

Study of the Product Failure Modes and Effects Analysis (PFMEA) on Welding Process- A Implementation Paper

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ABSTRACT: PFMEA (Product failure mode effect analysis) is one of the most successful tools for finding the failure mode and its effect in manufacturing process. By applying PFMEA we can find out how critical the process is and we can take action to reduce the failure in product and improve the manufacturing process. This paper is presented to provide the brief detail about the implementation of the Product Failure Modes and Effects Analysis (PFMEA) in welding process to improve the quality of the product. As the small and medium industries are facing problems with their process failures. So a study is carried out in this regards to control these failures in the industries so that proper quality can be maintained at each level of work.

In this study defects generated by welding process is studied and suitable solutions are used to eliminate these defects and failures. This study was conducted in the electro auto company, Govindpura industrial area, Bhopal for welding process. FMEA discovered the weak processes in the form of higher risk priority number in the welding process of product, which required reducing by identifying and implementing mitigation actions and thus the product quality & productivity will increased.

KEYWORDS: FMEA, PFMEA, Welding defects.

I. INTRODUCTION

Failure mode and effects analysis (FMEA) is one of the first highly structured, systematic techniques for failure analysis. An FMEA is often the first step of a system reliability study. It involves reviewing as many components, assemblies, and subsystems as possible to identify failure modes, and their causes and effects. For each component, the failure modes and their resulting effects on the rest of the system are recorded in a specific FMEA worksheet. There are numerous variations of such worksheets. An FMEA can be a qualitative analysis, but may be put on a quantitative basis when mathematical failure rate models are combined with a statistical failure mode ratio database.

A few different types of FMEA analyses exist, such as

- Functional
- Design
- Process FMEA
- Control plan
- PFME

The FME(C)A is a design TOOL used to systematically analyze postulated component failures and identify the resultant effects on system operations. The analysis is sometimes characterized as consisting of two sub-analyses, the first being the failure modes and effects analysis (FMEA), and the second, the criticality analysis (CA). Successful

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Vol. 6, Issue 5, May 2017

development of an FMEA requires that the analyst include all significant failure modes for each contributing element or part in the system. FMEAs can be performed at the system, subsystem, assembly, subassembly or part level.

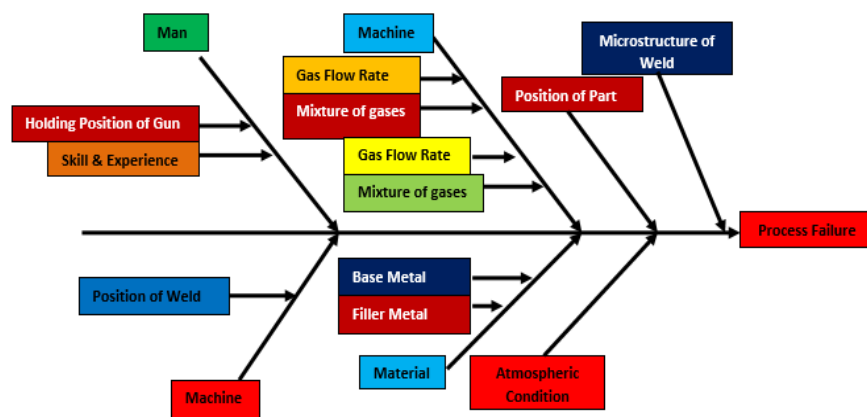


Fig:1Diagram of FMEA

II. OBJECTIVE OF WORK

The objective of this project was to develop a concept for the use in present scenario of industries to develop a well-defined model of quality control.

1. Study the current methods implemented for quality check of weld products.
2. Evaluate potential for use of welding parameters in the field.
3. Identify possible methods for implementation quality checking parameters for all the
4. Segments of welding process.
5. Make recommendation for further investigation and future implementation.
6. Validation of results for further use in industries.

III. LITERATURE REVIEW

The main focus of literature survey is to understand the process of PFMEA implementation, major implementation issues and to identify the scope for improvement in PFMEA implementation. The study covered many PFMEA works undertaken so far world over.

The research papers followed and studied were:

Tejas kumar S. Parsana and Mihir T. Patel (2014) attempted to present an effective tool for solving the problem of manufacturing process quality by executing process FMEA with proposed process control practices. This paper aims to identify and eliminate current and potential problems from a manufacturing process of cylinder head in the company through the application of Failure Mode and Effects Analysis (FMEA) for improving the reliability of sub systems in order to ensure the quality which in turn enhances the bottom line of a manufacturing industry. Thus the various possible causes of failure and their effects along with the prevention are discussed in this work. Severity values, Occurrence number, Detection and Risk Priority Number (RPN) are some parameters, which need to be determined.

Furthermore, some actions are proposed which require to be taken as quickly as possible to avoid potential risks which aid to improve efficiency and effectiveness of cylinder head manufacturing processes and increase the customer

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satisfaction. The prevention suggested in this paper can considerably decrease the loss to the industry in term of both money time and quality.

Riddhish Thakor, Rajat Dave, Tejas Parsana(2015) attempted to represent the potential tool for evaluates the problem of manufacturing process by implementing the process FMEA. This study has a goal to concentrate and eliminate the potential problem for manufacturing process of bearing in company through executing the Failure Mode and Effect Analysis. Various possible causes of failure and their effect of sub system has been evaluated for improving the reliability of the product as well as bottom line of the manufacturing can be improved. Process FMEA having some parameters needed to define which are Severity values, occurrence number, Detection and Risk priority Number (RPN). On the basis of the parameters some of the suggestions are proposed for avoiding the possible risk and ultimately decrease the loss to the industries in terms of money, time and quality.

Swapnil B. Ambekar, Ajinkya Edlabadkar, Vivek Shrouy (2013) argued that quality and reliability of products and manufacturing processes are critical to the performance of the final products. They are also important indices for meeting customer satisfaction. In order to fulfill customer's requirements for quality and reliability, some actions for assuring the quality and reliability of products or processes should be taken by all the persons involved. One of the most powerful methods available for measuring the reliability of products or process is FMEA. Probably the greatest criticism of the FMEA has been its limited use in improving designs. Customers are placing increased demands on companies for high quality and reliable products. FMEA provides an easy tool to determine which risk has the greatest concern and therefore an action is needed to prevent a problem before it arises. The development of these specifications will ensure the product will meet the defined requirements. Before starting the actual FMEA, a worksheet needs to be created, which contains the important information about the system, such as the revision date or the names of the components. On this worksheet all the items or functions of the subject should be listed in a logical manner. The initial output of an FMEA is the prioritization of failure modes based on their risk priority numbers and this alone does not eliminate the failure mode. Additional action that might be outside the FMEA is needed. This paper will definitely enhance the knowledge of researchers who really want to carry their research in this area.

Rachieru Nicoleta , BELU Nadia and Anghel Daniel Constantin (2013) indicated that the application of fuzzy PFMEA method can solve the problems that have arisen from traditional FMEA, and can efficiently discover the potential failure modes and effects. It can also provide the stability of product and process assurance. The fuzzy PFMEA approach might be helpful to the management processes. In all the management processes in manufacturing areas it is quite possible to use this tool successfully.

Parikshit K patel, Prof. Vidya Nair, Ashish Patel (2013) did work on a small blow moulding company, which manufactures the Air duct for automobile air conditioners. The initial research shows the past trends of rejection is between 8-9% which includes human error in material removal, wrong fitting of clamp, molding defects, etc. the need is to reduce that to compete in highest competitive market and to continuous satisfaction of customer. One of the successful tool for finding the failure mode and its effect in manufacturing process is PFMEA (Product failure mode effect analysis). By PFMEA we can find out how critical the process is and we can take action to reduce the failure in product and improve the manufacturing process. After the complete study of the manufacturing process and production data – failure causes, failure rate, & other relevant data etc, FMEA discovered the weak processes in the form of higher risk priority number in the manufacturing of product, which required reducing by identifying and implementing mitigation actions and this will improve the process and product quality & productivity.

Shiva kumar K M, Hanumantharaya R, Mahadev U M, Kiran prakasha A (2015) determined the risk associated with defects in the injection moulding process using FMEA method and reduce the defects to ensure that the same kind of defects should not arise in the future. Thereby reducing the total cost of production and increasing customer fulfilment. They found that After implementation of FMEA the RPN value has been reduced for each of the defect And

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the defects are reduced from 48,540 to 31,160 per month and total cost associated with the defects is reduced from 1,20,000 Rs to 77,900 Rs .

Aravinth .P, Subramanian .S.P, Sri Vishnu .G, Vignesh P (2012) in their work, process failure mode and effect analysis is done on general TIG welding process. A series of welding with different sample pieces are done and the potential failures and defects of the work piece are categorized based on FMEA, risk priority numbers are assigned to each one and by multiplying the ratings of occurrence, severity and detection. Finally the most risky failure according to the RPM numbers is found and the cause and effects along with the preventive measures are tabulated. This work serves as a failure prevention guide for those who perform the welding operation towards an effective weld. The results of this literature survey indicated the need to develop a new method to suit appropriate applications which have its foundation in FMEA. These applications are mentioned in this implementation paper in detail.

IV. EXPERIMENTAL RESULTS

CO₂ Arc welding process is used to perform the welding task. Carbon Dioxide (CO₂) is the most common of the reactive gases used in MIG welding and the only one that can be used in its pure form without the addition of an inert gas. Pure CO₂ provides very deep weld penetration, which is useful for welding thick material. Common weld defects were obtained:

- Lack of fusion
- Lack of penetration or excess penetration
- Porosity
- Inclusions
- Cracking
- Undercut

Failure Modes & Effects Analysis

Step 1: Identify components and associated functions

The first step of an FMEA is to identify all of the components to be evaluated. This may include all of the parts that constitute the product or, if the focus is only part of a product, the parts that make up the applicable sub-assemblies.

Step 2: Identify failure modes.

The potential failure mode(s) for each part are identified. Failure modes can include but are not limited to:

- Complete failures
- Intermittent failures
- Partial failures
- Failures over time
- Premature operation
- Failure to cease functioning at allotted time
- Failure to function at allotted time

Step 3: Identify effects of the failure modes.

Step 4: Determine severity of the failure mode.

Step 5: Identify cause(s) of the failure mode

Step 6: Determine probability of occurrence

Step 7: Identify controls

Step 8: Determine effectiveness of current controls

Step 9: Calculate Risk Priority Number (RPN)

Step 10: Determine actions to reduce risk of failure model.

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Vol. 6, Issue 5, May 2017

S.no	Specimen	Voltage	Current	Undercuts	Porosity	Blow hole	Lack of Penetration
1	Specimen 1	20V	200 amp	40%	60%	35%	25%
2	Specimen 2	20V	350 amp	45%	50%	25%	70%
3	Specimen 3	28V	270amp	10%	15%	5%	10%
4	Specimen 4	35V	200 amp	38%	55%	45%	50%
5	Specimen 5	35V	350 amp	45%	35%	15%	40%

Table: 1 Various Defects in the Specimen Prepared After and Before RPN

V. RESULTS

After Introducing FMEA in the welding process of the considered industry various defects were not seen in the specimens. Continuation of FMEA based actions can result in the better quality of production and products.

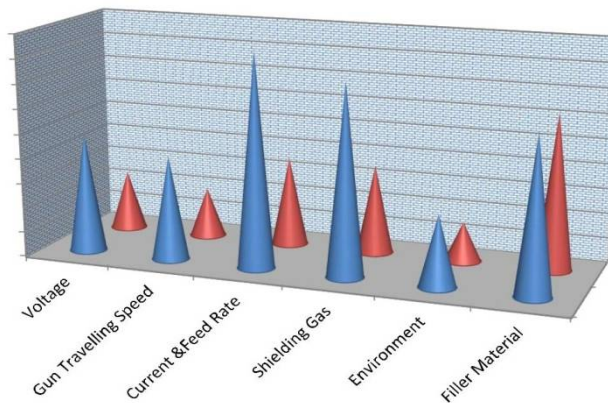


Fig: 2 Various Defects seen After and Before RPN

Sr. No	RPN (Risk Priority No.)	Before Action Taken	After Action Taken	% Improvement
1	Voltage	240	120	50%
2	Gun Travelling Speed	210	100	47.61%
3	Current & Feed Rate	432	180	41.66%
4	Shielding Gas	384	180	46.87%
5	Environment	144	80	55.55%
6	Filler Material	315	315	No improvement

Table: 2 Effects of defects before RPN and after RPN

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Vol. 6, Issue 5, May 2017

VI. CONCLUSION

In order to improve the efficiency and effectiveness of manufacturing process failure detection processes are applied by using FMEA. On the basis of the parameters proposed for avoiding the possible risk and ultimately decrease the loss to the industries in terms of money, time and quality.

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