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PREVENTIVE METHODS IN LOGISTICS POKA-YOKE AND FAILURE MODE AND EFFECT ANALYSIS (FMEA)

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ABSTRACT: Preventive methods are seldom used in logistics, although there is increasing awareness of their potential. This paper presents two examples of preventive methods currently in use, Poka-Yoke and FMEA (Failure Mode and Effect Analysis). The implementation of Poka-Yoke, the mistake proofing methodology, has been shown to drastically reduce the enormous warranty costs, including logistics costs, while FMEA, implemented for the purpose of assuring the smooth execution of industrial processes, has already been successfully applied during the early planning phase of a new packing centre under construction.
KEYWORDS: Preventive methods, logistics, FMEA, Poka-Yoke, industrial application

INTRODUCTION

In German industry, quality costs are estimated to be, on average, up to five to ten per cent of the turnover. This corresponds to 36 to 72 billion Euros. 70 per cent of these quality costs represent the costs involved in correcting defects, while only seven percent are prevention costs (quality inspection).

Preventive methods are seldom used in logistics and warranty generates huge costs for handling and transport. This paper shows, on the basis of industrial examples, that the mistake proofing methodology, Poka-Yoke, drastically reduces the enormous warranty costs including logistics costs.

In addition, a second preventative method, FMEA can be implemented for the purpose of assuring the smooth execution of industrial processes and has already been successfully applied during the early planning phase of a new packing centre under construction. In this way, possible failures and their causes and potential effects, as well as measures to be implemented for the avoidance and detection of such failures, can be analysed from the aspect of failure mode factors.

MISTAKE PROOFING METHODOLOGY POKA-YOKE

Poka-Yoke is a Japanese term that means "mistake-proofing or "fail-safing". This concept was formalised and the term adopted by Shigeo Shingo as part of the Toyota Production System [1, 2]. The target is to avoid missing parts, misassembled parts, incorrect processing and incorrect parts.

The definition of Poka-Yoke = Error Proofing:

- Poka-Yoke is a device, which prevents a process from making an error (**prediction**) or a defect from being passed on to the user (**detection**).
- When a defect is predicted or an error detected, the process is **shut down** or a **control** prevents the process from going ahead or a **warning** is sent.

Good Poka-Yoke devices, regardless of their particular implementation, share many common characteristics:

- They are simple & cheap. If they are too complicated or too expensive, their use will not be cost-effective.
- They are part of the process, implementing what Shingo calls "100%" inspection.
- They are placed close to where the mistakes occur, providing quick feedback to the workers, so that the mistakes can be corrected.

This paper shows, on the basis of industrial examples, that the mistake-proofing methodology, Poka-Yoke, eliminates the cause of an error at the source by detecting any error as it is being made or soon after it has been made, but before it reaches the next operation. Poka-Yoke helps to build quality into processes and products. As a result, the enormous warranty costs, including logistics costs, will go drastically down.

Poka-Yoke training programme

For the employees, the Target of the Poka-Yoke Training is to develop a Poka-Yoke mindset and gain practical experience in the implementation of Poka-Yoke. The Target group includes planning engineers, quality engineers, employees in problem solving process and „specialists in charge of Poka-Yoke solutions“.

The Training Concept is the communication, in an almost playful manner, of the Poka-Yoke theory and includes a high proportion of practical exercises. The exercises are based on real production problems and focus on Process-Poka-Yoke. The trainers conduct practical exercises during which they act as coaches. The results of these exercises are then presented to the management for their implementation. For the implementation of Poka-Yoke as a new methodology, a training programme has been developed. Table 1 shows the agenda and table 2 the key lessons of a Poka-Yoke training programme.

Table 1 – Agenda Poka-Yoke training programme

DAY 1 – Theory:
- Simulation: Poka-Yoke Training Station
  - Poka-Yoke Theory - Flip Chart Training
  - 5 Shingo plants, product- & process-Poka-Yoke,
  - Attributes of good Poka-Yoke solutions etc.
  - Examples: videos and several solutions for production problems presentations
  - Poka-Yoke exercises (on paper)
  - Basics of the problem solving process
  - Organisation day 2: Formation of teams, introduction of several production problems

DAY 2 – Practical experience:
- Teams select 3 problems each (missing, wrong, loose), data acquisition
- Teams discuss each of these problems and then,
- Selection of one production problem and one solution for cardboard simulation

DAY 3 – Practical experience:
- Teams implement the solution in a simple cardboard simulation
- Preparation of a presentation for management
- Teams present results
- Agreement for the handover of results to the production line

Table 2 – Key lessons of a Poka-Yoke training programme

- Key lesson 1: Introduction to Poka-Yoke
- Key lesson 2: How three types of Poka-Yoke detect and prevent errors in a production system, the contact method, the fixed-value (or constant number) method and the motion-step (or sequence) method
- Key lesson 3: How Quality can be built into products by the implementation of Poka-Yoke
- Key lesson 4: How Poka-yoke helps build quality into processes
- Key lesson 5: How the growing relevance of Poka-Yoke improves warranty and reduces costs including logistics costs.

Industrial Poka-Yoke examples

A Motor Company and Bosch Rexroth Corp. have implemented multiple error proofing applications to identify different sensors based on their torque signature:
- Poka-Yoke#1:Torque Red/Green Light display
- Poka-Yoke#2:Screen Display
- Poka-Yoke#3:Sensor control for long/short sensor selection
- Poka-Yoke#4:Alarm signal if the wrong senor selected
- Poka-Yoke#5:NOK acknowledge

The tool will be disabled if the wrong sensor is used. The operator then needs to press the acknowledge button to enable the tool. The Operator's full attention is required. The result of this automotive assembly project shows: reduced warranty and logistics costs by Poka-Yoke, no defects and better quality, which leads to higher customer satisfaction, see figure 1 [3].

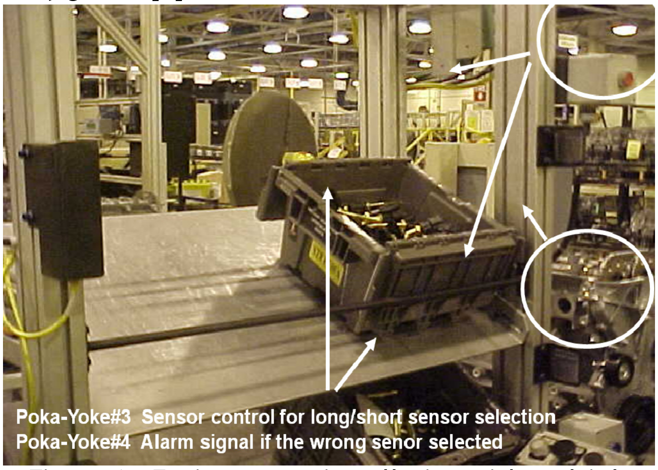

Figure 1 - Engine sensor installation with multiple Poka-Yoke applications

The expanding network size of logistical systems as a result of outsourcing and internationalization also leads to less reliable processes that are more prone to error. Increasing transport distances, network partners distributed throughout the world and the rise in the number of logistics interfaces lead to more unstable material flows. Error-tolerant logistic processes can, however, be achieved with the aid of Poka-Yoke solutions, as shown by the following examples (figure 2):
- Poka-Yoke shelf in automotive final assembly line [4].
- Error-free order picking with Poka-Yoke: in this example, the Poka-Yoke concept is realized through the use of Pick-by Light or Put-to Light with sensor monitoring of the removal and storage places as well as RFID-monitoring of the conduct of the process. As a result of this implementation of Poka-Yoke, the number of order picking errors are reduced by 80% to 95% compared to paper-based systems [5]
- Increasing Efficiency of Warehouse Operations [6] by equipping forklifts with PCs: an affordable solution for many new and existing warehouses is to empower operators by installing an onboard computer on each forklift and connecting them to a Warehouse Management System (WMS) via a wireless local area network. This makes the location of items and empty storage space immediately visible, which instantly reduces the waste involved in transportation, human motion and waiting. This results in better response times (less waiting) for dependent production processes and customer satisfaction. A shorter lead time provides an improved service and can also result in a reduction of inventory and floor-space requirements. This represents a poka yoke solution, in which the incidence of retrieving and shipping the wrong item is dramatically reduced by matching the item with information on the item's location. The use of barcodes and RFID almost completely eliminates such errors and significantly improves inventory accuracy.

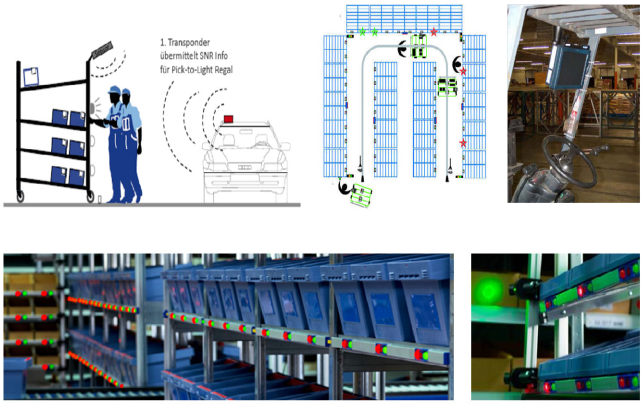

Figure 2 – Poka-Yoke applications in logistics [4, 5, 6]

RISK ANALYSIS FMEA - PLANNING OF A LOGISTICS PLANT

The Failure Modes and Effect Analysis (FMEA) is a development and planning accompanying system and risk analysis. It is integrated in the specialist departments and includes the optimisation of the system and risk reduction. As an important methodical instrument, the FMEA allows possible failures to be identified at an early stage, so that they can be prevented before they even occur. This is important in new concepts and developments as well as the further development of products and processes, see [7].

In quality assurance agreements for the assurance of delivery quality by suppliers, an FMEA is often mandatory. For example, according to the latest state-of-the-art technical requirements, a process FMEA is required to be carried out [8]. The results of an empirical study show that FMEAs are hardly ever used in project management for quality planning and assurance or for risk management, see figure 3 [9].

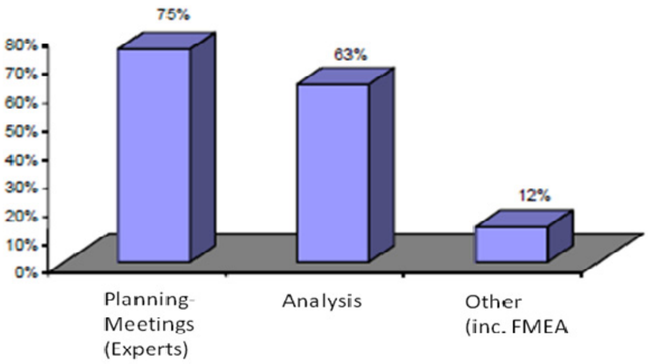

Figure 3 – Methods of risk planning

For the assurance of a smooth execution of the processes of a new packing centre under construction, a risk analysis was carried out with the aid of an FMEA performed in the early planning phase of this construction project, see [10]. This way, possible failures and their causes and potential effects, as well as measures to be implemented for the avoidance and detection of such failures, can be analysed from the aspect of failure mode factors, which includes man, machine, method, material and environment.

The FMEA is performed in 5 steps by a team comprising of members from all areas under the guidance of an experienced presenter. The 5 steps are as follows (see figure 4):

- *Representation of the system structures (hierarchical process structure),*
- *Representation of the functions and function structures (process flow),*
- *Failure analysis (possible failures, failure causes and failure mode),*
- *Risk assessment with respect to the severity of the failure mode as well as to the occurrence potential or detection potential of the occurred failure and its cause,*
- *Optimisation implementation. This involves the specification of the dead-lines and persons responsible and the coordination of the corrective measures (process sheets and operating instructions etc.).*

Figure 4 – Risk analysis packaging plant with FMEA

The potential failures can be subdivided into 2 groups during the risk assessment:

- *Refrain failures (omission of required activities, failures caused through ignorance etc.),*
- *Execution errors (mix up, unsatisfactory checks of the attribute, scan double etc.).*

The environment is also taken into consideration. In this context, it is the ergonomic conditions in particular, such as illumination, noise level, temperature etc., which can have an influence on the performance and motivation of the employees in a positive or in a negative regard. These conditions have been well-executed in the packaging plant, where much attention has been paid to avoiding the occurrence of refraining and executing errors on the part of the employees during the various manual tasks.

In the case of the aforementioned construction project, the possible risk of errors occurring during a variety of manual tasks could be reduced with the aid of remedial or avoidance measures. This mainly involved the provision of descriptions on how to carry out the individual processes (work instructions, descriptions of operational sequences, company rulings, maintenance timetables and programming SAP). An early preparation of these process descriptions is recommendable as they can then also be used for the training of the employees. If they are compiled simultaneously with the development of the process, they represent an up-to-date document of the process flow. The processes and the execution of the processes by the employees should be checked at regular intervals, in order to indicate where any improvements could be made.

An accurately timed use of a risk analysis is recommendable from both a technical and a business management planning perspective. Many functions are similar and can be transferred to other applications. In addition to a well-timed implementation of the FMEA, it is essential that the involvement of the operator is also favourable in terms of scheduling. At the start-up of the production, preventative measures are more difficult to set up. However, the FMEA can be used as a basis for follow-up planning from both a technical and a business management standpoint and can be maintained by the operator as a method for the continual improvement of the process after the start-up and during the stabilization phase.

Risk analysis with FMEA provides an early indication of the existence of potential failures and risks in the front-end of the process, thus allowing countermeasures to be already started in the early planning phase of this project. This way, the well-controlled execution of processes is guaranteed.

CONCLUSIONS

The expanding network size of logistical systems leads to material flows that are less stable. Error-tolerant logistic processes can, however, be achieved with the aid of Poka-Yoke solutions, which include the use of Pick-by Light or Put-to Light systems, barcodes, RFID-monitoring and the equipping of forklifts with PCs and connecting them to a Warehouse Management System (WMS) via a wireless local area network. Thus recent years has seen a significant increase in the implementation of Poka-Yoke, which, in turn, has led to a drastic reduction in the number of errors occurring during the actual logistics and production processes.

The Failure Modes and Effect Analysis (FMEA), on the other hand, allows possible failures to be identified already at the early conceptual phase of the process, thus enabling their prevention before they even occur. This is important in new concepts and developments as well as in the further development of products and processes. Therefore, an accurately timed use of a risk analysis with FMEA is recommendable from both a technical and a business management planning perspective, since it allows countermeasures to be already started in the early planning phase of projects. Since all major decisions concerning the complete process are already made in these early phases and any errors occurring then would be very expensive to correct at a later stage, the implementation of FMEA in the planning phases of projects, including logistics projects, would clearly be very beneficial, as these errors could then be prevented, thus guaranteeing a well-controlled execution of processes. However, in spite of these obvious benefits, FMEA is very seldom used in planning projects compared to Poka-Yoke solutions.

It can therefore be concluded that both Poka-Yoke and FMEA solutions are important tools in logistics and production processes and their combined implementation would enable a significant reduction in errors at all stages of the process from the early planning phase right up to product release. This would lead to a smooth functioning of the process and considerable savings in both time and money.

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