MULTIPLE PRACTICAL RATIONALIZATION OF WORKPLACE IN ACCORDANCE WITH POKA - YOKE METHOD

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Abstract

The present article is focused on the multiple practical application of the Poka - Yoke method on a selected workstation in an industrial enterprise, which operates in the mechanical industry and which is among the world's leading manufacturers of seat skeletons for the automotive industry. In the article, a step by step progressive rationalization of the semi-automatic workplace is captured which is used for easy application of a rubber seal on a mechanism for regulation of car seat movement in the forward and backward plane. Despite the relative simplicity of the whole operation, a significant number of failures occurred at the beginning of production caused by human factor. For this reason, the authors of the article suggested several proposals based on observing and analyzing the causes of failures, in accordance with the Poka - Yoke method. The proposals are as follows: Laser sensor, which confirms presence of the rubber seal in the groove, a pressure sensor, which controls the correct position of holders, slots to check the correct length of the manufactured product, a pneumatic actuator, for blocking the removal of the product from a nest in case of failure, an intelligent printer, that only prints the barcode after the completion of the entire operation, next the so called double button for protection of operator health and finally the warning label for visual control of finished product by operator. The reasons for rationalizations, their benefits and costs together with detailed photographic documentation form the content of the article.

Keywords: Poka - Yoke, Rationalization, Car seat, Defects

1. INTRODUCTION

Product quality is a major concern in today's modern production systems. Poor quality products decrease customer satisfaction, reduce efficiency, and increase the cost of business operations. For these reasons, it is very important to defeat the root of causes and eliminate variance in the production, in workstation’s processes [1], [4].

One of the tools which is used for increasing the rate of quality in production is the Poka – Yoke methodology. Poka - Yoke is a Japanese term that means "mistakeproofing or "fail-safing". This concept was formalised and the term adopted by Shigeo Shingo as part of the Toyota Production System. The target is to avoid missing parts, misassembled parts, incorrect processing and incorrect parts. Schmidt (2010) defines Poka - Yoke as follows:

1. 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).

2. 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. [2]

The term “Poka - Yoke” originated in the period after World War II, when there was a considerable effort in Japan to improve quality in order to capture world markets. The concept refers to an acceptance that human
error is bound to occur; but the Poka - Yoke approach to process design makes errors impossible, or at least warns the worker that an error is occurring. Shigeo Shingo pioneered the concept as part of the Toyota production system when serving as an industrial engineer and quality assurance expert [3].

The Toyota production system has since become known as Just In Time (JIT), and has been adopted in several variations of the same core principles such as Lean Manufacturing and Theory of Constraints. The term Poka - Yoke is derived from the Japanese word for avoidance (yokeru) of non-deliberate errors (poka). The subsequent “zero defect” movement embraced the Poka - Yoke approach as part of “quality at source”, replacing most post-manufacturing inspection with worker self-inspection. Originally the term used was “Baka - Yoke”, which literally meant “fool proofing”. It was later replaced by “Poka – Yoke”, which is less offensive. [3]

Good Poka - Yoke devices, regardless of their particular implementation, share many common characteristics:
1. They are simple & cheap. If they are too complicated or too expensive, their use will not be cost-effective.
2. They are part of the process, implementing what Shingo calls "100%" inspection.
3. They are placed close to where the mistakes occur, providing quick feedback to the workers, so that the mistakes can be corrected. [2]

This paper shows, on the basis of industrial examples, how the mistake-proofing methodology of Poka - Yoke eliminates the cause of defects on a selected workplace, which helps to increase the quality rate on the workstation quite substantially. More information about the selected workplace, where multiple practical rationalization was applied in accordance with Poka – Yoke by the authors of the article, is provided in the next chapter of the article.

2. BASIC INFORMATION ABOUT THE WORKPLACE

The workstation is situated in an industrial enterprise in Poland, which operates in the mechanical industry and which is among the world’s leading manufacturers of seat skeletons for the automotive industry. It is a semi-automatic workplace, which is used for putting on a rubber seal on a mechanism for regulation of car seat movement - forward and backward, which is shown in Fig. 1. The rubber seals are used for removing friction between two mechanical parts. The intermediate part of the mechanism for regulation comes to the workstation after the welding and painting process. After application of the rubber seal, the final product is exported either to internal or external customers of the company.

The workstation has been in operation since year 2008 and in the meantime, it has changed several times. The reasons for such changes, or rationalizations, was the fact that despite the relative simplicity of the whole operation, a number of failures occurred at the beginning of production caused by human factor. The rate of quality was 94.64% at the first year of production. All rationalization measures carried out in the workplace are mentioned in the next chapter. The current work procedure of workplace is as follows:

1. Take out the intermediate product from input magazine.
2. Insert the product into the nest of workstation.
3. Take out two rubber seals from magazine and put them to the grooves.
4. Cover the grooves with the holders.
5. Push the double button for starting the operation.
6. Take out the product from nest, put it to drain for barcode sticking.
7. Take the printed barcode from printer, stick it on the product.
8. Place the final product to the output magazine, make a visual control for detection, if the rubber seal is really installed on the product.
3. MULTIPLE PRACTICAL RATIONALIZATIONS OF THE WORKPLACE

Overall, 7 rationalizations were made on the workplace in accordance to Poka - Yoke methodology. The first rationalization was conducted in the summer of 2011, the most recent at the beginning of year 2013, ie in the range of about year and a half. The rationalizations, sorted from oldest to newest, are as follows:

1. **Plastic slots**, for check the correct length of the manufactured product
2. **Pressure sensor**, which controls the correct position of holders
3. **Laser sensor**, which provides presence of the rubber seal in the groove
4. **The pneumatic actuator**, for blocking the removal of the product from a nest in case of failure
5. **Double button** for a protection of the operator health
6. **Intelligent printer** that prints the barcode only after the whole completion of the operation
7. **Warning label** for visual control of finished product by operator

The reasons for rationalizations, their benefits, together with a detail photo documentation are shown in the subchapters below. All rationalizations were made by intern employees of company, from Maintenance Department and IT Department.

3.1 Plastic slots

Two types of mechanisms for regulation of car seat movement are made in the department, differing from each other in the length of the main pipe - one longer, one shorter. Each is designated for their own workstation. A very common mistake in production was the exchange of intermediate products between workstations. This was mainly because the operator responsible for the supply of magazines with intermediate products to workstations exchanged the magazines. The magazine designated for workstation X was delivered to workstation Y and vice versa. In addition, the operator on the workplace didn’t check the correctness of produced parts. Installation of simple plastic slots to the nest of workplace, which produce the intermediate product with a shorter pipe, solved this problem. They ensure that operators no longer insert the product with the longer pipe into the nest of workstation. An example is shown in Fig. 2. The same slots are installed in workstations which produce the intermediate product with a longer pipe. Although the operator should insert the product to the net, he can see, during exchange a large gap between pipe and slot.
3.2 Pressure sensor

For proper execution of putting on rubber seal on the intermediate product, so called “holders” are used in the workstation. They serve to cover the groove where the rubber seal is located. The holder eliminates the possibility of jumping – out of the rubber seal from its groove during the process of putting on the rubber on product. This measure has been installed on the workstation from the beginning of production. However, the operators often forgot to close holders during the production. This resulted in the rubber either being applied incorrectly or not at all. For this reason, the pressure sensor was installed below the holders, as the Fig. 3 shows. After closing both holders properly, the sensors transmit two electrical signal to the control unit. The control unit needs two electrical signals to start the process of putting the rubber seal on the intermediate product. The process will not start without two signals, even when the operator pushes the button to start.

3.3 Laser sensor

The reason why this rationalization was implemented is very simple. Operators in the workstation frequently forgot to put the rubber seal in the groove before the operation. This resulted in the operator putting products without the rubber seal into the magazine for finished products. For this reason a laser sensor was installed into the groove for the rubber seal. The laser detected the presence of rubber in the groove on the basis of measuring the distance between two lasers against each other. When the groove is empty, the distance is longer than the distance with the rubber seal in the groove. In the presence of the rubber seal, the sensor transmits two electrical signal to the control unit, as well as the pressure sensor above. Therefore, after this rationalization, the control unit needs four electrical signals to start the process of putting the rubber seal on
the intermediate product. The process will not start without four signals, even when the operator pushes the button to start.

![Image of the laser sensor in practice](image1)

**Fig 4. The laser sensor in practice**

### 3.4. The pneumatic actuator

The fourth rationalization on the workplace was the installation of a simple pneumatic actuator with a blockade. The blockade prevents extraction of the intermediate product from the nest in cases where the rubber seals are not fitted completely. The blockade does not unlock until the rubber seals are in their right place. This rationalization was carried out due to situations when the operators were extracting products prematurely, and respectively due to situations when the operators were putting the product to the output magazine in the case where the rubber seal wasn’t put on correctly or completely. After the rationalization, in the case of error, the blockade locks the product in the nest permanently, and can only be unlocked by a shift supervisor with a special key. Because of this rationalization, the algorithm of the control unit was changed again. The control unit now needs the electrical signal from the laser sensor in the groove to unlock the blockade. The laser sensor transmits its signal at that moment when the groove is empty, which means that rubber seal has to be put on completely.

![Image of the pneumatic actuator](image2)

**Fig 5. The pneumatic actuator**

### 3.5 Double button

The following rationalization was carried out mainly for safety reasons. The rationalization consists of implementation of a so called “Double button”. This is a simple measure, thanks to which the operation cannot start unless both buttons are pushed at the same time by the operator, with both hands. In practice,
the operator on a workstation had often put the product into the nest with one hand and pushed the button with his other hand, for timesaving. However, this procedure resulted in different minor injuries to upper limbs as well as inappropriate installing of the product to the nest. By installation of the double button these inadequacies were removed.

3.6 Intelligent printer

Application of the following rationalization was necessitated by a situation where customer complaints were received regarding finished products. A number of finished products did not contain rubber seals, in spite of the previous Poka - Yoke rationalizations. It was impossible that rubber seals had fallen during the transport, so the authors of article assumed that the error occurred because the operator took out the intermediate product from the input magazine, was disturbed by some external factor and subsequently put the product into the output magazine without the process of putting on the rubber seal on the workstation. However, the barcodes were present on the returned products, which meant that the operator had to have applied the barcode despite the fact that the operation on the workstation was not conducted. For this reason, a new algorithm was made for the barcode printer, which is situated near the workstation. After the rationalization, the printer prints the barcode only at the moment when the entire operation has taken place correctly. Before the rationalization, the printer printed the barcode at the moment at which the operator removed the previous barcode. The concept of the rationalization is simple. The control unit of the workstation transmits the signal to the control unit of printer for initiation of the print only in the case when the control unit of workstation receives all signals mentioned above.
3.7 Warning label

The last rationalization was carried out together with the previous rationalization as a result of the customer complaint mentioned above. The rationalization consists of installing a warning label on the workstation, which visually alerts the operator for the visual control of products before putting the product to the output magazine. Visual control is based on detection of whether the rubber seal is really installed on the mechanism for regulation of car seat movement. The label is placed near the groove, where the operator sticks the barcode on the final product.

Fig. 8 The warning label on the workstation

CONCLUSION

After the last rationalization, which was made at the beginning of 2013, through to the beginning of year 2014, no workplace errors caused by human factor have been detected. It clearly shows that the application of rationalizations in accordance with Poka - Yoke methodology have helped to significantly improve the quality rate of the workplace. Highy pleasing is the fact that improvement is even to the quality level of 100% over the period of one year. The quality level was 94.64% before the first rationalization. Rationalizations thus helped to improve the quality rate of the workplace by 5.36% during the reporting period. This represents, with daily production of 1 400 units, savings of approximately 19 500 scrap units per year. The time savings for repair failures represents approximately 28 workplace shifts, or in other words 215 hours of production. All rationalizations were made by intern employees of the company, from Maintenance Department and IT Department. They were managed by employees from the Manufacturing Department, where the authors of the article operated. All rationalization costs were included in the operating costs of the company, so there was no need to allocate additional funds from the company management. Most valuable are the ideas which helped execute the rationalizations. In addition, achievements from the rationalizations clearly confirm that the time sacrificed for preparation and subsequent realization of rationalizations is returned.

LITERATURE