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SOLVING QUALITY PROBLEMS WITH THE POKA-YOKE TOOL ASSISTANCE. CASE STUDY.

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Rezumat. *Lucrarea prezintă metodologia de aplicare a instrumentului Poka-Yoke în tratarea problemelor de calitate identificate în cadrul unei organizații din industria de automobile. Studiul de caz este realizat pentru un reper de tip „paletă de transport”. Este prezentat procesul tehnologic de fabricare a reperului şi sunt analizate operațiile acestuia din punct de vedere calitativ. Pentru soluționarea problemei de calitate identificată într-un post de lucru este propus un dispozitiv Poka-Yoke de interdicție. Sunt prezentate elementele componente şi modul de funcționare al dispozitivului. Analizând eficiența soluției implementate se observă o scădere a timpului de lucru al operatorilor şi o îmbunătățire a activităților lor. Procedurile de tratare a unei probleme de calitate şi utilizarea dispozitivelor Poka-Yoke garantează organizației că niciun produs neconform nu va fi livrat clientului.*

Abstract. *The paper presents the methodology for applying the Poka-Yoke tool in solving the quality problems identified within an automotive industry organization. The case study is conducted for a workpiece called „pallet for transport”. It is shown the process of manufacturing of the workpiece and its operations are analyzed from a qualitative point of view. An interdiction Poka-Yoke device is proposed to solve the quality problem identified at a working post. The components and operating mode of the device are presented. Analyzing the efficiency of the implemented solution, there is a decrease of the operators’ working time and an improvement of their activities. Procedures for dealing with a problem of quality and using Poka-Yoke devices guarantee to the organization that no non-conforming products will be delivered to the customer.*

Keywords: quality tools, Poka-Yoke devices, pallet for transport, automotive industry

1. Introduction

A quality problem can be defined as the difference between a real situation and a desirable situation mentioned in referential documents. In any organization, there is at least one quality problem that affects a higher or lower proportion of its good progress [1, 8].

The stages for solving a quality problem are the following [2, 4]:

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1. choosing a team - consists of identifying a group of people working in areas close to the identified problem;
2. description of the process generating the problem - in this stage, graphical schemes are used, such as: flow diagram;
3. identifying the cause of the problem - tools for quality are used, for example: brainstorming and the Ishikawa diagram (identifying the root of the problem); after evaluating the alternatives to solve the problem, the team focuses on that which promises the most;
4. implementation - involves team members previously set to collaborate with the staff involved in the production flow where the quality problem has been identified to ensure that the proposed decisions will be implemented;
5. control - by implementing the control elements, the established team checks whether the established solutions have realistic performances.

These stages are characterized by specific and precise objectives and are implemented through quality management procedures. In this way, we ensure that no non-conforming products will be delivered to the customer.

2. The process of solving quality problems with the Poka-Yoke tool

Poka-Yoke is a quality tool developed by Japanese engineer Shigeo Shingo in the 1960s, which helps to prevent systematic errors and defects. The word poka-yoke has the following meaning: poka - avoidance, yoke - error [3].

Poka-Yoke technique can be used to prevent the root cause of errors. A Poka-Yoke device allows the operator to concentrate without further action to prevent an error in his workplace.

2.1 The elements of the Poka-Yoke quality tool

Figure 1 shows the elements of a Poka-Yoke system [12]:

- read - before correcting an error, any Poka-Yoke system must identify the action that is intended to be checked;
- algorithm - represents the main component of the system, the decision maker if an error affecting the final result has been identified;
- information - the component with which the Poka-Yoke device transmits the result of the check to the user or the system it is part of;
- lock - this component removes the possibility of continuing the operation if a non-conformity is detected;
- disturbing factors - are those factors that define all those elements that interfere with the Poka-Yoke system, influencing its proper functioning.

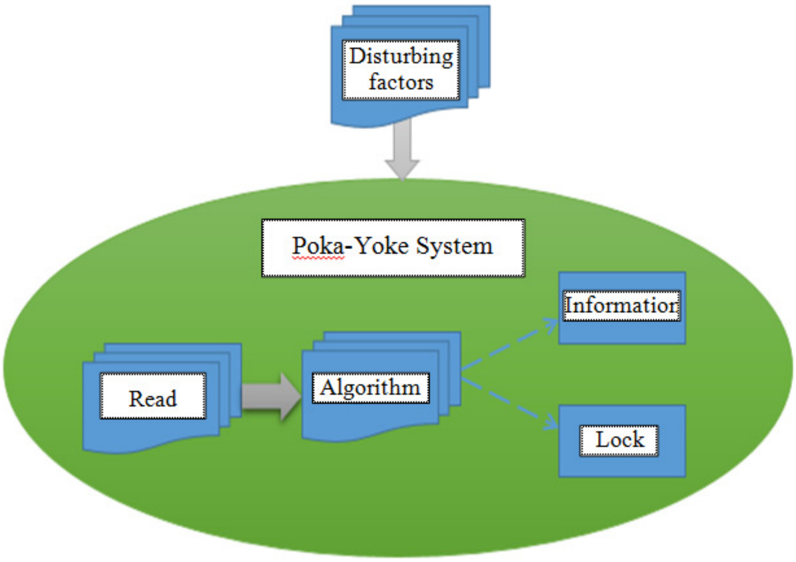

Fig. 1. Elements of a Poka-Yoke system.

2.2 The implementation of the Poka-Yoke tool

The stages for the implementation of the Poka-Yoke quality tool are [3, 9, 10]:

- identify the problem - its first action is the centralization of the complaints from the client; these complaints are analyzed, and then, depending on their outcome, select the specific problem for which a Poka-Yoke device should be developed; the defect analyzed will be tracked until the problem generator working post is identified;
- analysis of the working post - consists of identifying the causes of occurrence of the problem at the place where the non-conformity was identified; if it results that the problems are not caused by the operator then other improvement tools are used, otherwise the next step is taken;
- developing the Poka-Yoke solution - starts with a brainstorming to identify ideas that will generate Poka-Yoke device solutions; these solutions are analyzed and ranked, and the best solution is selected; the main selection criteria are: the cost of implementation, timing work, how it is used;
- implementing the Poka-Yoke solution - the Poka-Yoke device design is made, then it is executed and implemented in the working post; in some cases it is necessary to modify the working procedure at the respective post;
- tracking the effectiveness of the implemented solution - the workpieces made at the working post are checked to identify the defects for which the Poka-Yoke system was designed; the performance of the device is monitored.

The project of implementation of a Poka-Yoke system is closed when it is found that the device created performs the functions for which it was developed. Otherwise, it is necessary to re-evaluate / reconsider it.

2.3 Objectives of using Poka-Yoke devices

Using Poka-Yoke devices involves [7]:

- continuous improvement of processes and products, this being a constant concern for every person in the organization;
- periodic evaluation of established criteria of excellence to identify areas requiring improvement;
- educating each employee so that they can use the techniques and methods of continuous improvement;
- setting objectives for improvement and the measures needed to achieve them;
- promoting prevention-based activities;
- recognizing the results of the organization's staff in terms of continuous improvement of the process.

There are three levels of Poka-Yoke devices:

- interdiction/forbiddingness (make impossible the occurrence of errors);
- control (measures, informs, but does not forbid);
- alert (alerts the operator when forbiddingness appear).

Continuous improvement strategy through Poka-Yoke aims to continually improve product quality, but also increase productivity and therefore production process efficiency.

3. Case study for the product "pallet for transport"

3.1 Product description

The "pallet for transport" product is designed to ensure the transport of the chassis of a refrigerator until it is mounted in Iveco coaches (Fig. 2). This product consists of the elements shown in Fig. 3.

The "pallet for transport" product has the following quality characteristics:

- strenght - the support must support the chassis of the refrigerator;
- made of a suitable material (pickled sheet);
- allows mounting of other parts (assembling with the chassis of the refrigerator).

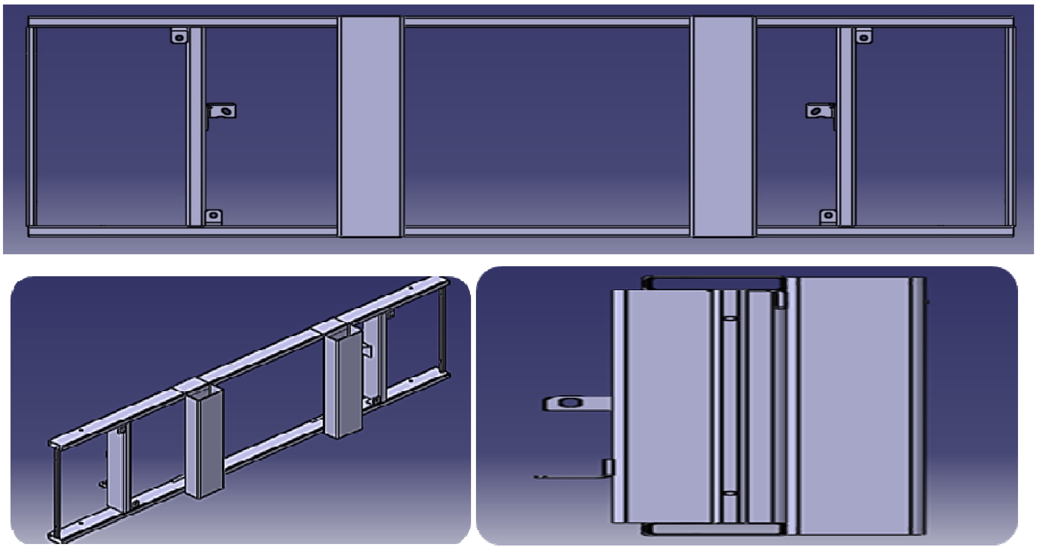

Fig. 2. The 3D drawing of the “pallet for transport”.

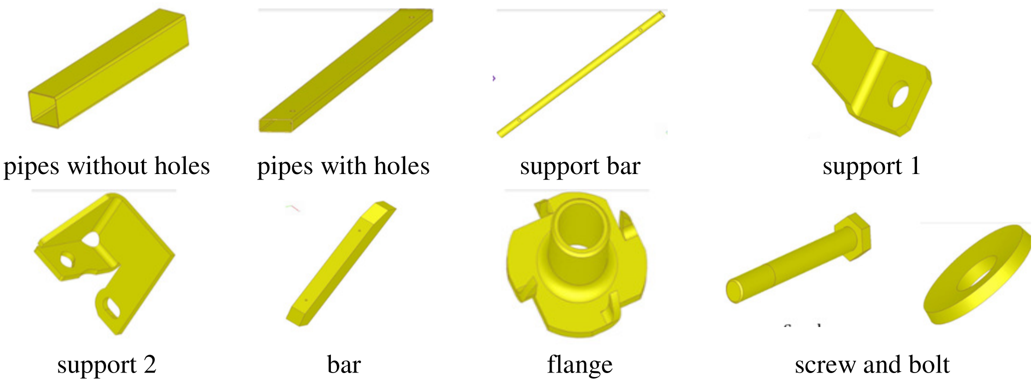

Fig. 3. The components of the “pallet for transport”.

The material used in this product is DD 11 pickled sheet. This type of sheet is obtained by cold rolling (this is because the length and width of the pallet is larger than the thickness) and its use reduces the thickness of the work material.

3.2 The technological process of the product

In order to correctly and quickly identify the non-conformities that may occur during the technological process of producing the “pallet for transport” it is necessary to know the succession of the stages of this process, which are presented in Table 1 and Fig. 4.

Table 1. Stages of the technological process of the product „pallet for transport"

Working operation 1: **Reception of sheet**	The sheet is received at the reception. The type of sheet used for the "pallet for transport" is pickled sheet.
Working operation 2: **Laser cutting**	The sheet is sent to the laser cutting machine with numeric control.
Working operation 3: **Bending**	The bending operation is performed on the Abkant machine with numerical control. Operators use the manufacturing order for this operation.
Working operation 4: **Operational control**	Operational control is carried out by operators in two ways: - visually if the defect is fingerprint, welding etc.; - using a caliper or measuring tape if the defect is such as a non-conforming dimension
Working operation 5: **Preparing kit**	In the kit preparation operation for the welding process, all "pallet for transport" components are placed in a mobile storage saddle for welding.
Working operation 6: **Welding**	The pallet components are welded by a robot welding device.
Working operation 7: **Cataphoresis**	Cataphoresis is the durable corrosion protection process that combines chemistry and electricity to deposit a fine layer of paint between fifteen and forty microns thick.
Working operation 8: **Removal of the weld splash**	The process of the removal of the weld splash is organized in the welding station prior to delivery to the stamping station, where the part number will be engraved in order to ensure traceability of the parts.
Working operation 9: **Stamping**	Stamping is done by an operator with the stamp device.
Working operation 10: **Storage**	Storage involves keeping the parts in a storage space. The contact areas of the parts are protected by means of cardboard. The pieces are placed on stacks of seven or eight pieces, then they are connected with a metal strip.

4. Solving the problem of product quality for „pallet for transport"

4.1 Identify the quality problem

Following a complaint received from the Piroux customer in France for the "pallet for transport" product, there was found a defect consisting of a non-conformity at welding level between two pieces welded on the pallet during working operation 6 - welding (Fig. 5).

The complaint received will be checked for three days to determine whether it is valid. Validation of the complaint is to prove that the defect notified by the customer is not the fault of the customer but it is caused by the supplier.

After the complaint is validated, it is analyzed both by the quality department and the working station managers to whom the problem has been reported, in order to correct the non-conformity and even to anticipate its occurrence in the future.

It is very important to analyze the complaint to check if there are any further non-conformities with the “pallet for transport” product.

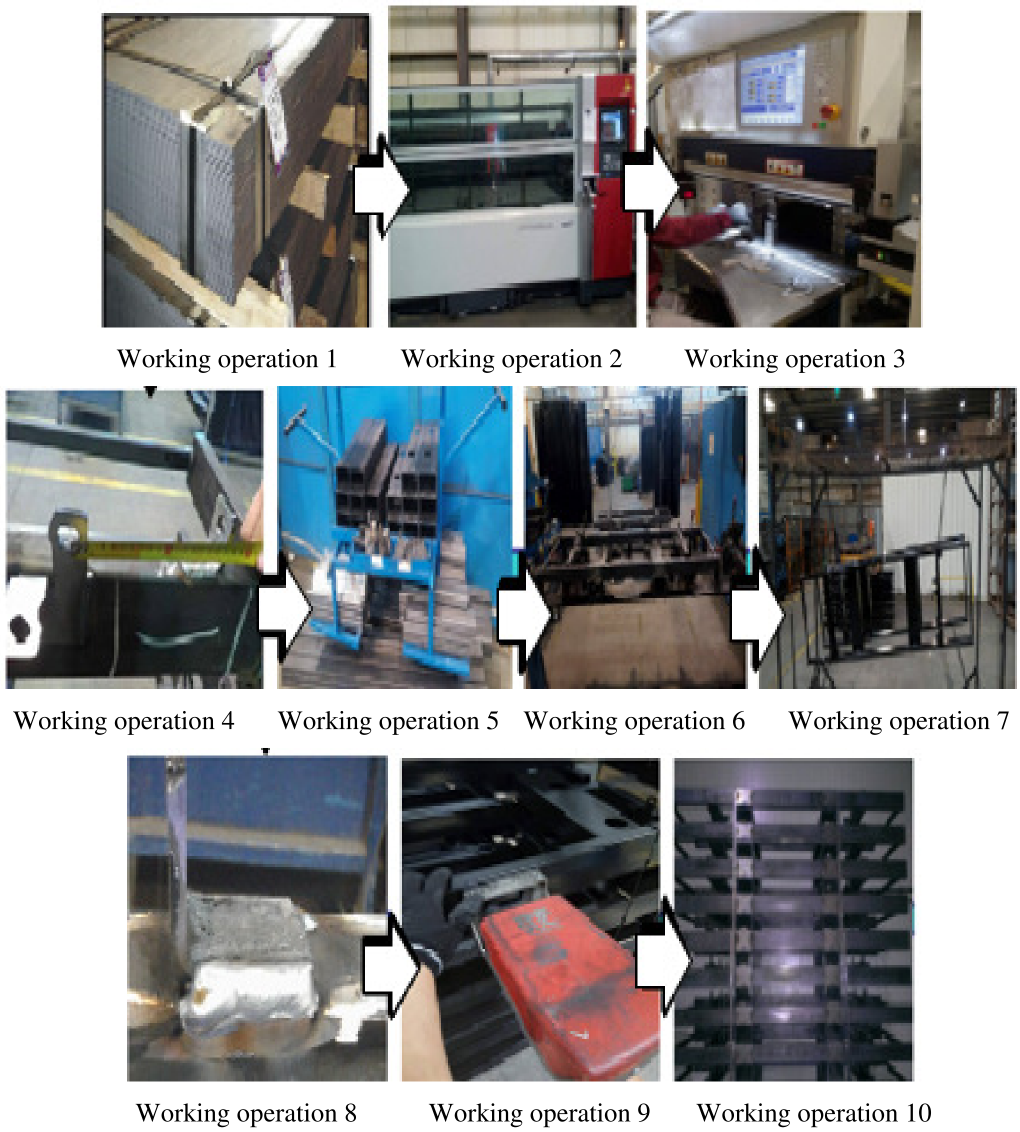

Fig. 4. The stages of the technological process of “pallet for transport”.

4.2 Analysis of the working post

At the working post called “pre-welding preparation” it is made the manual assembly process of the pipe components with and without holes (Fig. 6).

Analyzing this working post by timing the activities performed by the operator has highlighted that this process is not a productive one since the operator loses more time to assemble these components than the one specified in the job sheet.

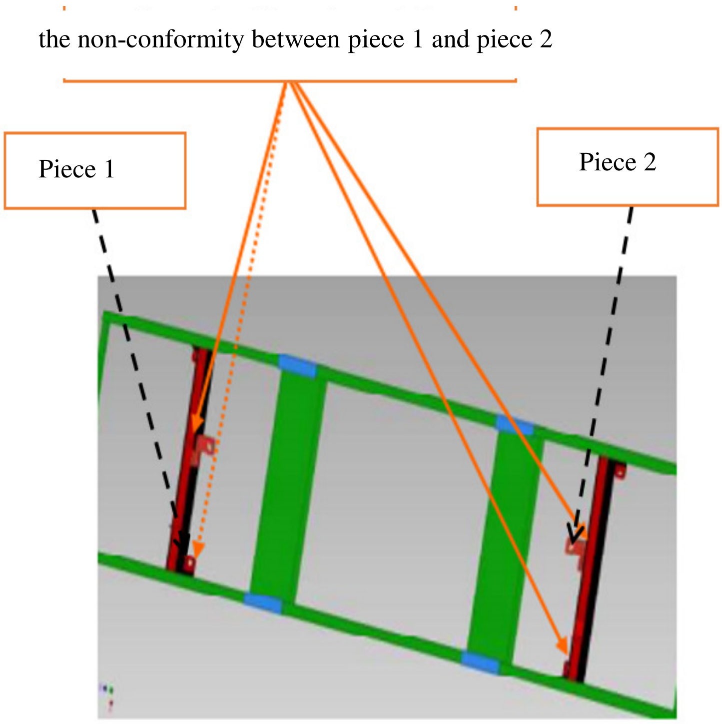

Fig. 5. The type of defect identified on the product „pallet for transport”.

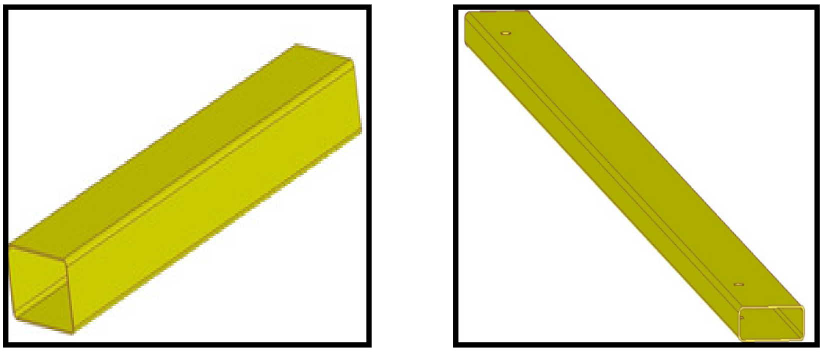

Fig. 6. Assembled components manually on the welding device.

Figure 7 shows the duration of the activities carried out in the “pre-welding post”. These are:

1. take the pipes with holes from the installation kit;
2. visual inspection is performed;
3. mount pipes with holes on the device;
4. take the pipes without holes from the installation kit;
5. visual inspection is performed;
6. mount pipes without holes on the device;
7. place the assembly on the welding table.

WO	*Observation number*																				*Processed data*				
	1		*2*		*3*		*4*		*5*		*6*		*7*		*8*		*9*		*10*		T_{tj} [s]	T_{oj} [s]			T_o [s]
	F	W	F	W	F	W	F	W	F	W	F	W	F	W	F	W	F	W	F	W		Min	Max	Med	
1	3	7	3	11	3	10	3	12	3	11	4	9	4	7	3	8	3	10	4	10	28	3	4	3.2	
2	23	26	21	25	24	27	24	27	21	25	21	26	24	27	20	23	23	27	22	25	30	5	7	5.9	
3	3	12	3	11	3	12	3	12	3	13	3	10	4	13	3	11	3	12	4	10	82	6	9	8.2	
4	18	23	16	21	18	24	19	24	16	21	16	21	19	24	16	20	18	23	17	22	50	4	6	5	37.1
5	23	26	21	25	24	27	24	27	21	25	21	26	24	27	20	23	23	27	22	25	30	3	5	3	
6	26	31	25	30	27	32	27	31	25	29	26	32	27	32	23	28	27	32	25	29	84	7	9	8.4	
7	31	34	30	33	32	35	31	35	29	34	32	35	32	35	28	31	32	35	29	33	34	3	5	3.4	

Notifications: WO - the number of the working operations coresponding with Fig. 7; F - the necessary time for training operations; W - the necessary time for working operations.

Fig. 7. The standard work-time form with the timing of work for the target work post.

It can be seen from the standard work-time form for the welding post that a high amount of time is required for working operation 3 (pipe with holes fitting on the welding device) and working operation 6 (pipe without holes mounting on the welding device) made by the operator of the post analyzed.

Thus, following the analysis of the post using the timing method it was possible to identify the root cause of the quality problem within the quality department. The next stage will be done to remedy and eliminate the problem [5, 6].

4.3 Eliminating the quality problem

Following the analysis of the above work post in order to identify the cause of the problem, it was decided: designing and deploying an interdiction Poka-Yoke device (Fig. 8).

Fig. 8. Interdiction Poka-Yoke device.

5. Implementation and effectiveness of the Poka-Yoke device

The Poka-Yoke device is designed to make the work easier for the operator and to stop working when an error is detected. The device designed for the work post will make impossible the appearance of the error because it is a device that only allows getting through the pieces with the correct orientation.

This system was thought that when the operator mounts the two pipes on the welding device, assembly is stopped if the two components are misaligned and thus the time to perform the activities within this post decreases.

The goal of implementing the device is to increase productivity for the product „pallet for transport". The steps taken in the Poka-Yoke device are shown in figures 9-12.

Fig. 9. Control of pipes by the operator.

Fig. 10. Set the pipe on Poka-Yoke device.

Fig. 11. Mounting on the welding device.

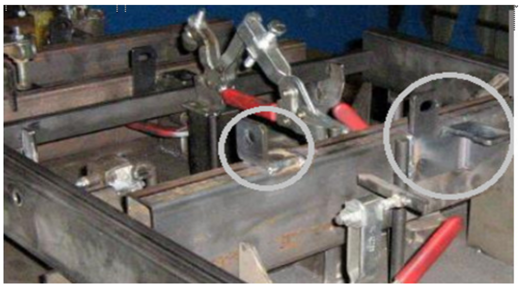

Fig. 12. Mounting other components.

After the implementation of the Poka-Yoke device, a new timing of the activities carried out within the analyzed work post was carried out and the results are presented in Table 2.

It can be seen from the timing charts (Fig. 13) that the duration of working operation 3 and 6 decreased following the implementation of the Poka-Yoke interdiction device for the pre-welding work post of the “pallet for transport” product components.

Table 2. Timing results after Poka-Yoke device implementation

WO	*Observation number*																				*Processed data*				
	1		*2*		*3*		*4*		*5*		*6*		*7*		*8*		*9*		*10*		T_{tj} [s]	T_{oj} [s]			T_o [s]
	F	W	F	W	F	W	F	W	F	W	F	W	F	W	F	W	F	W	F	W		Min	Max	Med	
1	3	7	3	11	3	10	3	12	3	11	4	9	4	7	3	8	3	10	4	10	28	3	4	3.2	31.6
2	23	26	21	25	24	27	24	27	21	25	21	26	24	27	20	23	23	27	22	25	30	5	7	5.9	
3	18	23	19	21	18	24	19	24	16	21	16	21	19	24	16	20	18	23	17	23	52	4	7	5.2	
4	18	23	16	21	18	24	19	24	16	21	16	21	19	24	16	20	18	23	17	22	50	4	6	5	
5	23	26	21	25	24	27	24	27	21	25	21	26	24	27	20	23	23	27	22	25	30	3	5	3	
6	23	26	21	25	24	27	24	27	21	25	21	26	24	27	20	23	23	27	22	25	30	5	7	5.9	
7	31	34	30	33	32	35	31	35	29	34	32	35	32	35	28	31	32	35	29	33	34	3	5	3.4	

Notifications: WO - the number of the working operations coresponding with Fig. 7; F - the necessary time for training operations; W - the necessary time for working operations.

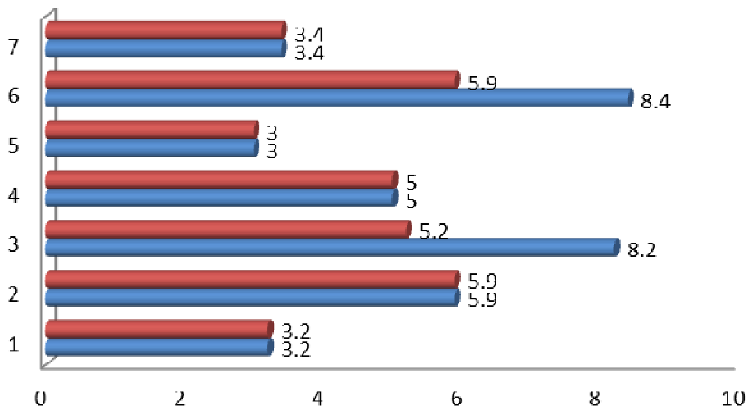

Fig. 13. Results achieved before and after the implementation of the Poka-Yoke device: with blue – the results before implementation and with red – the results after implementation.

Conclusions

Continuous improvement is the total of activities carried out in each stage of a product to improve the performance of all processes and their outcomes to meet customer needs and increase production efficiency [11].

A good Poka-Yoke device must be able to achieve the “zero defects” goal and must result in the elimination of quality controls that are only present to show the defects of production.

A Poka-Yoke device must allow the operator to focus on his / her work without the need for unnecessary actions to prevent errors. Production errors must be zeroed with a well-designed Poka-Yoke system.

For the “pallet for transport” product analyzed, total working time in the work post was reduced by 5.5 s, from 37.1 s to 31.6 s, after the implementation of the Poka-Yoke interdiction device. There is observed also an improvement in the activities of operators.

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