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IMPROVEMENT OF WINDMILL ASSEMBLY PROCESS WITH FMEA

PROSTEAN, G[abriela]; TAMASILA, M[atei] & TAUCEAN, I[lie] M[ihai]

Abstract: *The paper present the effects of change of lean manufacturing implementation in a company focusing on following objective: to synthesis all involved procedures, stages and instruments, to draw up a FMEA table for a real case study (a windmill farm), to measure the efficacy, efficiency for cell versus line manufacturing.*
Key words: *windmill, efficiency, FMEA Analysis, assembly process, lean*

1. INTRODUCTION

Lean is a toolbox of concepts, tools, techniques and ideas that an organization uses to meet company goals and objectives. And while not everything in the lean toolbox may apply to every operation, overall objectives are met when everyone involved choose the appropriate tools and techniques and determinates where they fit best (Ward, 2007).

Womack and Jones (Womack & Jones, 1996) distilled lean principles to five, and we use these as a tool for the assembly process analysis in final phase of the assembly process of the windmill product there is a organizational problem and also a production efficiency and effective problem.

2. METHODOLOGY

Here we design the model for lean implementation propose to be use and pretest it by using a assembly process as a study case to preliminary validate the model. The model can be use as an instrument/tool for management of technological change.

This model includes the concepts of lean and the FMEA Analysis, these applied for the presented case (assembly process for a windmill farm) for significant period of time.

One of the main goals of lean implementation in manufacturing it is to eliminate the seven plus one "deadly sins" of manufacturing: overproduction, correction, processing, conveyance, inventory, motion, waiting and finally unused people's creativity.

FMEA Analysis

As an instrument we used a Failure Mode and Effects Analysis (FMEA) (wikipedia.org) is a procedure for analysis of potential failure modes within a system for the classification by severity or determination of the failure's effect upon the system. It is widely used in the manufacturing industries in various phases of the product life cycle.

Failure causes are any errors or defects in process, design, or item especially ones that affect the customer, and can be potential or actual.

FMEA steps are (Tamasila et al., 2009):

Step 1: ***Severity.*** Determine all failure modes based on the functional requirements and their effects. It is important to note that 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. Each effect is given a severity number (S) from 1 (no danger) to 10 (important). If the severity 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.

Step 2: ***Occurrence.*** In this step it is necessary to look at the cause of a failure and how many times it occurs. This can be done by looking at similar products or processes and the failures that have been documented for them. 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. A failure mode is given a probability number (O), again 1-10. Actions need to be determined if the occurrence is high (meaning more than 4 for non safety failure modes and more than 1 when the severity-number from step 1 is 9 or 10). This step is called the detailed development section of the FMEA process.

Step 3: ***Detection.*** When appropriate actions are determined, it is necessary to test their efficiency. Also design verification is needed. The proper inspection methods need to be chosen. First, an engineer should look at the current controls of the system, that prevent failure modes from occurring or which detect the failure before it reaches the windmill farm.

Hereafter one should identify testing, analysis, monitoring and other techniques that can be or have been used on similar systems to detect failures. From this 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 number represents the ability of planned tests and inspections at removing defects or detecting failure modes.

After these 3 basic steps, Risk Priority Numbers (RPN) is calculated: RPN = S x O x D. The failure modes that have the highest RPN should be given the highest priority for corrective action.

At the other hand the effects analysis refers to studying the consequences of those failures and eliminate them through: trying to begin the continuous improvement, it means to find/choose the right person to coordinate this program and to acquire the basic of lean thinking; find the areas where are problems and try to reduce the wastes of them.

3. CASE STUDY

The study case was based on the analysis of the final assembly process of a windmill in order to build a wind farm.

The analysis was made by a team composed by key representative from the company witch realize this farm, direct interested in research theme, and the authors. Here it was analyzed the final phase of the assembly process.

For assembly process was establish an RPN using FMEA matrix, and also recommended actions in order to reduce the risk level.

3.1 Assembly process

The design and manufacturing trends differ as far as small and large turbines are concerned. As regards small mechanisms, there is a tendency to use moulds which are as light as possible, the effort aiming at costs reduction. Many parts of small turbines are made of aluminum, while the mechanisms requirements for large turbines imply specific steel processing, that comply with the parameters imposed by the material endurance test requirements. The observance of all design requirements, especially for rotors (hubs, blades) represents one of the greatest challenges of the manufacturing process in the field of wind energy (Szeidert et al., 2008).

A wind turbine consists of three fundamental parts: the tower, the nacelle, and the rotor blades.

The tower is made up of a steel lattice, similar with the electric guns, or of a tubular steel which has an inside ladder to the nacelle.

The rotor is made up of a hub to which there are attached the wing-like blades. Today, most of the rotor blades are manufactured of fiberglass-reinforced-plastic. Other materials which are also used for the rotor manufacture include steel, various composite materials, and carbon-filament-reinforced-plastic. As the rotor size increases in the manufacturing process of larger dimensions mechanisms, there is a tendency to use materials of greater endurance.

The nacelle is strong, having the form of a hollow shell, being usually manufactured of fiberglass. The nacelle contains the main drive shaft, the gearbox, the blade pitch control system, and the yaw drive. The blade pitch control is generally a hydraulic system which controls the blades angle, and the yaw drive controls the turbine position to the wind.

Item/Process	**Components assembly**	**Components move (lifting)**
Potential Failure Mode	Nonconformance of components	Mechanical damage
Potential Effects Failure	Damage windmill	Damage windmill
Severity	6	8
Potential Cause(s) of Failure	There is no possibility to test ensemble	There is no possibility to test ensemble
Occurrence	7	5
Current Control	Process Audit	Visual check
Detection	3	4
RPN	**126**	**160**
Recommended actions and results		
Recommended Actions	Cell assembly	Cell assembly
Responsibility & Target date	Cell leader	Cell leader
Actions Taken	Yes	Yes
Severity	6	8
Occurrence	4	4
Detection	3	2
RPN	**72**	**64**

Tab 1. FMEA for final assembly and verification

The greatest challenge as regards manufacture, namely in the supply process for obtaining a wind turbine, is the continuous updating and optimization of the manufacturing orders, the reduction of the operational costs, and the optimization of the processes due to the changes of the requirements, based on the optimization of the supply process.

As you can see in the table 1, RPN value for assembly process and verification was 126 and 160, but after recommended actions implementation (cell assembly, but not flow assembly) they are significantly smaller (72 and 64).

3.2 Results

The proposed reorganized assembly process resolved a part of the problems: declining number of mechanical defects for windmill and components due to the manipulation by the two cranes, we call that in cellular type after the nacelle and rotary blades are already together versus usual way to assembly; the final inspection involved very low risk operations; the functional verification test indicates an extremely low number of defects.

At another hand, we have to mention further evidence of a new effective assembly process having a shorter time of assembly process which involves positive economic effects also from the view of producing energy by a windmill as soon as possible.

Reorganization of assembly process can be made using other method and instruments (Kaizen, 6 sigma, Triz, Heijunka, 5S) which improve assembly efficiency and other economic effects, in correlation with this paper method and approach.

4. CONCLUSIONS

The presented model and the study case have implications to academic as well as to policy makers and practitioners in the field of management and lean manufacturing implementation in order to be more efficient and effective.

The key contribution of the paper refers to an original approach to experiment the lean implementation in an organization. Here it is proposed a lean analysis through FMEA instrument, which highlights the failure modes that have the highest RPN, involving the highest priority for corrective action.

It is possible to see in the presented table, that the lean manufacturing system implementation is not synonymous to integral manufacturing problems elimination. Lean is not a manufacturing type, but is a concept which must be used, providing a guideline in windmill assembly process for wastes elimination.

The lean system gives a real satisfaction only in the case when the preoccupation for improvement is continuous.

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