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AN EFFECTIVE USE OF POKA YOKE FOR A NEW PROCESS IN ASSEMBLY LINE

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Abstract - *This generation is more conscious about cost reduction, which leads one of the construction equipment industries to come up with a new model of Double drum compactor machine (NDD) for their customers. The project focuses on study of the similar kind of machine in line for NDD and analyzes any potential failures for the assembly of product in line and applies poka-yoke for that process through Process failure mode effect analysis (PFMEA). The aim of the project is to increase the efficiency of workstation, minimizing the failures and thereby increasing the productivity in the assembly line. The data of similar machine in line was collected and analyzed and repeated failures were identified. The critical failures of existing double drum compactor (EDD) was found to be in two places, steering cylinder and drum vibration motor from the data collected. The team was formed for brainstorming session and the project has been addressed with one poka-yoke solution. The techniques of Poka-yoke, Cause and effect diagram, which are elements of Failure Mode Effect Analysis, are applied effectively for new model.*

Key Words: PFMEA, NDD, EDD, Poka-Yoke

1. INTRODUCTION

PFMEA recognizes and evaluates the potential failures and identifies suitable actions that could eliminate or reduce the chances of potential failures.

PFMEA is often developed at the time when a new product or process is being introduced. This activity is very beneficial when ordering tooling and equipment as well as determining process controls. It is a collection of possible causes and mechanisms for failure modes, as determined by a team. It can also play an important role in day to day improvement and problem solving.

Since new product development in an industry deals with large number of materials/parts handling and assembling, it can be subjected to failure modes, delays hence here is the scope for applying FMEA technique to assembly process which helps in identifying potential failure modes, prioritizing the same, based on which additional preventive and detective actions are given to eliminate or reduce the potential failure modes. Similar model in line can be selected for process study, five steps methodology of applying FMEA is employed which first starts with structural analysis followed by functions, failure, actions and optimization stages which are all drafted in a FMEA chart. And finally statistical analysis techniques such as Pareto analysis can be used to prioritize failure modes to give additional preventive and detective actions to reduce the risk association with the potential failure modes, so the new product in assembly line to be proactive in nature.[3]

Poka-yoke is a Japanese term that means "fail-safing" or "mistake-proofing". A poka-yoke is any mechanism in a lean manufacturing process that helps an equipment operator avoid mistakes (poka). Its purpose is to eliminate product defects by preventing, correcting, or drawing attention to human errors as they occur. The concept was formalized, and the term adopted, by Shigeo Shingo as part of the Toyota Production System. It was originally described as baka-yoke, but as this means "fool-proofing" (or "idiotproofing") the name was changed to the milder poka-yoke.[4]

2. OBJECTIVES

Objectives of this project are:

• To study the benefits of creating an FMEA for a new product NDD which will be assemble in line in future.

• To identify the potential failures of EDD so that when NDD comes to assembly line the processes go off smoothly.

• To provide solution or design poke yoke system to avoid failures if required.

3. REVIEW OF RELATED LITERATURE

George Pantazopoulos and George Tsinopoulos [1] in the journal "Process Failure Modes and Effects Analysis (PFMEA): A Structured Approach for Quality Improvement in the Metal Forming Industry" explained the application of a FMEA. A FMEA is applied to the brass disk annealing process with the goal of optimizing the operational performance by decreasing the RPN and increasing the process capability which reveals the hidden process weaknesses, leading to the quantification of failure related indicators/failure risks and the creation of a prioritization matrix for further improvement actions. Risk reassessment and further preventive action planning could lead to effective risk minimization.

Ramin Sadri, Pouya Taheri, Pejman Azarsa and Hedayat Ghavam [2] have carried out research to improve the productivity through Mistake-proofing of Construction Processes. Construction defects are always the key concern of the construction industry. Different constructed facilities generate different types of defects and demand different levels and types of quality, depending on the functions, system types, and materials used. To achieve mistake-proofing concept in a construction site, zones where are prone to error should be identified. These mistakes could be quality problems, delay in delivering a mid-process product, safety issues and so on. By tracking where the problems locate, the project manager could place his/her attention on investigating and resolving the problem, and implement the mistake-proofing device to prevent recurrence of problems in the future. There are six of main mistake-proofing principles listed in order of preference in fundamentally addressing mistakes: (1) Elimination seeks to eliminate the possibility of error by redesigning the product or process so that the task or part is no longer necessary; (2) Replacement substitutes a more reliable process to improve consistency; (3) Prevention engineers the product or processes so it is impossible to make a mistake at all; (4) Facilitation employs techniques and combining steps to make work easier to perform; (5) Detection involves identifying an error before further processing occurs so that the user can quickly correct the problem; (6) Mitigation seeks to minimize the effect of errors. The results show that the construction operations have high potential of mistake-proofing, and therefore the application of Poka-yoke devices can finally lead to drastic promotion in construction industry. At last section, a case study related to the simple operation of a trolley hoist also conducted to evaluate productivity improvement due to the process mistake proofing in practice.

4. METHODOLOGY

Methodology that can be employed to create Process FMEA is a five step process as described below:[3]

1. Structural analysis:
   Process flow is reviewed; system elements are identified and system structure is created.
2. Functional Analysis:
   Functional mechanism of the system is defined.
3. Failure analysis:
   Malfunctions to the functions are assigned, failures are linked and the failure mechanism is determined. Quantify the impact of potential failure effects (RPN calculations)
4. Actions analysis:
   Document current preventive and detective actions, rate the current status. Identify and prioritize actions to reduce or eliminate the potential failure causes.
5. Optimization:
   Reduce risks with additional actions.

4.1 Data collection

After studying the process of existing double drum (EDD), data has been collected for 3 months and FMEA chart has been filled. The probability of severity(S), occurrence (O) and detection (D) are selected on the scale of 1-10 in increasing order of criticality and multiplication of all three results in risk priority number (RPN). From the FMEA chart it has been observed that the two failures are critical which can results in fatal if it gets repeated for new double drum (NDD) and rest failures are for EDD.

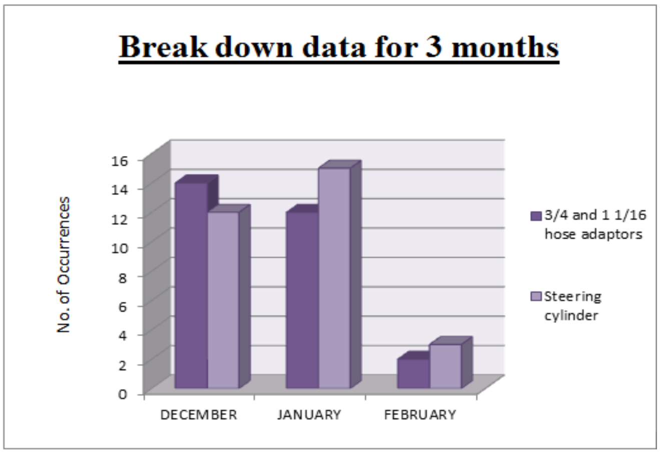

Chart -1: Bar chart of data collected

Here, for the three months total 15, 19 and 4 numbers of machines are assembled respectively and the number of occurrences were 14, 12 & 2 for loosening of ¾ and 1 $^1/_{16}$ hose adaptors of drum vibration motors for three months respectively and 12, 15 & 3 for wrong hose connection of steering cylinder for three months respectively.

4.2 Summary of failure

One failure is in wrong hose connection of steering cylinder, as whenever the operator starts the machine at station 7 to test drive inspection (TDI) area, if the operator willing to take left the machine moves right and if the operator willing to take right the machine moves left. This can be very critical regarding the human and the equipments around the area, so this issue needs to be addressed first. Secondly is loosening of ¾ and 1 $^1/_{16}$ hose adaptors of drum vibration motors, as whenever the machine starts the adaptors are getting loose due to the vibration effect and the oil is getting spill out. This can be serious as the chance of machine breakdown is getting more.

4.3 Cause & Effect diagram for steering cylinder

When utilizing a team approach to problem solving, there are often many opinions as to the problem's root cause. One way to capture these different ideas and stimulate the team's brainstorming on root causes is the cause and effect diagram. This will help to visually display the many potential causes for a specific problem or effect. It is particularly useful in a group setting and for situations in which little quantitative data is available for analysis.

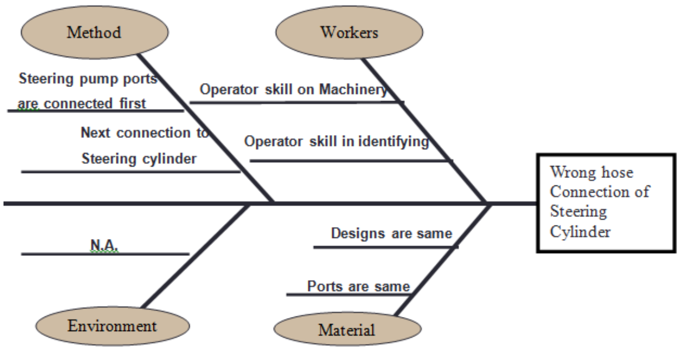

Fig -1: cause & effect diagram for steering cylinder wrong connection

Above cause & effect diagram shows that what all the possible factors for wrong hose connection for steering cylinder. A brainstorming session was held by a team comprising of 4 members and one audit sheet has been made.

Table -1: Audit sheet for steering cylinder

Cause	Parameters	Standard	Observed	Conclusion	Actions to be taken
Worker	Operator Skill	No standard to identify the correct hoses, it is based on experience	Operators are experienced but sometimes they also did mistakes since the adaptors and ports are same.	Not OK	Change the design of port of steering cylinder maintaining the I.D and also the same for hose adaptors of one side.
Method	Connection Sequence	Can choose any one	Observed operator is following sequence choosing any one	ok	
Material	Designs are same	Can select any one	Found ok	ok	
	Ports are same	Can choose any one			

After the audit sheet done it is found that the problem lies with the workers. They are failing to identify the correct hoses for connection.

Fig -2 Steering cylinder with hose adaptors

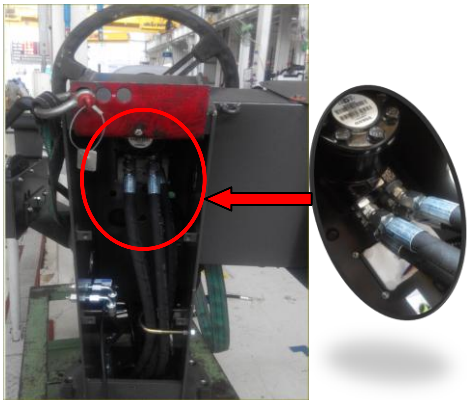

Fig- 3 View of steering pump where hose getting connected from steering cylinder

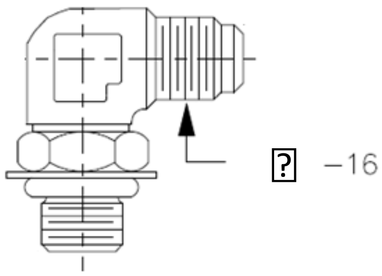

Fig -4 Hose adaptor of ¾ -16 [5]

Here ¾ is the internal diameter and ¾*16 = 12mm is the outer diameter of the adaptors. Presently both the adaptors are same that's why the workers are making mistakes to identify the right one. The solution to this problem is that to change the outer diameter of one of the adaptors maintaining the internal diameter same so that the flow won't get disturbed. This is the mistake proofing solution since the hoses of one will not get fits to the other.

New hose adapter will be ¾ - 18
And outer diameter will be ¾ * 18 = 13.5 mm

4.4 Cause & Effect diagram for drum section

The loosening of ¾ and 1 $^{1}/_{16}$ hose adaptors of drum vibration motor is a big concern as this takes place round more than 10 times in a month. Although the EDD is in very less number in assembly line then also this failure is a regular one. The same failure can be happen to new model NDD, and some solution has to solve this issue. After observation and discussion with the team members it is founded that because of the accessibility issue and also for the width of the spanner this problem is arising. Since the width of the spanner is more it is not able to hold of the check nut and the nut is getting loosen after vibration.

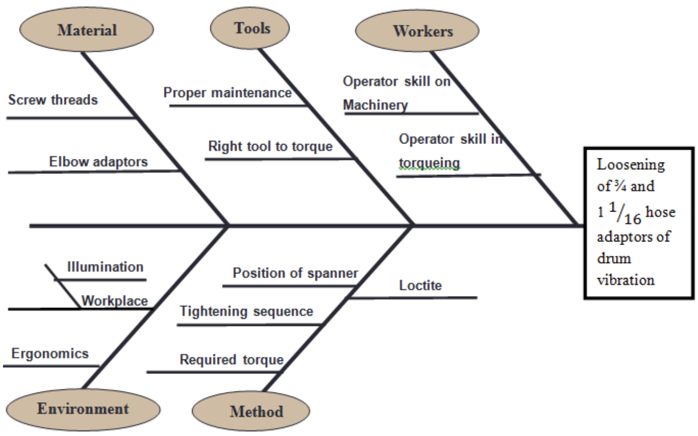

Fig -5 Cause & Effect diagram for drum vibration motor

After cause and effect diagram it is require observing each causes individually since it is a repetitive failure in the assembly line, for this audit sheet has been prepared.

Table -2 Audit sheet for drum vibration motor

Cause	Parameters	Standard	Observed	Conclusion	Actions to be taken
Workers	Machine Operator Skill	Must be an experienced person to torque well to 1080 kn.	Torqueing but it's not tightening properly because of accessibility issue	Not ok	Desired width of torque spanner is required
Tools	Proper maintenance	Weekly maintenance	Fixtures are in good condition	ok	
Material	Material properties	Mild steel	Properties are ok	ok	
	Screw threads	Standard thread length	As per design	ok	
Method	Position of spanner	As per accessibility	Doing from possible space	ok	
	Tightening torque	Tightening as per given 1080 KN	Found ok	ok	
Environment	Ergonomically parameters	Found ok	Found ok	ok	

Fig -6 30-32 spanner

While tightening the drum vibration motor check nut the operator was facing problem to hold the spanner in that place. Since the width of the existing spanner is 0.7 cm or 7 mm which is taking the space and not letting the check nut to go inside.
The solution is for 30 – 32 spanner wrench with width of 0.3 cm or 3 mm which will easily get hold in that area and the check nut will insert easily and also get tighten properly.

3. CONCLUSIONS

After carrying out the PFMEA for NDD, many improvements was achieved. The EDD was facing some failures out of which two failures were critical and having a chance of gets repeating for NDD. After doing cause and effect diagram one problem got solved with Poka yoke solution and other one solved by the best solution.

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