem being addressed, resulted from improper rotation of fixture table, malfunctions in wire liner and wire feed rollers. These errors were systematically eliminated using root cause investigations. The countermeasures taken resulted in drastic reductions in welding defects-based rejections of ring gear/flex plate assemblies by 80%.

Keywords: Pareto, Quality Circle, Welding Defects, Ring Gears, Flex Plates

1. Introduction

Welding is utilized to join similar or dissimilar metals. In contrast to machining, casting, forging etc., welding is a joining process widely used to assemble different parts together in multifaceted configurations [1]. Welding is essential for automobile component manufacturing where quality plays a prominent role. The same applies to the quality and reliability of welded joints as well. Modern automobiles have many welded parts. Many accidents are caused due to welding defects in the automobile structure , thus highlighting the importance of focussing on efforts to reduce such welding defects [2].

Gas metal arc welding is one of the most common techniques used in vehicle manufacturing. A typical four wheeler may have upto 3000 welds, including those on seat rails, doors, chassis, roof etc. All these welds are documented in terms of numbers and positions. For quality assurance, the results of ultrasonic tests are attached to the numbers and positions of all joints in an assembly [3]. Process quality information management is essential for timely control of manufacturing defects [4].

The work carried out by Yusof and Jamluddin [5] highlights the welding defects and associated implications in various manufacturing industries. They have also discussed the errors in the commonly used welding methods. Barnes and Pashby [6] reviewed the solid and liquid-state welding alternatives available to the automobile industry. They emphasize on the point that the traditional spot welding method can compete in the new era of aluminum body frame structures. Praveen and Yarlagadda [7] have investigated pulse gas metal arc welding for joining new aluminum alloys for automobile components.

Shojaeefard et al [8] have modelled and optimized friction stir welded butt joints using Pareto method. Trevino et al [9] estimated a Pareto optimal set for multi objective optimization of welding in automotive industry. The Pareto method has been mostly utilized in multi objective machining optimization applications [10]. Bhat et al [11] analyzed the performance of Pareto optimal bearings subjected to surface error variations.

A review of the available literature reveals that very few researchers have worked on welding defects reduction based on Pareto technique. Reducing welding defects goes a long way in increasing product quality which ensures customer satisfaction. Customer satisfaction in turn helps create brand value for the products, which leads to increased sales and profits. This also improves worker morale and helps reduce recessionary pressures on the management.

2. Welding of Ring Gear and Flex Plate

The procedure of gas metal arc welding is simple procedure and easy to learn. However, a variety of external factors lead to errors even by experienced welders. This results in variations in the quality of welded joints. Basically, in this method the electrode is fed through the head of the torch tip. The operator has to guide the welding gun at a proper position and orientation with respect to the weld area.

In the manufacturing of ring gears, welding of ring gears with flex or drive plates is the first activity carried out after ring gear manufacturing. Figure 1 shows typical ring gear / flex plate assemblies. Figure 2 shows a welding fixture table for automobile ring gears. After welding, this assembly is sent for riveting and balancing followed by inspections, washing, oiling and finally, packaging (Fig.3).

Fig.1 Ring gear / Flex Plate Assembly

Fig.2 Welding fixture table

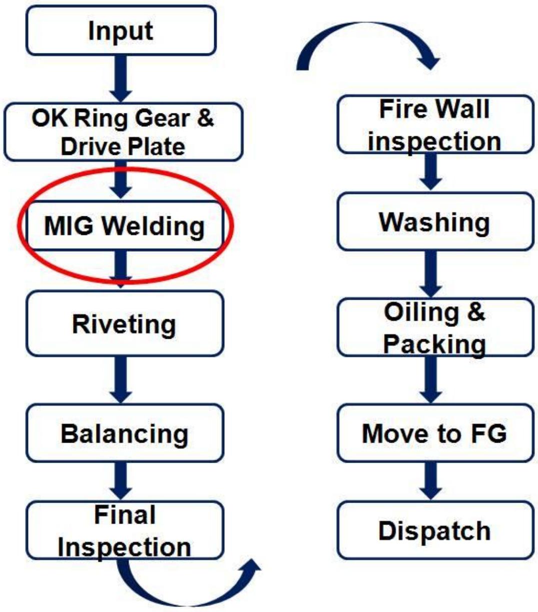

Fig.3 Ring gear / flex plate welding and subsequent processes.

3. Quality Circle Approach and Pareto Study

In the present work, a typical ring gear manufacturing firm was selected for the study. A cross-functional quality circle team was constituted to brainstorm the possible sources of errors leading to product rejections during inspection. Pareto analysis was then carried out to identify significant errors causing ring gear/flex plate assembly rejections. The study revealed that welding defects accounted for maximum number of rejections (Fig.4). Therefore, the subsequent study was focussed on reducing the welding defects.

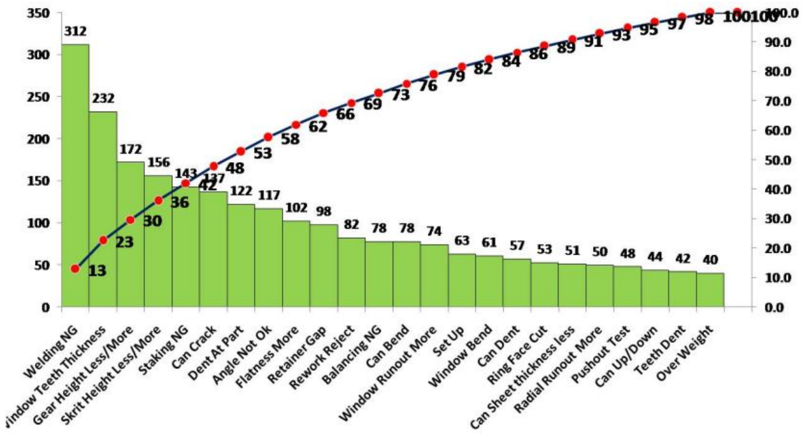

Fig.4 Pareto Chart (ring gear rejections)

4. Analysis of Welding Defects

A number of welded ring gear / flex plate assemblies were inspected for possible defects. Prominently, the following five kinds of welded defects were identified: lesser weld length, weld shifts, welding dislocated up or down, blow holes and non-uniform welding (Fig.5).

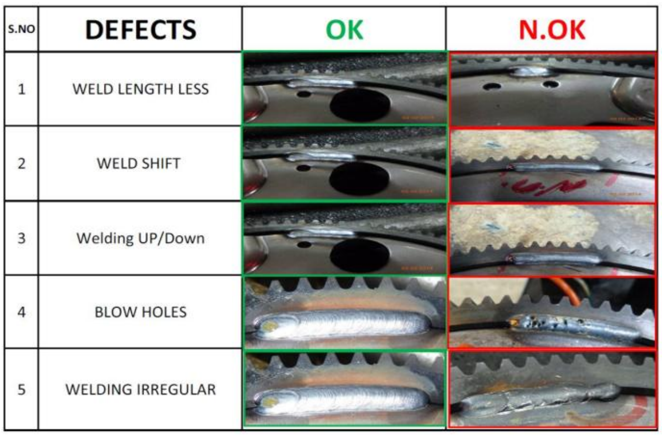

Fig.5 Welding Defects

5. Results and Discussions

5.1 Root Cause Analysis

Root cause analysis was carried out to identify the relevant causes for the observed welding defects, as shown in the cause effect diagram (Fig.6). This analysis helped in attributing the weld defect causes to man, machine, material and methods (Fig.7).

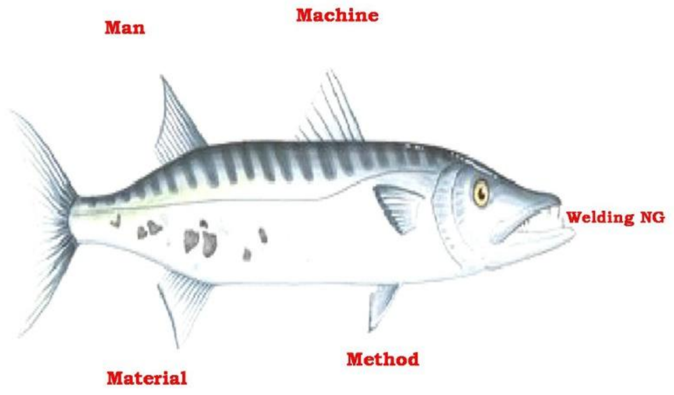

Fig.6 Fish bone diagram (cause and effect)

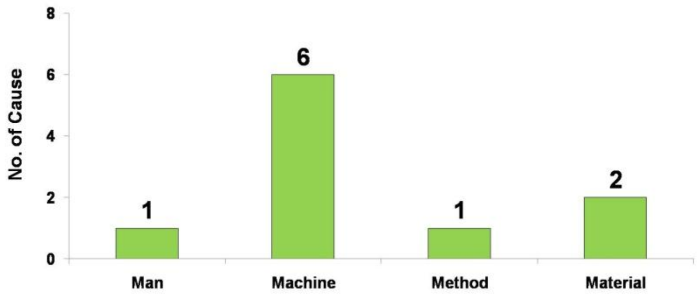

Fig.7 Categorization of causes into 4M

The categorization of welding defects with respect to sources revealed that maximum defects emerged from machinery related issues.

Further, the gas metal arc welding machinery was inspected for possible errors. Inspected components included fixture table, current and voltage supply fluctuations, wire liners, welding gas supply, wire feed roller and part clamping.

5.2 Validation of the Causes of Errors

Appropriate validation procedures were carried out to verify the significance of the identified machine related errors. As a result following three three significant error sources were identified viz; fixture table not rotating properly, wire liner malfunction and wire feed roller defective (Fig. 8).

Cause	Validation	Remark
Fixture Table not proper rotate	Yes, it is observed that there is problem in table rotation some times. And its create welding Length Short/ Bead Improper & welding Shift	Significant
Current & Voltage Fluctuation	No, such changes observed. Because that is PLC control	Non Significant
Wire Liner not proper working	Yes, Liner jam problem observed due to liner life over	Significant
Gas Improper	Gas flow found proper. Flow meter installed on m/c	Non Significant
Wire Feed Roller not Proper	Yes its found that wire feeder found loose & working not proper which lead to Blow Hole & Bead not proper	Significant
Part Clamping improper	Yes found that part proper clamped on fixture. Its pressure gauge installed on m/c	Non Significant

Fig.8 Error cause Validations

5.3 Error Elimination Procedures

The identified significant errors were systematically eliminated to control and reduce the welding defects.

After a detailed study of the defect of improper fixture table, it was observed that the fixture rotation bearing had worn out. This also pointed towards a missing checkpoint in preventive maintenance check sheet. Also, no specific frequency had been decided for checking / changing the bearing. Therefore, as a countermeasure, the fixture rotation bearing was immediately changed and a suitable check point was added in the preventive maintenance schedule to avoid future errors.

In case of the defective wire liner, it was found that the wire liner was not straight. This lack of straightness resulted from the longer wire liners being used. As a countermeasure, it was suggested to utilize shorter wire liners for better wire feeding to the welding machines.

Inspection of the wire feed roller revealed that the feed roller had loosened up. This happened because the wire feed roller had not been tightened frequently. In fact, roller checking frequency had not been decided. As an amendment, the wire feed rollers were tightened and suitable check points were included in the daily machine check sheets.

All these countermeasures resulted in drastic reduction in overall welding related defects in the ring gear/flex plate assemblies from 6517 PPM to 1241 PPM (to an extent of 80%) over a period of four months (Fig.9). This result underscored the efficacy of the Pareto technique in reducing welding defects by focusing on eliminating just three significant error sources. Similar gains were obtained in terms of cost savings by avoiding of rejection and rework costs.

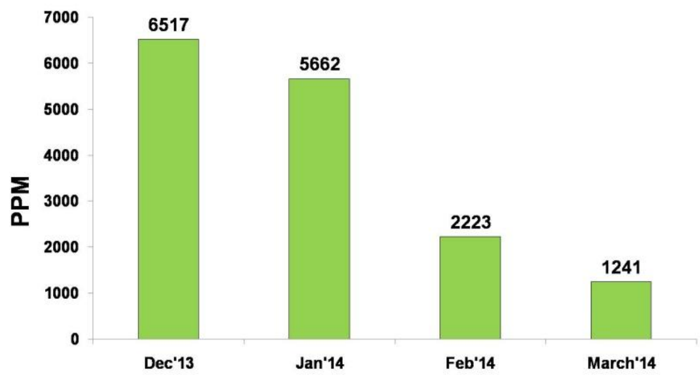

Fig.9 Reduction in welding defects (ppm) after implementation of countermeasures

6. Conclusions

This study was based on the Japanese concept of quality circle. A cross-functional team carried out a brainstorming session to find out different causes of product rejections. Thereafter, Pareto method was used to identify the most significant contributor to rejections, i.e., welding defects. These welding defects were analysed as per their sources from man, machine, method and materials. Machine based errors were found to be maximum, hence a number of possible machine errors were validated. These errors were systematically treated and appropriate systems were put in place to avoid their reoccurrence. Results showed significant reductions in overall rejections in inspections, thus ensuring improved quality of work and a healthy work environment.

The results also highlight that the productivity and work efficiency of the production lines can be increased and the expenditure on the specified machines reduced effectively using quality circles and Pareto approach.

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