ANALYSIS ON THE PROCESSING TIME REDUCTION FOR AN AUTOMOTIVE INDUSTRY PRODUCTION FLOW

Dan MIRICESCU[1] and Martin HEINISCH[2]

ABSTRACT: One of the main objectives of production management was and has always been to increase manufacturing efficiency. This means that the ratio of the output and input value from the process should be as high as possible. This paper addresses to this very current issue regarding the increase production flow efficiency by eliminating waste from the system, using Lean Manufacturing techniques. It is presented a practical approach, developed and implemented on a production flow within an organization acting on the automotive market.
KEY WORDS: Lean Manufacturing, time reduction, flow, management, waste.

1. INTRODUCTION

One of the main objectives of production management was and has always been to increase manufacturing efficiency. This means that the ratio of the output and input value from the process should be as high as possible.

In the development of a product it is necessary to conduct a number of activities. These activities have the ultimate goal of transforming raw materials into the final product for consumers.

These activities can be classified into two broad categories:

1. Activities that bring added value. These are:
   - activities that alter the shape, size and function of the product to meet consumer requirements;
   - work for which the consumer is willing to pay;
2. Activities that do not add value.
   - waste;
   - activities that do not add value but are absolutely necessary.

In Figure 1 we can see the proportion of each type of activity.

As it can be seen, the activities that add no value are approximately 98% of the activities that take place in a company. But not all of these activities are actually waste.

[1] “Lucian Blaga” University from Sibiu, Engineering Faculty, Emil Cioran 4, 550248 Sibiu, Romania

[2] MHI Ingenieurgesellschaft GmbH, Remshalden, Germany

E-mail: dan.miricescu@ulbsibiu.ro; info@heinisch.com

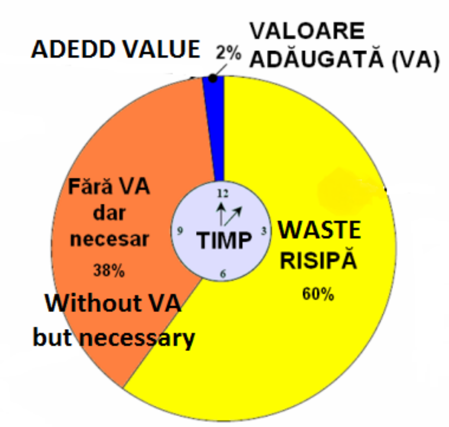

Fig. 1 The proportion of the activities from the production process

Waste is caused by those activities that do not add value but waste time and money instead, those activities that consumers do not want to pay for and those activities that generally are symptoms and not the real cause of the problems.

All kinds of existing waste were grouped into seven categories. These are:

1. *Overproduction* – production above the customer requirements, production of materials and unnecessary products. Another definition is to produce more, sooner or faster than required by the next process.
2. *Inventories and work-in-progress production (inventory)* – Preservation or purchase of raw and unnecessary materials, production in progress or finished products.
3. *Transportation* – Multiple handling activities, handling delays in material handling, steering and unnecessary handling.
4. *Waiting* – Delays, unused time (time when no added value is recorded).

5. *Motion* – Actions of people or equipment that do not add value to the product.
6. *Over-processing* – processing steps and elements which are not required (working without added value).
7. *Corrections* – The production of defective parts (scrap) or that require finishing touches (corrections).

2. ADDING VALUE FLOW ANALYSIS TO REDUCE PROCESSING TIME

2.1. Background on implementation analysis

The chart Value Stream Map (VSM) will be used to know the entire operation flow from start to finish for a family of products within the production line.

VSM analyzes the flow of manufacturing from customer requirements back to raw materials on both internal logistics flows: material flow and information flow. To get a perspective of stream value, there must be a comprehensive big picture approach and one regarding singular manufacturing processes.

The value stream includes all activities (both those that create value and those that do not create value), which are necessary so that a product will go through the main flows, that are required for any product: production flow from raw material until the product reaches the customer and the flow of product development from concept to the beginning of production.

To determine the product family that will be the subject analysis, it was needed to identify the types of products made on the line that was to be improved and their share in total sales, the analysis being conducted jointly with the implementation team, as highlighted in Figure 2.

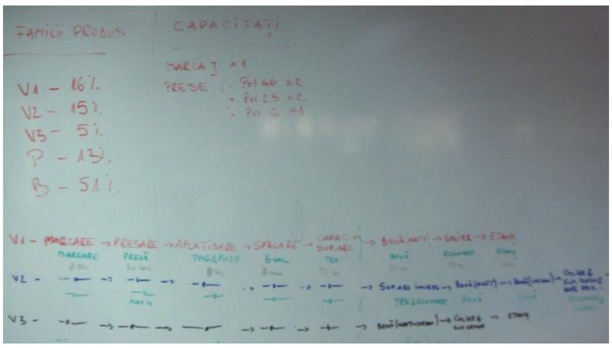

Fig.2 Product families

Under this procedure it was established that the value stream analysis will be made for a family of parts that will be mounted on the rear axle of the vehicles.

Share wastage and added value is determined with the help of the chart of time, and the stocks registered on the spot will be considered as a basis for calculating the waiting time.

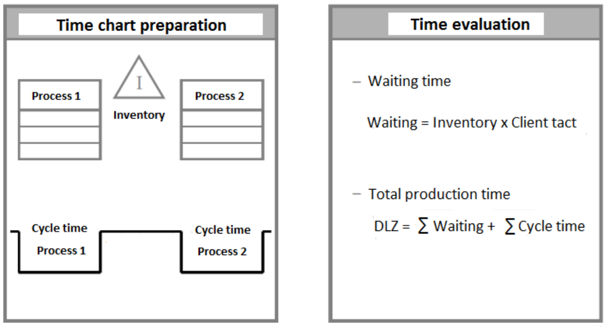

Fig.3 Exemplification on establishing the process time and the waiting times

Developing the value-added analysis is always done from the customer's perspective, from the client, following production flow upstream. Thus, the necessary data must be collected from the manufacturing flow. Based on information flow the nature of the material flow, production time and processing time can be determined.

All such information is collected by team members constituting the workshop and on their basis, in a fairly easy manner, with the help of cardboard cut outs and attached to a panel, the preliminary findings related to the existing structure of VSM (Figure 4) are outlined.

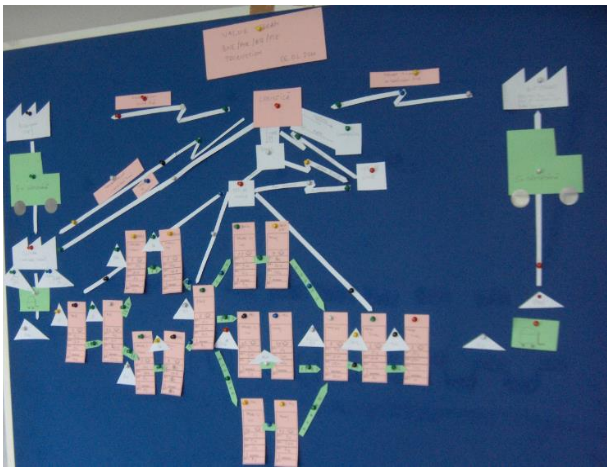

Fig.4 Initial VSM

After discussions and consultations with middle and top management (department heads or other persons responsible in the conduct and implementation of processes within the organization) the final form of the VSM is created, also in an electronic format.

This is highlighted in Figure 5 and on this base were established the potential points for improvement and the action plan for a period of time, in order to maximize value-adding activities to the detriment of those who do not achieve this goal.

The production system intended to be implemented (Lean Manufacturing) aims to introduce and implement specific management methods, systematizing the methodology to manufacture the product, focusing on some extremely important elements: *short processing time, customer orientation by increasing response capacity as an alternative to relatively large stocks found at the time of analysis and as a solution to short-term changes in orders.*

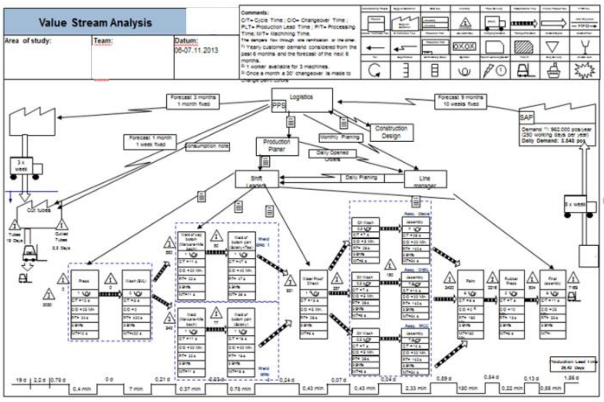

Fig. 5 Final VSM, obtained after the analyses

2.2. The main actions proposed

To improve these shortcomings, and cause the analyzed flow to become competitive, it is necessary to complete a few steps and to implement viable solutions, in conjunction with the use of concrete specific methods and techniques of production of "Lean", in eliminating punctual sources of waste found in the initial analysis of the added value, the following were established:

- Implementation of 5S workshops for optimal organization of jobs, to increase environmental quality and improve product quality;
- Implementation of specific techniques in TPM equipment within the production process for the continuous increase of efficiency and to reduce the accidental stops;
- The realignment of existing equipment of the technological process for production lines (relayout) to facilitate the work of operators, reduce unnecessary movement for materials and devices;
- Reduction of adjustment time between batches of processed materials (SMED);
- Adjusting the flow of materials and information so as to eliminate intermediate stocks and where circumstances permit, to apply the FLOW principle in the extreme version one piece flow (OPF);
- Analysis and reorganization of storage spaces, of the materials being processed in the spare parts production line.

3. REDUCTION OF ADJUSTMENT TIME IN A CYCLE OF PREPARING PROCESSING PARTS

3.1. General recommendations

While conducting any production process in the transition from one landmark to another, it is always required time to set or adjust equipment, which is basically an unproductive time.

During unproductive activities it was established that there are some activities that do not produce added value but are strictly related to completion of the process for the previous command, control time itself and activities related to the beginning of production for the order or the next batch.

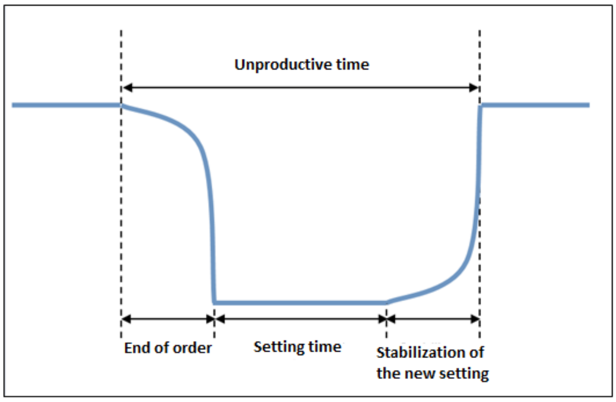

Fig.6 Unproductive time

For the purpose of the organization specific production system, the adjustment setting is defined as "the time located between the last product from the previous batch and the stable manufacturing of the first product according to the new group."

The activities carried out during setup are divided into several components:

– mechanical assembly and disassembly;
– adjustments and settings;
– 5S activities;
– control activities;

- transport and handling of materials or devices;
- equipment faults;
- waiting time or searches for various materials.

Operations performed by the operator to adjust equipment on another landmark fall into two broad categories:

- operations executed while equipment works on the batch of products from the previous order or on the next batch after the validation of the process, generic named *external adjustment*;
- operations executed while the equipment does not work where their actual setting takes place called *internal setting*.

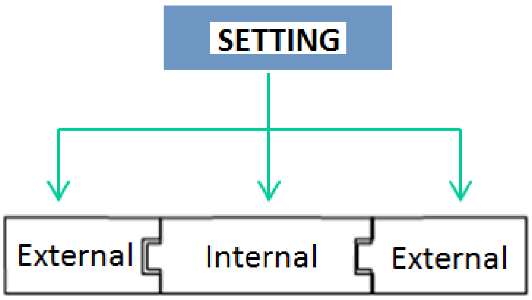

Fig. 7 Dividing operation setting

The purpose of a SMED action is to reduce the time of setting to a minimum possible time by defining the activities necessary to control and create a standard so that it can always be implemented without affecting in any way the quality of manufactured products.

3.2. SMED Workshop

In this activity (SMED workshop), there was formed a team constituted of:

- a production operator serving equipment in the area;
- an adjustment professional and a supervisor in the workshop;
- the process engineer from the production line;
- a person from the quality department;
- a Lean manufacturing system trainer, which is the person who organized and moderated the entire action.

After training the team on SMED method, to reduce tuning time which aimed to understand the method and the need to act, within the team the action targets were established. These were:

- initial setting time reduction by 30%;
- development and implementation of a control standard for cycle training.

The stages of development of the workshop took into account the following activities:

- part of theoretical training and preparation for initial analysis;
- initial registration of a setting;
- determination of the activities that compose a setting and activities analysis;
- creating a plan of action;
- coming up with an theoretical optimized setting;
- testing and recording it in production;
- analysis of results;
- developing a standard for setting;
- the official presentation of results and training of staff.

The theoretical training consisted of retraining on Lean manufacturing system and on detailed presentation of the method of analysis and setting time reduction called SMED, and on the modality of using the techniques defined in the method: Chart of movement and the Spaghetti Diagram.

For the initial analysis the types of adjustments made in the production cycle were defined, so it was chosen to analyze the type of setting that has the largest share in the production cycle.

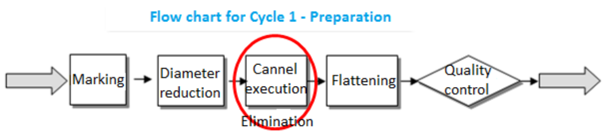

Fig. 8 Flow diagram

From an initial analysis resulted the data presented in the follow aspects.

The total duration of adjustment for the 3 pieces of equipment used was 89.4 minutes.

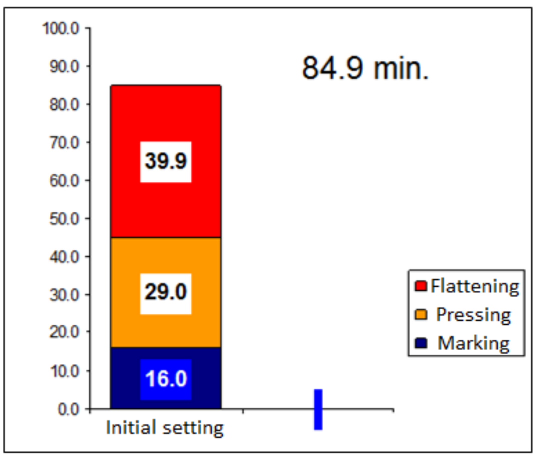

Fig. 9 Initial setting chart

Operator movements totaled 545 m and were influenced by the search for tools and materials needed for adjustment, but also necessary movements for the validation of the process.

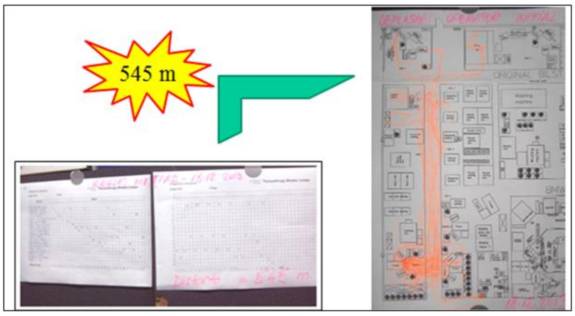

Fig. 10 Operator movements at the initial setting

The evolution of activities' duration and their division into categories is given in Table 1.

Following the analysis of activities it is necessary to eliminate those activities that generate waste and reduce the adjustment time by moving the internal activities that are likely to be executed in external setting, reducing thus the downtime of equipment, and the total length of adjustment.

Table 1. Activities duration at the initial setting

Activities	Initial adjustment (seconds)
Mechanical assembly and disassembly	1013
Adjustments and settings	888
5S Activities	250
Control	807
Shipping	555
Handling and movements	969
Waiting and searching	612
Faults	0
TOTAL	5094
TOTAL (minutes)	84,9

All activities were run in a time chart before being filtered through the *ECMS* analysis – optimizing control activities through an *Elimination – Combination – Modify – Simplification* – used to optimize internal and external control operations. (E – *Elimination* – these activities can be eliminated without consequences for setting; C – *Combine* - activities can be combined, thus tasks can be performed with both hands simultaneously or by two people simultaneously; M – *Modify* - change the sequence of the setting activities in progress; S – *Simplification* – activities that can be improved.)

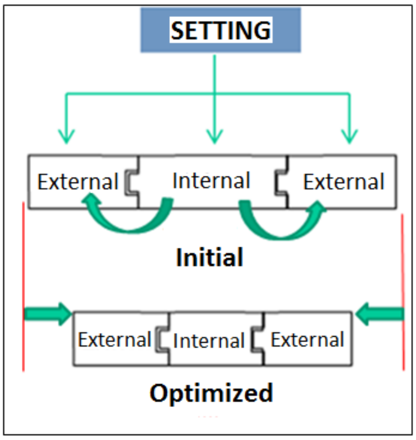

Fig. 11 The theoretical optimization setting scheme

After analyzing the work items of the setting content, resulted an optimized adjustment of 45 minutes. As a result of this analysis it was time to achieve established improvements:

– develop a checkpoint in the area of training, equipped with everything necessary for auto-controlled work by the operator or adjuster who is implementing the change of setting;

Fig. 12 Improvements in preparation cycle – realizing of a checkpoint

– manufacturing supports for some tools and devices used in the production process;

Fig. 13 Improvements in preparation cycle – realizing a panel for tools and devices

– manufacturing additional devices, opting for the systematization of devices and providing a training panel with tools.

– changing the registration form for the approval of quotas so that the operator fills out the input data of a batch command only once;
– changing the layout to have an optimal flow of material in the preparation cycle to create optimal action of professionals in the maintenance department and to comply with occupational safety conditions.

All these improvements have been made to eliminate the causes of waste related to setting and, also time.

The next step was to prepare the conditions required for adjustment setup thus, the spaces of storage for materials, tools, AMCs were established, and the steps as well as places where the operator needs to go during adjustment time were discussed again.After timing and recording the adjustment period, it was observed that 48.4 minutes had passed, period which was passed as a diagram of the time on completing tasks where adjustment was recorded in part at each machine that was part of the preparation cycle:

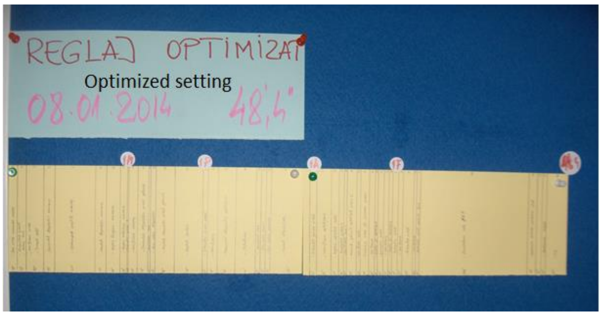

Fig. 14 Time diagram

We have analyzed the work items on categories and the time totaled was:

Table 2. Comparing time on activities after improvement

Activities	Initial setting (seconds)	Optimized setting (seconds)	Difference (initial – optimized)
Mechanical assemblies and disassemblies	1013	538	**475**
Adjustment and setting	888	530	**358**
5S activities	250	170	**80**
Control	807	744	**63**
Shipping	555	138	**417**
Handling and Movements	969	651	**318**
Waiting and searching	612	32	**580**
Faults	0	101	**- 101**
TOTAL	5094	2904	**2190**
TOTAL (min)	84,9	48,4	**36,5**

The time obtained was also affected by a fault occurring during adjustment.

The distances traveled were analyzed using the chart of movements and the Spaghetti Diagram and it was concluded that the improvements helped reduce the distances with 309 meters, resulting in a new distance covered of only 236 meters.

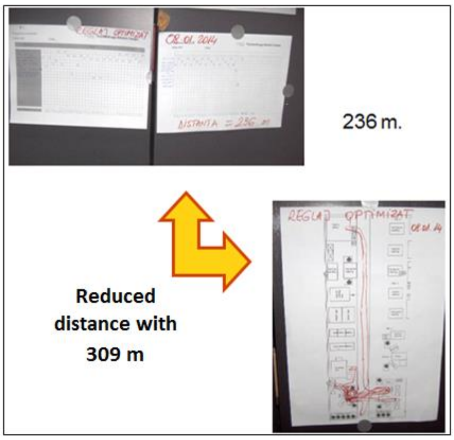

Fig. 15 Distance reduction

A graph was created to highlight the duration of activities on each piece of equipment from the preparation cycle and the reduction of the total tuning time.

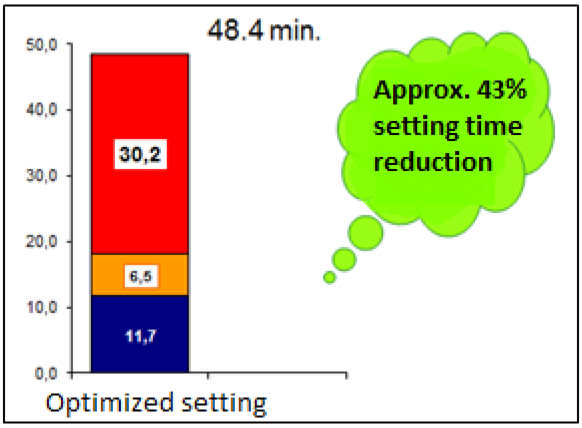

Fig. 16 Activities duration chart

A setting standard was developed and implemented where the following aspects were mentioned:

– sharing setting on internal and external activities;
– the sequence of steps for necessary activities;
– necessary tools and AMCs;
– places where they have to move during the time of making the adjustment.

This standard is the basis for further training for all staff that will work in this area and can be applied in all other training cycles.

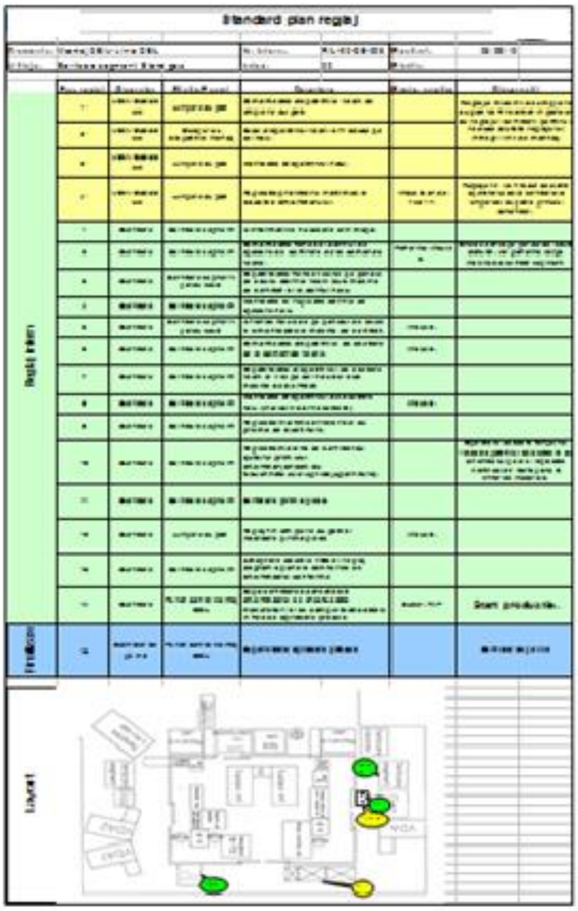

Fig. 17 Standard model for setting

4. THE OPTIMIZATION OF MATERIAL FLOW BY ORGANIZING A ONE PIECE FLOW ZONE

The analyzed process influences the quality of the final product in the analyzed production flow. Optimizing this process with flows of material, information and staff can bring substantial improvements in terms of production in progress, costs of materials, with substantial economic effects on medium and long term.

An analysis of material flow in this area of production highlights the following milestones:

- Landmarks from suppliers enter in the warehouse where materials are received on a quantity and quality basis and afterwards are spread across locations;
- When launching an order those parts are commissioned and carried by the production logistics operator within the Kanban processing workshop;
- Performing any technological operations associated with the technological process starting with the washing operation to prevent potential quality problems in the following processes;
- A flaring operation or bottleneck which is achieved by cold working on hydraulic machines with special devices;
- Marking according to specifications;
- A circular welding operation under pressure;
- A welding operation with clamping bushing intake;
- Check for leaks;
- Wash and conservation in order to transfer it into the assembly workshop.

After repeated simulations it was proposed to shift to the implementation of a cell-type One-Piece Flow (OPF), in which the material is transferred from one machine to another one piece at a time.

To achieve such a cell, the answer to a number of important questions that determine the possibility of practical accomplishments of this cell type and its mode of operation needs to be identified:

- Do we have the right product family?
- Which is the customer tact (pace)?
- What are the elements of work to make a part / product?
- What is the required amount of time for each item of work?
- Can the equipment meet customer tact (pace) requirements?
- What is the level of automation?
- How can the physical production process be implemented, so that a person can manufacture a part as effectively as possible?
- How many operators are required to meet client tact?
- How to distribute work content between operators?
- How to plan the cell?
- How will the cell react to changes in customer requirements?

In defining the product family for a cell OPF basic element that have the following aspects should be considered: flexibility reported to customer demand, the variation of total labor content below 30%, the similarity of processing steps and equipment, etc.

To solve these problems, records have been made in line in which it was observed the initial work method, then all the steps in the production process were analyzed, all the work has been timed repeatedly, the smallest repeated time period being considered for each work item.

All work items (man and machine) recorded were included in the initial state diagram. The obvious waste was removed and an optimized chart which excluded machine times was created, focusing on the amount of work required by operators to make a part.

The products which may be part of that family were analyzed in terms of the technological process and it was concluded that the production cell can achieve almost the entire family of parts to be mounted on the rear axle with a few exceptions generated by technical possibilities of the machines that will be part of the cell. The weight of these parts is 10 – 12% exempt from all parts of the range, and therefore it was decided their exclusion from the product family.

Another decision is regarding the fact that the washing parts machine and hydraulic press which is used to achieve constriction or flaring tubes that needs it, were going to be left outside the OPF cell.

The machines that will be part of this cell are: cash machine; circular welding machine; cover sleeve welding machine; the device to verify the seal.

After defining the cell and the elements that compose it the main activities to be undertaken for implementing OPF cell were established:

- Creating a new layout, adapted to the requirements OPF.
- Equipments were placed closer without obstacles between them, respecting the health and safety at work.
- Interior width of the cell was performed at 1.5 m to reduce the movement of workers from one job to another over long distances.
- The maximum possible storage places where WIP (ie stored interoperable components, this means that when a problem occurs in the cell, production stops until it is solved) can be accumulated were reduced.
- A U-shaped layout was designed with the first and last process adjacent so that the end to be next to the beginning of the process to reduce the distance covered by operators.
- For better workplace ergonomics, a constant height of work surfaces was developed for operators so that there are no difficulties in performing specific tasks workplace.
- On each machine were mounted panels with necessary tools for tuning devices as close as possible to the place of use, significantly reducing unproductive time generated by changing landmarks.
- The required materials were brought as close as possible to the point of use to eliminate the waste generated by the movement of the operator to transport them, so a Kanban shelf was designed that was powered by an operator in production logistics and a material storage place for the next order.

We calculated the number of workers that will serve this cell OPF as follows:

$$Operators\ no. = \frac{total\ work\ content}{client\ tact}$$

Tact client is given by the necessary products made per shift, generated from the production to be carried out and the number of shifts in which they work, following the rules on the time required for preparation and completion of the manufacturing process, time-outs required, etc.

The demand of parts per shift is 1125 pcs.

$$Total\ production\ time\ per\ shift = 7{,}2\ hours \times 60\min \times 60\sec = 25920\ sec.$$

Client tact = 24 sec.

The total content of work is obtained by successive timing of a single operator after taking into account the problems that he has raised and met in the course of business. Content labor = 46 sec.

Thus:

$$\text{Operators no.} = \frac{46}{24} = 1.9 \text{ operators,}$$

Therefore we chose to serve OPF cell by two operators.

In the area where the OPF cell was held after creating the standard of supply and organization, its functionality was tested to confirm that it can achieve the established number of parts. To control the production and increase the reaction time when various problems arise, a panel was created for hourly monitoring of their production per shift. Every hour the direct supervisor must check and confirm the production and when the output is less, he must react.

A relayout was created in the analyzed area with the machines that were set in advance following the observations mentioned above.

A standard setting was developed and implemented, similar to that shown in SMED analysis for machines from the target area that facilitates the work of operators by offering them materials, tools and devices needed to run production, in order to significantly reduce unproductive time of machines generated by the length of time required for activities related to the transition to a new command.

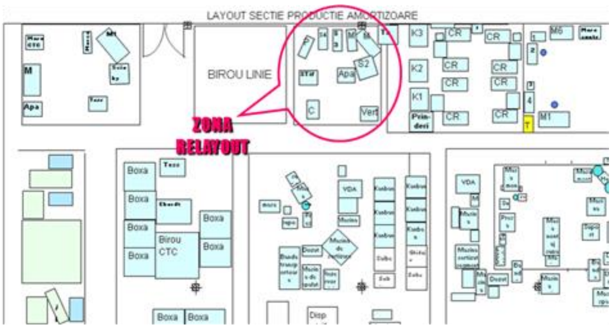

Fig.18 The zone where the equipments where rearranged

Following the implementation of these elements and effective implementation of OPF cell, the following advantages were revealed, data regarding processing time duration:

- Real time plus added value 8.98 min. and the time required to cover the whole process for the analyzed area is 0.61 days i.e. 878 min.
- Another advantage is generated by the economy of operators as follows:
  - an operator to check for leaks, operation to be executed within the cell, having the advantage where non-compliances are generated in the process they are quickly detected after only 3 parts that are required for the following operations parts from the first operation up to checking for leaks, which generates a rapid response to remove non-conformities;
  - an operator receiving new tasks related to production logistics, mainly dealing with supplying parts from the warehouse in production lines, waste disposal and cleaning parts before and after welding;

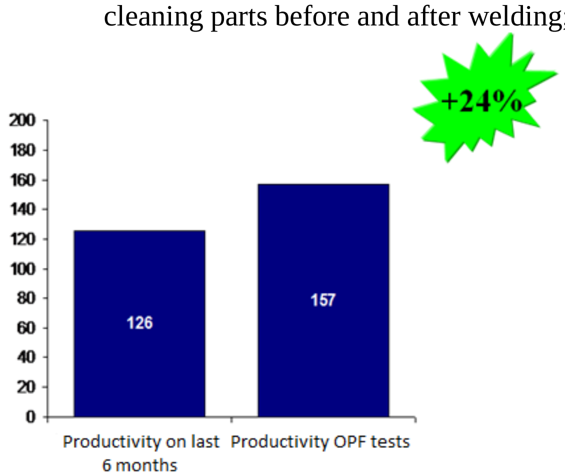

Fig. 19 Productivity increase

But the most important improvement achieved in the area is given by the increasing productivity, so that the average hourly productivity increased by 24% (Fig. 19) according to the results of monitored for the last 6 months.

5. CONCLUDING REMARKS

As a result of the actions requested and approved by senior management of the company, the following improvements resulted:

1. A flow projection of added value was performed on a product family for reaching decisions regarding material and information flows and observing processes where waste is generated more easily;
2. Actions of organizing the work place were conducted in several workshops, improving product and environmental quality. All 5S actions were completed using verification standards performed, in order to maintain the improvements made and implemented.
3. Relocation of equipment (relayout) existing in the processes belonging to different workshops or production lines to facilitate the work of operators and reduce unnecessary travel for materials or devices;
4. Reduction of adjustment time between batches of processed materials (SMED) – adjustment (settings) was decreased by 43%;
5. Adjusting the flow of materials and information so as to eliminate intermediate stocks and where circumstances permit it, applying of the FLOW principle extreme version OPF – reduced the distance with 309 meters;
6. The controller on the production line was relieved from tasks that were not necessary and self-control was implemented by the operator;
7. Better working conditions were created for the operator and the security and safety in work (SSM) conditions were improved.

The most important improvements achieved were productivity gains and efficiency, so that average hourly productivity increased by 24% only in the cell exemplified by reporting the results of tests monitor in the last 6 months, to which staff savings are added.

All of these actions performed according to the methods and techniques presented have a real purpose and may extend to all similar processes in the organization since it has been shown that they can generate substantial potential savings. The key to these actions is that the staff that applied and uses these implemented standards must understand and accept them. These issues can bring the whole organization to a new threshold of competitiveness in the automotive industry.

6. REFERENCES

►Brîndaşu D. P., Beju Livia Dana (2014) *Designing Educational Materials through Product Lifecycle Management*, Balkan Region Conference on Engineering and Business Education, Volume 1, Issue 1, Pages 73–78

►Carreira B. (2004) *Lean Manufacturing That Works*, AMACOM, New York

►*Hobbs D.P.* (2004) *Lean Manufacturing Implementation – A Complete Execution Manual for Any Size Manufacturer*, J. Ross Publishing, APICS

►Massaki Imai (1997) *Gemba Kaizen – a commonsense, low-cost approach to management*, Kaizen Institute Ltd.

►Miricescu, D. (2008) *Metode şi tehnici manageriale utilizate în managementul industrial*. Editura Universitătii "Lucian Blaga" din Sibiu, Sibiu

►Moraru Gina (coord.) (2009) *Dezvoltarea competenţelor managerial şi tehnologice ale personalului operaţional*, Editura Universitătii "Lucian Blaga" din Sibiu, Sibiu

►Stalk G., Hout T. (1990) *Competing Against Time*, The Free Press, New York

►*** – *Implementing Continuous Flow*, Cell One Piece Flow