A CRITICALITY STUDY BY DESIGN FAILURE MODE AND EFFECT ANALYSIS (FMEA) PROCEDURE IN LINCOLN V350 PRO WELDING MACHINE

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ABSTRACT

Failure Modes and Effects Analysis (FMEA) is methodology for analyzing potential reliability problems early in the development cycle where it is easier to take actions to overcome these issues, thereby enhancing reliability through design. A process or a design should be analyzed first before it is implemented and also before operating a machine the failure modes and effect must be analyzed critically. In this work, design failure mode and effect analysis is done on LINCOLN V 350 PRO welding machine. A literature survey and a series of welding with different sample pieces are done and the potential failures modes of the machine are categorized based on FMEA, risk priority numbers are assigned to each failure mode by multiplying the ratings of occurrence, severity and detection as per FMEA methodology. Finally the most risky failure in the welding machine according to the RPM numbers is found and the cause and effects along with the preventive measures are tabulated for all the failure modes. This work serves as a failure prevention guide for those who perform the welding operation towards an effective weld.

KEYWORDS: *failure modes and effects, INVERTECH V350 PRO, control measures, welding*

I. INTRODUCTION

A failure modes and effects analysis (FMEA) is a procedure in product development and operations management for analysis of potential failure modes within a system for classification by the severity and likelihood of the failures. A successful FMEA activity helps a team to identify potential failure modes based on past experience with similar products or processes, enabling the team to design those failures out of the system with the minimum of effort and resource expenditure, thereby reducing development time and costs. It is widely used in manufacturing industries in various phases of the product life cycle and is now increasingly finding use in the service industry. Failure modes are any errors or defects in a process, design, or item, especially those that affect the customer, and can be potential or actual. Effects analysis refers to studying the consequences of those failures. Customers are placing increased demands on companies for high quality, reliable products. The increasing capabilities and functionality of many products are making it more difficult for manufacturers to maintain the quality and reliability. These are techniques done in the late stages of development. The challenge is to design in quality and reliability early in the development cycle. FMEA is used to identify potential failure modes, determine their effect on the operation of the product, and identify actions to mitigate the failures [1-4]. A crucial step is anticipating what might go wrong with a product. While anticipating every failure mode is not possible, the development team should formulate as extensive a list of potential failure modes as possible. The early and consistent use of FMEAs in the design process allows the engineer to design out failures and produce reliable, safe, and customer pleasing products. FMEAs also capture historical information for use in future product improvements [5-7]. Traditionally, reliability has been achieved through extensive testing and use of techniques such as probabilistic reliability modeling [8].

II. IMPORTANCE OF FAILURE ANALYSIS OF WELDING EQUIPMENT

The role of joints whether welded, brazed, soldered or bolted is the most critical aspect to hold any assembly together. Joints are usually the weakest link in the total assembly and decide the overall integrity of equipment. Joint failures are as specific as the nature of joining process. Welded joints can fail due to lapses during the welding parameters, operational skills or merely because of properties inferior to base metal. AEIS personnel have analyzed welded joint failures from a variety of weaknesses such as cracking, lack of fusion; undercuts, faulty fit ups, improper pre heat, or stress relieving, wrong consumables. These may be the failures caused as a result of welding but it is very important to analyse the failure modes and effects of welding equipment. Prior notification of these failures can prevent the customer to safeguard the equipment.

III. IMPLEMENTATION

In FMEA, failures are prioritized according to how serious their consequences are, how frequently they occur and how easily they can be detected [9,10]. A FMEA also documents current knowledge and actions about the risks of failures for use in continuous improvement. FMEA is used during the design stage with an aim to avoid future failures (sometimes called DFMEA in that case). Later it is used for process control, before and during ongoing operation of the process. Ideally, FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product or service. The outcomes of an FMEA development are actions to prevent or reduce the severity or likelihood of failures, starting with the highest-priority ones. It may be used to evaluate risk management priorities for mitigating known threat vulnerabilities. FMEA helps select remedial actions that reduce cumulative impacts of life-cycle consequences (risks) from a systems failure (fault). In this work, a multipurpose welding machine INVERTECH V350 PRO is analyzed by the principle of failure mode and effect analysis and the fmea chart is drawn with risk priority numbers. Fig1 shows the welding equipment. Fig2 shows the process of FMEA [11,12].

Fig 1: Lincoln v350 pro

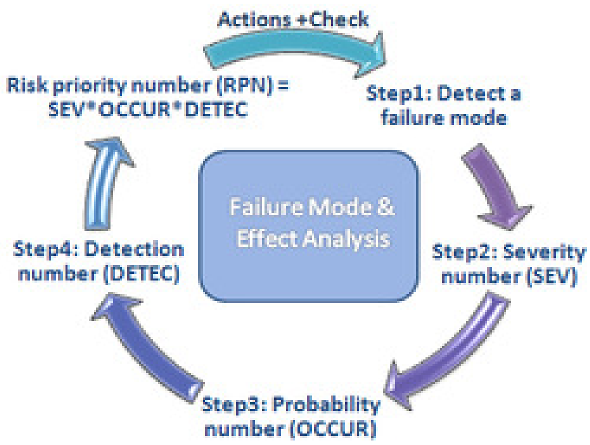

Fig 2- Methodology of FMEA

Table 1: FMEA chart

S No	Item	Potential failure mode	Potential effects	S	Potential causes	O	Current controls	D	RPN
01	Power LED	No indication	Cannot determine whether the machine is on or off	2	Faulty supply	2	Proper supply should be given	1	4
02	Ventilation		Fumes and gases	5	Improper ventilation	1	OSHA PEL and ACGIH TLV limits using local exhaust or mechanical ventilation	7	35
03	Work cables	Erosion	Weld current may pass through lifting chains, crane cables or other alternate circuits.	5	Work cables connected to the building framework or other locations away from the welding area	5	Connect the work cable to the work as close to the welding area as practical.	2	50
04	Compressed gas cylinders	External damage	Explosion of cylinder	9	Improper regulators, torch touching the cylinder	2	Use only compressed gas cylinders containing the correct shielding gas for the process used and proper ly operating regulators designed for the gas and pressure used. All hoses, fittings, etc. should be suitable for the application and maintained in good condition.	6	108
05	Grounding	Misplaced or cut	Radiated interferenc e	9	Improper grounding and high frequency interference	7	Ground metallic objects	2	126
06	Fuse	Fuse wire being cut	Current shut offs	4	High input currents	2	Use delayed type circuit breakers	1	8
07	Attachment plug	Physical damage	Over-voltage the power source	5	Improper attachment to connecting chord	4	All attachment plugs must comply with the Standard for Attachment Plugs and Receptacles, UL498.	2	40
08	Cooling fan	Dirt deposition	Heat will not be removed	2	Improper surrounding	2	Proper cleaning	3	12

09	Capacitors	External damage	Over voltage is produced	5	Improper discharging	3	Proper disc harging must be done for atleast 5 minutes	3	45
10	Work cable rubber coverings	Cuts and cracks	High frequency leakage	7	Less natural rubber content	3	Cables with high natural rubber content, such as Lincoln Stable-Arc better resist high frequency leakage than neoprene and other synthetic rubber insulated cables	3	63

where

S- severity rating

O- occurrence rating

D- detection rating

3.1 Step 1: Occurrence

In this step it is necessary to look at the cause of a failure mode and the number of times it occurs. This can be done by looking at similar products or processes and the failure modes that have been documented for them in the past. A failure cause is looked upon as a design weakness. All the potential causes for a failure mode should be identified and documented. Again this should be in technical terms. Examples of causes are: erroneous algorithms, excessive voltage or improper operating conditions. A failure mode is given an occurrence ranking (O), again 1–10. Actions need to be determined if the occurrence is high (meaning > 4 for non-safety failure modes and > 1 when the severity-number from step 1 is 1 or 0). This step is called the detailed development section of the FMEA process. Occurrence also can be defined as %. If a non-safety issue happened less than 1%, we can give 1 to it. It is based on product and customer specification.

Table 2: Occurrence rating

Rating	Meaning
1	No known occurrences on similar products or processes
2,3	Low (relatively few failures)
4,5,6	Moderate (occasional failures)
7,8	High (repeated failures)
9,10	Very high (failure is almost inevitable)

3.2 Step 2: Severity

Determining all failure modes based on the functional requirements and their effects. Examples of failure modes are: Electrical short-circuiting, corrosion or deformation. A failure mode in one component can lead to a failure mode in another component, therefore each failure mode should be listed in technical terms and for function. Hereafter the ultimate effect of each failure mode needs to be considered. A failure effect is defined as the result of a failure mode on the function of the system as perceived by the user. In this way it is convenient to write these effects down in terms of what the user might see or experience. Examples of failure effects are: degraded performance, noise or even injury to a user. Each effect is given a severity number (S) from 1 (no danger) to 10 (critical). These numbers help an engineer to prioritize the failure modes and their effects. If the sensitivity of an effect has a number 9 or 10, actions are considered to change the design by eliminating the failure mode, if possible, or protecting the user from the effect. A severity rating of 9 or 10 is generally reserved for those effects which would cause injury to a user or otherwise result in litigation.

Table 3: Severity rating

Rating	Meaning
1	No effect
2	Very minor(only noticed by discriminating customers)
3	Minor (affects very little of the system, noticed by average customers)
4,5,6	Moderate (most customers are annoyed)
7,8	High (causes a lot of primary function; customers are dissatisfied)
9,10	Very high and hazardous(product becomes inoperative)

3.3 Step 3: Detection

When appropriate actions are determined, it is necessary to test their efficiency. In addition, design verification is needed. The proper inspection methods need to be chosen. First, we should look at the current controls of the system, that prevent failure modes from occurring or which detect the failure before it reaches the customer. Hereafter one should identify testing, analysis, monitoring and other techniques that can be or have been used on similar systems to detect failures. From these controls an engineer can learn how likely it is for a failure to be identified or detected. Each combination from the previous 2 steps receives a detection number (D). This ranks the ability of planned tests and inspections to remove defects or detect failure modes in time. The assigned detection number measures the risk that the failure will escape detection. A high detection number indicates that the chances are high that the failure will escape detection, or in other words, that the chances of detection are low.

Table 4: Detection rating

Rating	Meaning
1	Certain ,fault will be caught on test
2	Almost certain
3	High
4,5,6	Moderate
7,8	Low
9,10	Fault will be passed to customer undetected

After these three basic steps, risk priority numbers (RPN) are calculated

IV. RESULTS AND DISCUSSIONS

RPN play an important part in the choice of an action against failure modes. They are threshold values in the evaluation of these actions. After ranking the severity, occurrence and detectability the RPN can be easily calculated by multiplying these three numbers: RPN = S × O × D. This has to be done for the entire process and/or design. Once this is done it is easy to determine the areas of greatest concern. The failure modes that have the highest RPN should be given the highest priority for corrective action. This means it is not always the failure modes with the highest severity numbers that should be treated first. There could be less severe failures, but which occur more often and are less detectable.

After these values are allocated, recommended actions with targets, responsibility and dates of implementation are noted. These actions can include specific inspection, testing or quality procedures, redesign (such as selection of new components), adding more redundancy and limiting environmental stresses or operating range. Once the actions have been implemented in the design/process, the new RPN should be checked, to confirm the improvements.

V. CONCLUSION

Thus a welding machine is analyzed and the expected failures are noted. This analysis will be very much useful for anyone who does welding. These corrective actions should be taken before welding and proper maintenance should be done for an effective weld. The integrated approach, FMEA serves as a better way to maintain the equipment defect free. It is found that the most important parts with higher risks are compressed cylinders and grounding. The causes, effects and the preventive measures of all the possible failures are given along with the priorities. Whenever a design or a process changes, an FMEA should be updated. The risk priority numbers of the defects are given which indicates the necessity of the care for welding processes for a defect free weld.

VI. FUTURE WORK

The future work of this paper includes development of software that gives all the details of the failure prevention measures of a failure mode that is inputted. Also a database can be formed for all types of welding machines and also the processes and it will be useful as a failure prevention guide for the workers as well as the researchers.

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