

OPTIMIZING THE PREPARATION PROCESS FOR PAINTING AUTOMOTIVE PLASTIC COMPONENTS

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Rezumat. *Necesitatea studierii procesului de pregătire pentru vopsire al barelor de protecție din domeniul autovehiculelor, a venit în urma constatării unor defecte de calitate pe produsul final, care conduceau la costuri suplimentare pentru retuș și la un timp suplimentar care, de asemenea necesita costuri financiare și întârzierea livrării autovehiculului către client. Scopul lucrării este de a implementa idei de optimizare a procesului de pregătire pentru vopsire al barei de protecție pentru a elimina spre zero defectele de calitate, de a optimiza procesul, de a reduce cheltuielile cu personalul, cu noncalitatea, cu materialele utilizate și într-un final, pentru a produce bare de protecție fără generare de costuri suplimentare și realizate bine din prima.*

Abstract. *The need to study the process of preparation for painting bumpers in the automotive field came from the finding of quality defects on the final product, which led to additional costs for rebutting and additional time which also required financial costs and delaying the delivery of the vehicle to the customer. The purpose of the work is to implement ideas to optimize the protection bar paint preparation process to eliminate to zero the quality defects, to optimize the process, to reduce the cost of staff, non-quality, materials used and finally, to produce bumpers that are well-made at the first attempt without generating additional costs.*

Keywords: optimization, costs, process, non-quality, staff.

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1. Introduction

Quality assurance means preventing the occurrence of non-quality by taking appropriate measures to ensure that a product or service will meet the quality requirements. [1] The models that underlie the actions to improve the operations in the bar preparation process are Lean Manufacturing and Kaizen.

Kaizen is a Japanese philosophy that focuses on continuous improvement in all aspects of life. The activities improve all functions, from management to assembly line workers. By improving standardized activities and processes,

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Kaizen aims to eliminate losses. [2] Kaizen is simply an umbrella concept that covers most of the world-famous Japanese practices. [3]

Lean Manufacturing defines value as "what the customer is willing to pay". Therefore, internal processes must be analyzed in terms of added value and losses, namely actions and decisions that either add value or increase the cost of production. The logical consequence is that performance improvement comes either from maximizing the effects of processes that add value, from minimizing processes that cause losses, or from the concomitant action of both categories of processes.[4]

Lean Manufacturing comparing with mass production requires $\frac{1}{2}$ of: the human effort in the factory, the manufacturing space, the investment tools, the engineering hours and the time to develop new products.[5]

Losses can be any activity that adds time or cost to the production or delivery process without adding value. Organizations that implement Kaizen understand what value means to clients and focus their processes or activities to continuously increase this value. At the same time they identify activities that do not bring value and minimize them by trying to eliminate them.

Losses were initially grouped into 7 categories, which take into account:

1. Overproduction. In the analyzed workshop, work is done on stock so that the demand for manufacture is covered in a timely manner. If a bar shows quality defects and cannot be mounted on the car immediately, then it is called to stock. This stock requires space and human resources that must be handled correctly and frequently.
 2. Time wasted to wait on something. In this case, the wasted time occurs mostly because of the machines and the outdated way of working. Stopping the flow of manufacturing leads to time loss, abnormal functioning of the manufacturing flow and the generation of quality defects, which ultimately translates into an increase in expenses at the organization level.
 3. Unnecessary transport. The transport of bars with defects is useless, because it is sent to the rebut, replaced with one from the stock and sent to be repainted without knowing if, at the end of the process, it will be used as a quality final product or if it will be sent to scrap.
 4. Unnecessary processing.
 5. Unnecessary stocks.
 6. Unnecessary movements. In the initial situation, operators are forced to move continuously because they perform all the operations to prepare a set of bars, their positions being fixed.
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Within the enterprise, measures are constantly taken to improve the way operators work, to maintain good ergonomics, to eliminate downtime and to avoid accidents at work, providing security and safety.

7. Defects, Corrections, Repairs or Reprocessing. The product shows certain defects due to non-compliance with the working mode, the machines and materials used and rebut actions requiring additional material, time and human resources, which translates into expenses.

A large part of these losses will be eliminated by the actions to be taken in the workshop.

The idea behind Kaizen and Lean is to maximize customer value while minimizing losses or in other words, to create more value for the customer with less resources.

The most effective improvements where an immediate gain is observed and losses are eliminated are:

- Reducing the manufacturing time while increasing the volume of products made;
- Reducing the costs while increasing the economic efficiency of the company;
- Improving the structure of jobs and the working conditions for workers with increased satisfaction of operators.

It is known that all organizations are concerned about success on the market they operate in. This success helps the company build a reputation, attract new investments, stimulate innovation, provide loyal customers, help save money and bring repeated businesses. [6]

2. Presentation of the processes of preparation and painting of plastic parts in the automotive industry

The process of preparing for the painting of bumpers for motor vehicles involves the following main steps (see Figure 1):

1. The partial coverage (or marouflage) operation shall be carried out by covering the bar with wax paper and partially glued with tape to the surface where it is not to be painted. Behind this operation is the activity of paper debiting according to the templates and soldering of the paper on a panel from which the operators take it for the coverage.

The marouflage operations are closely related to these operations: the grinding of the bars that show defect from the supplier (present burr) and loading the bars on the conveyor belt.

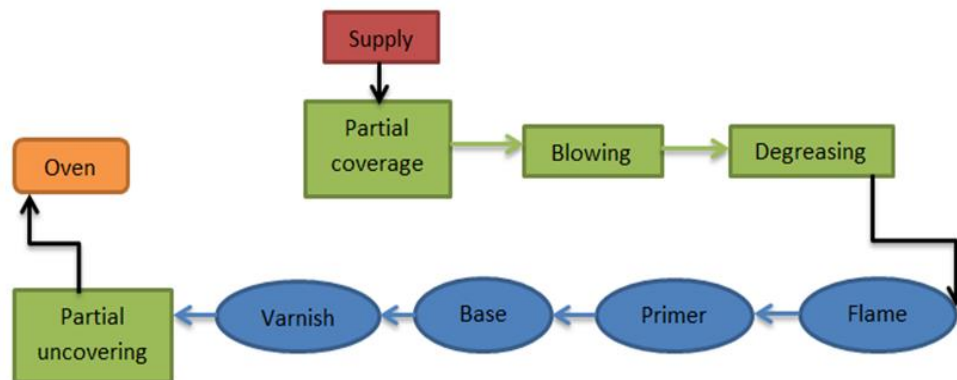


Fig.1. The main stages in the preparation and painting of the bumpers

2. Blowing is an operation that involves removing impurities from the surface of the bar by an operator using a pressure-blower gun.
3. Degreasing is the operation through which an operator degreases the surface of the alcohol bar.

The process of painting the bars involves:

1. The external flaming or burning of plastic parts shall be carried out robotically at very high temperatures and aims at achieving a porous surface on the plastic which allows the following layers to be fixed by successive passages over the areas of the plastic parts (bars) at a distance of 5-8 cm in order to avoid any ignition or burning of the paper or bars.
2. The primer (or dressing) is the first coat of paint that covers the bar.
3. The base involves the actual painting the bar.
4. The varnish is the operation performed by a robot, it provides protection of the bar and acts as a barrier against scratches and degradations, also has the role of giving a visually pleasing appearance.
5. After the bars pass through the three stages of painting (primer, base, varnish), there is a partial uncover operation that involves the detachment of the tape and the visual control of the bar, detecting defects that occur during the painting process.

In the case of plastic parts (bars), due to fast-drying solvent paint, there is only one oven for all stages of painting.

The constraints of the initial situation are consisting in:

- Working on stock due to the relatively longer time (5.50 tcy) required to increase a set of bars than the actual time of manufacture of a vehicle (0.70 tcy);
- On the stream, are loaded bumpers that do not require partial coating with waxed paper, and the operators wait, thus creating dead times, of non-productivity;
- Supports have rigid edges that can damage the waxed paper with which the bar is coverage, which leads to quality defects in the painting process;
- When changing the supports there is a risk of injury to the operator;
- Supports have only one position; they cannot be positioned or adjusted according to each operator;
- The number of steps required for operations is 50.

The conditions for success are as follows:

- The devices used for marouflaging will be universal for all bar models;
- The devices will be provided with a bar fastening mechanism, a folding system for indoor and outdoor covering, with a height adjustment and tilting system.

Following a self-assessment, a Lean development was created, where actions are carried out to improve the bar preparation activity by creating two hand-operated carousels.

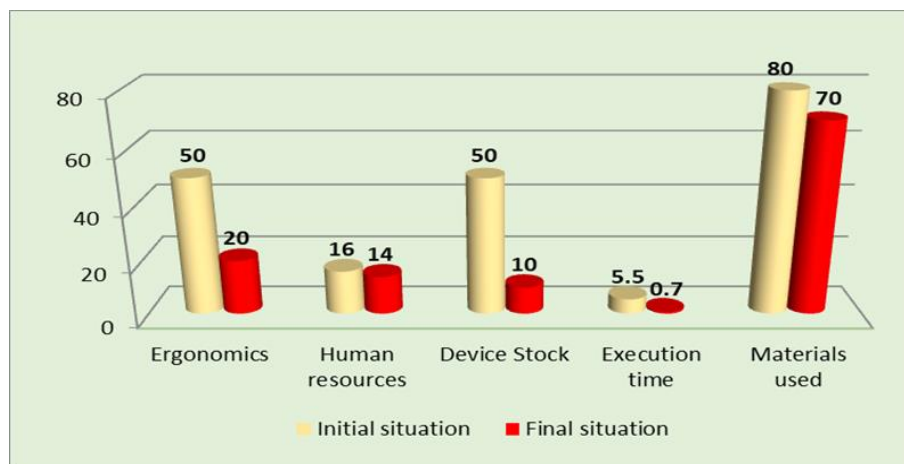
The implantation of the two carousels made the following gains:

- ✓ Improving operator ergonomics by decreasing the number of steps by up to 60% (from 50 to 20 steps);
- ✓ Reduction of staff costs, a post from the supporting operations is eliminated;
- ✓ Making common marouflage devices for all types of bars, which has led to the elimination of the required stock of devices for each bar model;
- ✓ Reducing the execution time by 87.3% (from 5.50 to 0.70 tcy) due to the fact that the operations are divided equally with the operators and they work at the established pace and not at their own pace, as happens in the previous situation;
- ✓ Reducing the cost of materials by 12.5%, at present 700mm of adhesive tape is used for the style line for a set of bars (instead of 800mm).

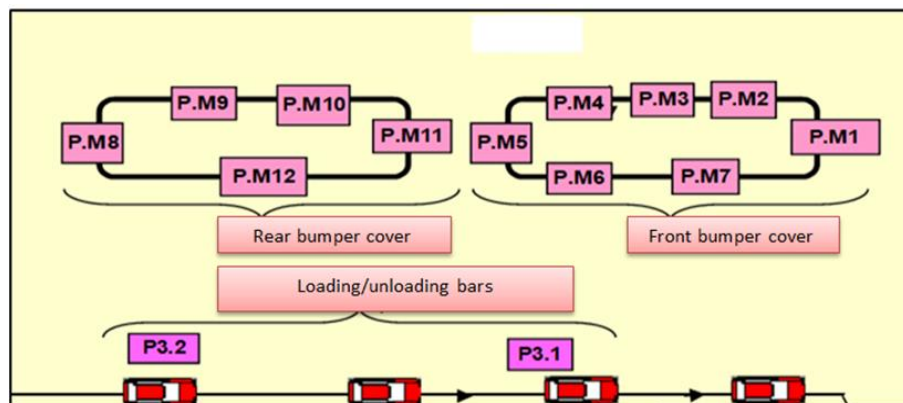
These gains are summarized in Table 1 and represented graphically in Figure 3.

Table 1. Situations of the main categories on which improvements have been made

No.	Improved category	Initial situation	Final situation	Account type
1	Ergonomics	50	20	no steps/operation
2	Human resources	16	14	no people/1 team
3	Device stock	50	10	pieces
4	Execution time	5.5	0.7	Tcy/post
5	Used materials	80	70	Cm/set of bars
Total		201.5	114.7	—

**Fig. 3.** Situations of the main categories on which improvements have been made

Also, in the initial situation a burr grinding post was present. Following analysis on the companies that supply raw material it was concluded that the change of supplier is necessary. Thus, a new supplier has been contracted to deliver bars without excess material, and the grinding post is eliminated (Fig. 4).

**Fig.4.** Bar preparation line. The final situation.

2.2. Proposals to improve the way of working in the bar preparation process

Today, businesses are looking for all means to achieve significant returns to ensure its sustainable development. To achieve this, managers seek to reduce costs within it. [7]

To improve the bar covering process it is proposed to replace the waxed paper currently used with a self-adhesive foil resistant to high temperatures, but without the risk of ignition to the flame robots due to the fact that it sticks entirely to the plastic material.

In the initial situation, the coverage of the bar assumes that the main stages partially cover the bar with a waxed paper that was glued to the bar with an adhesive tape and then with a fineline tape on the shape of the bar specially marked, all manually.

In the current situation, the coverage is carried out as follows: On the outside or painted side of the bar, the foil sits and sticks as close as possible to the separation line after which it comes only with the fineline tape for the marking of the separation line, thus eliminating the 15 mm tape that fastens the waxed paper.

On the lower part of the bar by automatically gluing the foil on the element, the 19 mm adhesive tape and the operations for gluing it were removed (Fig. 5).

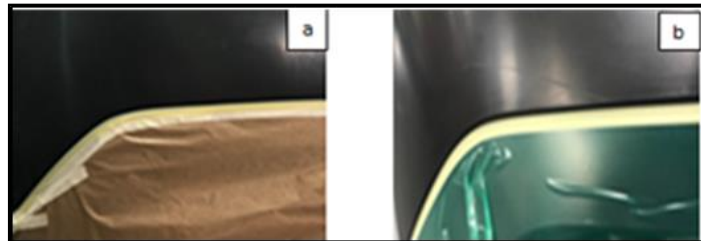


Fig. 5. Bumper cover

a. The initial situation, using waxed paper

b. Improved situation, using self-adhesive foil

To optimize the process it is recommended to use an applicator that reduces the disadvantages of manual application. This V-shaped manual tool has the following benefits:

- it can be adapted to use a narrower self-adhesive tape, only 9 mm compared to 12 mm as originally used;
- it facilitates the operation performed by the staff, the operator only has to guide the applicator on the surface of the bar;
- reduces the execution time;
- reduces the risk of a crowding of paint under the tape;

- can be used on all curves or shapes of the bar.

The self-adhesive foil is cut at each working station with the help of rolls adaptable to each post. Thus, the cutting of the foil is carried out during the working time that the operator had to glue the 15 mm adhesive tape on the waxed paper (Fig. 6).

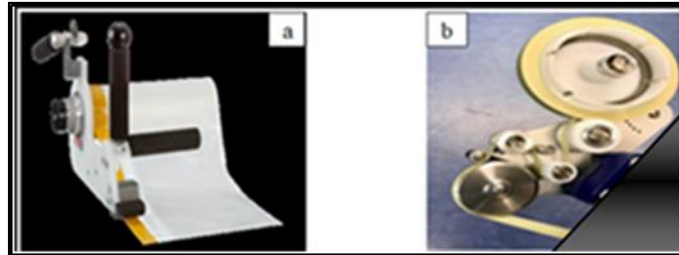


Fig.6. Tools used in covering operations

a. Self-adhesive foil binder

b. Fineline tape applicator

Replacing the current process of protecting bars with waxed paper to self-adhesive foil has many advantages, both financial and organizational.

Advantages of using self-adhesive foil:

- eliminating the initial processes of paper cutting and soldering on templates, which leads to winning a post and reducing the execution time of the marouflage process by 20%;
- does not break when wet, which means that it eliminates the generation of quality defects, such as splashes of paint;
- the chemical properties of the self-adhesive foil allow passage through the furnace without affecting the bonding on the bar and thus is won the post of partial removal, and consequently, eliminate the quality defects generated in this post (prints on paint);
- reducing fire risks in flame robots because the self-adhesive foil is molded on the bars without leaving corners outside the bars as happens with waxed paper. Thus, there is no more loss of time and material, the burnt bar was then rejected, and the installation had to be turned off and restarted.

Conclusions

The actions proposed in this paper for the coverage operation within the processes of preparation for painting of the bars can bring economic benefits, both at the workshop level and at the company level.

By comparing the two situations, the initial and the final ones, it can be observed (see Table 2 and Figure 7) that for the coverage operations, the monthly expenses for a single working team with the main necessary elements are as follows:

- monthly expenditure on the human resource only for the coverage operations is 21,250 euros in the initial situation, and 17,500 euros in the final situation, (a decrease of 3,750 euro/month). This was due to the elimination of 3 posts: grinding, paper cutting and partial uncover;
- regarding the expenditure on the materials used, i.e. the waxed paper in the first situation and then the self-adhesive foil replacing the previous one, it is noted that the purchase price is the same of 9,475 euros, but due to the self-adhesive foil the quality defects in the marouflage operations are eliminated;
- only for the retouch of a single defect on the bar, for example: non-compliant separation line, the cost of labor and materials used reaches 10 euros. In a month, about 420 defects are retouched on bars generated in the analyzed workstations, reaching a cost of up to 4200 euros/month;
- an improper marouflaging operation carried out in the initial situation with waxed paper, where there is a risk of corners left unglued, would lead to the ignition of the bars because of the flaming robots and to the scrapping of the bars. The cost of the bars due to their burning are at least 365 euros in a month, which are eliminated after improvement.
- in the final situation, less fineline tape is used than the initial situation, expenses are reduced by 100 euros and the scotch tape is eliminated.

With the change of the way of working, the tools and materials used, these defects and implicitly the costs of retouching are eliminated (Table 2). In the figure 7 are presented the monthly gains resulting from the actions carried out in the process of preparing bars for painting.

Table 2. Monthly expenses (euro) resulting from the two situations analyzed

No.	Type Monthly expenses	The initial situation	The final situation	Difference
1	Human resources	21250	17500	-3750
2	Wax paper	9475	0	-9475
3	Scotch tape	900	0	-900
4	Finelina tape	840	740	-100
5	Foil self-adhesive	0	9475	9475
6	Retouch defects	4200	0	-4200
7	Refuse bars	365	0	-365
Total savings				9315

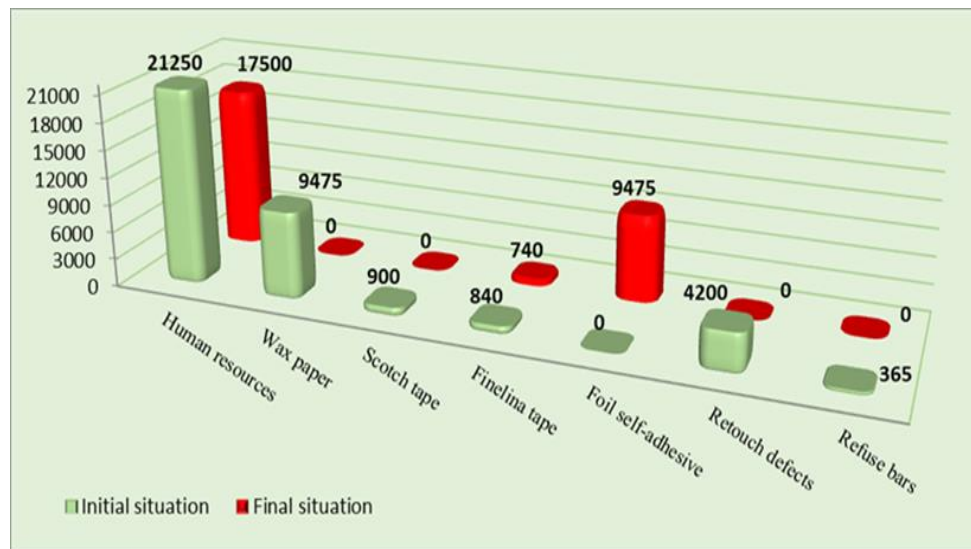


Fig.7. Monthly expenses (euro) resulting from the two situations analyzed

In conclusion, the continuous improvement of the working processes within an enterprise must be its strategic objective, in order to maintain its current performance, to cope with the ever-accelerating changes of the market and to preserve or even win new customers.

An organization faces this need for continuous improvement due to causes such as:

- increasing competition in the automotive market;
- the manufacturing process becomes more complex and diversified;
- customer requirements go to an increasing standard;
- the need to continuously reduce production costs, to eliminate waste of materials and time.

If companies meet this objective of continuous improvement, but with small and well thought-out steps, they will be able to react quickly and flexibly to all internal and external changes.

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