Improvement Project of Production Line Using Automation

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Abstract **– This paper is oriented on the usage of automation on the manual post 40 on the production line Cinematic. This paper is divided into two main parts. First main part deals with characteristics of the production line Cinematic, while in this part one can also find information about layout, assembly elements on this production line and measurements of cycle time and production capacity. The second main part is about project proposal for production line improvement, in which one has also information about new layout, technical data of the new automated post 40 and measurements of cycle time and production capacity after improvement.**

Keywords **– cinematic production line, automation, assembly station, layout, cycle time.**

1. Introduction

Nowadays everything is developing incredibly fast, and this is due to technologies, information systems, experts in the field and corporate education [1], [3]. For each company, maintaining in the market is challenging, because of overcoming competition and the necessity to constantly improve in its activities, and to check the costs, because each company tries to minimize them [2], [4].

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Increasing the efficiency of production processes in an industrial company is one of the main ways to take advantageous position on the market [5], [6]. As a result of competition and the advent of new and better business technologies, it is necessary to look for new ways of effective company´s management [9], [11]. These steps can help companies in their production processes and consequently in a positive impact on their economic result [12], [13].

2. Characteristics of the Production Line Cinematic

The contribution is focused on the semi-automatic production line Cinematic. The output of this line is an assembly unit for the Iveco production line [8], [17]. In Fig. 1 we can see the Cinematic assembly unit, which forms the pre-production part of the finished lock for the Iveco car lock.

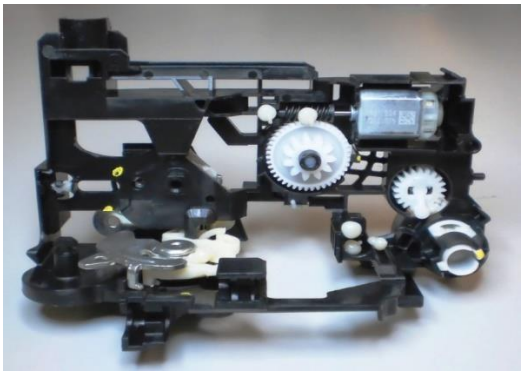


Figure 1. Cinematic assembly unit

The assembly line is constructed in the shape of O, and it consists of conveyors on which palette moves [10]. Pallets are nests to which mounting elements are added at each station and are designed in the such way that allow to produce both (left and right) sides of the assembly unit. Cinematic subassembly is produced in two versions – mechanical and electrical, while the difference is the addition of two components for electric opening of the lock [7], [16].

In Fig. 2 we can see the final Iveco lock, in which the Cinematic pre-production assembly unit is incorporated as the main part.

Figure 2. Final lock Iveco

Aluminum profiles allow designing the production line to the required final form and the design intervention is without troubles. Their low cost, the ability to run various wirings and low weight enables company to modify them very easy. For the purpose to design a more efficient production process on the assembly line in the company, it is necessary to analyze this process step by step.

This will help to identify bottlenecks in which inefficiencies are generated, i.e. stoppages. From the layout of the assembly line it is clear that operators are necessary for this production. Tab. 1 lists the individual operations that operators perform.

It is a product line with moving product, while on each assembly post are added components on the pallet that move along conveyor belts driven by electric motors.

Combined arrangement of machines will be used as part of the proposals for the placement of individual workplaces in the production hall in the selected company. This arrangement is in line with the company's goals, according to the number of machines in the hall, according to the nature and extent of production.

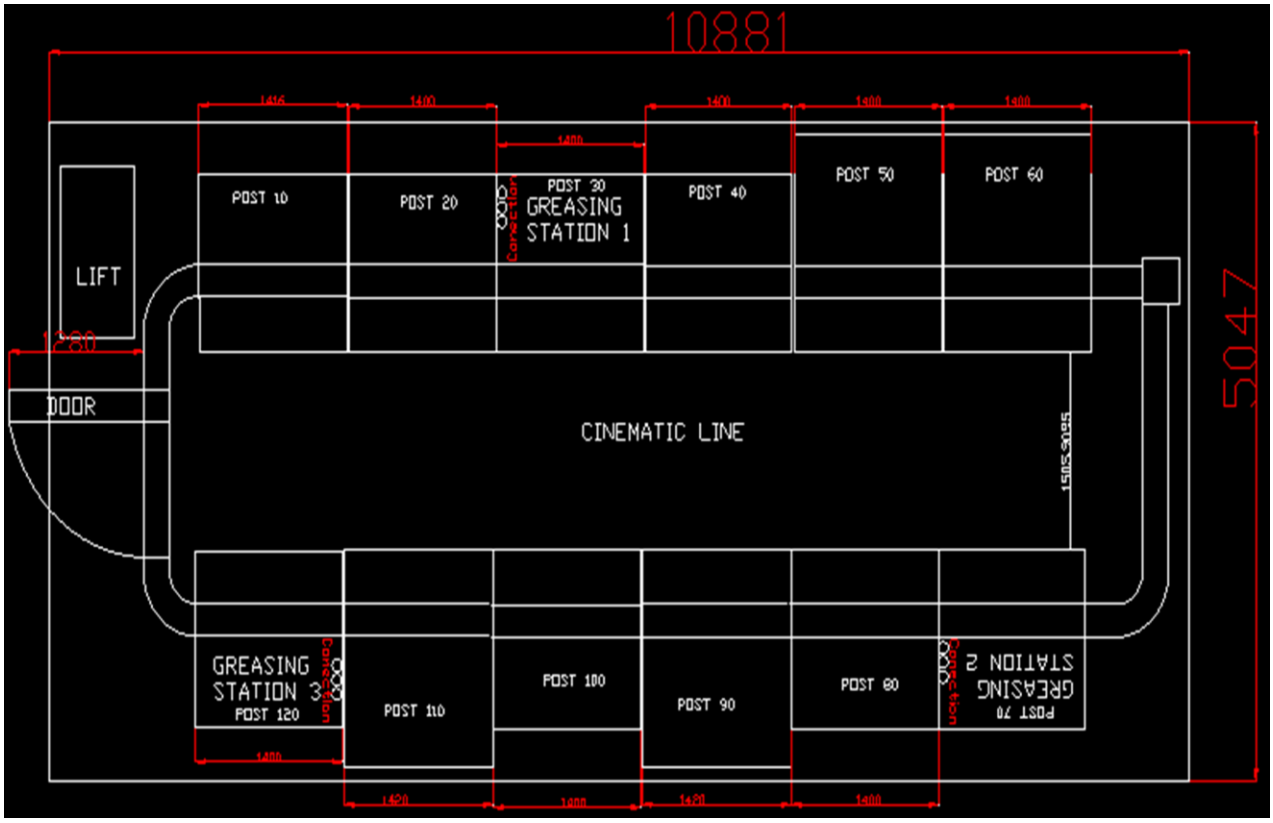


Figure 3. Layout of Cinematic production line

Fig. 3 shows the current layout of the Cinematic production line, where the production process of the Cinematic assembly unit takes place. The individual posts are shown. In the posts 10, 20, 40, 50, 60, 90 components are stored manually, while the remaining posts are robotic, where lubrication and connection take places of the parts and components [14], [15].

In the current layout there are posts in sequence that copy the technological procedure of production. The proposal will contain rearrangement of the layout of this production line, mainly due to inter-operational losses. Tab. 1 shows the activities and visually displayed added elements in the posts of the Cinematic assembly line.

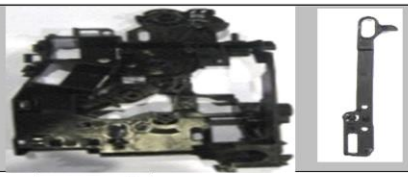
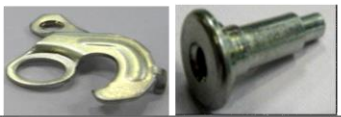
In the selected company there is a three-shift operation. One working shift takes 8 hours (there are of course working breaks of 30 minutes, and the time that is necessary for machine preparation). The working time is therefore 7.5 hours per working shift. The company works 250 days per year after subtraction of weekends and national days. The production capacity in the selected company is pieces per year.

After the calculations, it was determined that the production line had to complete one piece every 26 seconds in order to fill the required quantity by the customer within a given time frame.

Tact time (TT) is the time that defines how quickly one piece of a product has to be produced to fulfil demand. TT was calculated as 7.7. After calculation of TT, it is necessary to compare TT with cycle time. Cycle time (CT) is a value that represents the time that is necessary to complete one operation (cycle). CT has to be lower or equal compared to TT.

If the CT is less than TT, it means that the production process produces faster than the demand is. This fact will cause the company a waste of overproduction. If the CT value is equal to the TT value, it means that the demand was perfectly fulfilled.

Table 1. Assembly elements in each posts of the Cinematic production line

Post	Operations at the station	Used assembly units
P10 Man	At this post, the STR and LSD components are manually placed in the palette	
P20 Man	Placement of ROI component to the STR and FLOI components	
P30 Auto – Lubrication of added components		
P40 Man	Assembly of components LOI and PIO	
P50 Man	Assembly of components REN and PCE and winding of pallet support	
P60 Man	Assembly of ROE and LIO components	
P70 Auto – Lubrication of added components		
P80 Auto	Insertion of LOE and AOE components	
Post 90 Man	Insertion of RIO and LIC	
Post 100 Auto	Positioning the pallet in its original state and then storing MOT and PGN components in the STR component (for electrical versions)	
Post 110 Auto	Insertion of PGN and R10 components	
Post 120 Auto – Lubrication of added components and packaging		

CT analysis is an essential part by optimization of the production process. The essence of CT analysis is measuring the times of individual operations. Machine and work operations in the production process as well as all movements and walks are included. The time of each operation was measured using a stopwatch under normal conditions and entered in Tab. 2.

The measured values indicate that the times of individual operations differ. In the interest of efficient and lean production, the flow of pieces has to be continuous and complement on each other. The realized measurements were carried out on mechanical as well as on electric locks, in the production of both left and front locks, in which the transport time between individual posts is included. The results of the process measurements are shown in Tab. 2 [15].

Table 2. Initial measurements of CT at individual posts

Version	Side	P10	P20	P30	P40	P50	P60	P70	P80	P90	P100	P110	P120
Mechanical Front	left	5.8	6.1	6.5	8.7	4.2	5.6	6.4	6.7	6.3	6.3		6.6
		5.3	6.7	6.4	8.5	3.4	5.1	6.1	6.1	6.2	6.1		6.3
Mechanical Front	right	5.8	6.1	6.5	8.6	4.2	5.6	6.3	6.7	6.3	6.4		6.5
		5.3	6.7	6.4	8.3	3.4	5.3	6.2	6.1	6.2	6.2		6.2
Mechanical Rear	left	5.8	6.1	7.1	8.6	4.2	5.6	6.6	6.7	6.6	6.5		6.6
		5.3	4.7	7	8.3	3.4	5.1	6.4	6.1	6.4	6.3		4.9
Mechanical Rear	right	5.8	6.1	7.1	8.5	4.2	5.6	6.6	4.7	6.6	6.5		6.6
		5.3	7	7	8	3.4	5.1	6.4	6.1	6.4	6.3		4.9
Electric Front	left	7.2	5.6	6	8.6	5.6	5.8	6.5	6.7	6.5	6.7	6.7	4.6
		6.4	7	5.9	7.9	5	5.1	6.3	5.6	6.3	6.6	6.7	4.2
Electric Front	right	7.2	5.6	6	8.6	5.6	5.8	6.5	6.7	6.5	6.7	6.7	4.5
		6.4	7	5.9	8	5	5.1	6.3	5.6	6.3	6.6	6.7	4.2
Electric Rear	left	5.3	5.6	6	8.7	5.6	5.8	6.5	6.7	6.5	6.7	6.7	4.6
		5	7	5.9	7.9	5	5.1	6.3	5.6	6.3	6.6	6.7	4.2
Electric Rear	right	5.3	5.6	6	8.7	5.6	5.8	6.6	6.7	6.5	6.7	6.7	4.6
		3	6.7	5.9	8.3	4.1	5.1	6.3	5.6	6.3	6.6	6.7	4.2

In Tab. 2 there are highlighted fields by the green colour, where the manual operation takes place. The station 40 is characterized by the longest operation, where the longest time is 8.7 s. Measurement analysis was performed when the assembly line was occupied with six operators. In our case CT is 8.7 and TT is 7.7, which is the unacceptable situation and it is necessary to solve this problem.

Tab. 3 shows the number of pieces in the production process of locks and their average is stated at 417 pieces per hour, which gives us an average of 3024 pieces of pre-production configurations per working shift.

From Tab. 3 it is clear that at 7.25 hours for production with six operators, the maximum output from the production line is 3074 pieces. The hourly output from the production line is maximally 424 pieces. The working shift is calculated with 90% efficiency in the company.

Table 3. Initial measurement

Production per hour / pieces	Production per working shift / pieces	Bottleneck / seconds
414	3000	8.7
419	3030	8.6
419	3030	8.6
424	3074	8.5
419	3030	8.6
419	3030	8.6
414	3000	8.7
414	3000	8.7

It is not a standard for the companies to have 100% efficiency, because unexpected events can always occur, such as possible component failure, possible absence of employees, or possible breakdowns, respectively downtimes. Production capacity of production line is in Tab. 4.

Table 4. Production capacity of production line

Maximal value of CT	**8.7**
90 % efficiency/working week/15 working shifts	45 000 pieces
90 % efficiency/ working week + 1 overtime working shift/16 working shifts	48 000 pieces
90 % efficiency/month/ 66 working shift	198 000 pieces

From Tab. 4, it is clear that during 15 working shifts, i.e. by three-shift operation in one week, 45 000 pieces of Cinematic pre-production configurations are produced. The Iveco production line has a contract for the year 2020 for 2 610 000 pieces, which is in current state impossible to fulfil for the period. The Cinematic production line currently produces 2 250 000 pre-production configurations.

Figure 4. Manual post 40 of Cinematic production line

In the next part of this paper we will preliminary offer an automatic robotic station 40 on a given project. The proposal of the post will meet the design simplicity, minimization of the production service and management by operator. The emphasis is on the reliability of the device. LOI and PIO components are mounted on the manual post, and when the green confirmation button is pressed, the pallet is released from the post and proceeds to the next post. The post has the longest production time, therefore it is called as bottleneck and we will propose to automate the post.

In Fig. 4 we can see the current post 40 on the Cinematic production line; where on a semi-automatic belt comes a pallet on which the components are gradually assembled into one pre-production unit.

3. Project Proposal for Production Line Improvement

We propose that the automatic robotic post 40 will be the part of the Cinematic production line and its function will be the assembly of LOI and PIO components. Tab. 5 shows the technical data of the proposed device.

Table 5. Technical data of the proposed device

Producer	External company
Line dimensions (mm)	š x d x v 1 400 x 1 500 x 2 000
Weight	950 kg
Number of workstations	1
Number of trays	2
Working cycle of the production line	6 s
Supply voltage	3/N/PE, 50Hz, 230/400V~ / TN-S
Power	1.34kVA
Maximal stream	20A
Compressed air supply	1,5bar / 16bar

The post will be automatic and it will consist of a main frame on which a conveyor with stops and an additional frame will be mounted. The robot assembling the individual components, the LOI and PIO vibrational trays and the manipulators for storing them will be part of the device. On the additional frame there will be refiling with the above-mentioned components, which is also possible during machine operation. In Tab. 6 the components of the proposed assembly station are listed.

Table 6. Components of the proposed assembly station

Components of the machine	Dimensions [mm] (width x depth x height)	Weight [kg]
Main frame	1400 x 1250 x 2070	750
Additional frame	1400 x 440 x 1220	200

The layout of machines and workplaces is based on the results of previous analyses that are mentioned above. The result of the layout should be optimized with respect to the basic requirements, i.e. production efficiency, transparency of layout, straightness and irreversibility of technological flow, minimal manipulation, minimal occupied space, requirements of work safety, etc.

In the proposed layout change is the elimination of the employee's movement between working stations. Compared to the previous layout, its length was shortened by 516 mm, but posts were added to the width, increasing it to 1200 mm. The layout is in the ratio of five posts on one side and also five posts on the opposite side, which shortens the transport time of the conveyor along the entire length and thus

contribute to higher efficiency while reducing the inter-operational times, which are included in the measurement at each post.

Fig. 5 illustrates a new layout of production line which results in a narrowing of the production line (from the original 10 881 mm to the current 10 365 mm) and elimination of unnecessary operator movements.

Currently the manual post 40 is the slowest post, as mentioned above, the bottleneck with its longest measured time of 8.7 seconds. In cooperation with the external company with which the company has a contract, the working cycle of the automated robotic post 40 has been determined for 6 seconds. The production line has further semi-automatic mode and it is O-shaped. In Tab. 7 there are measured CT after implementation of automatic post 40.

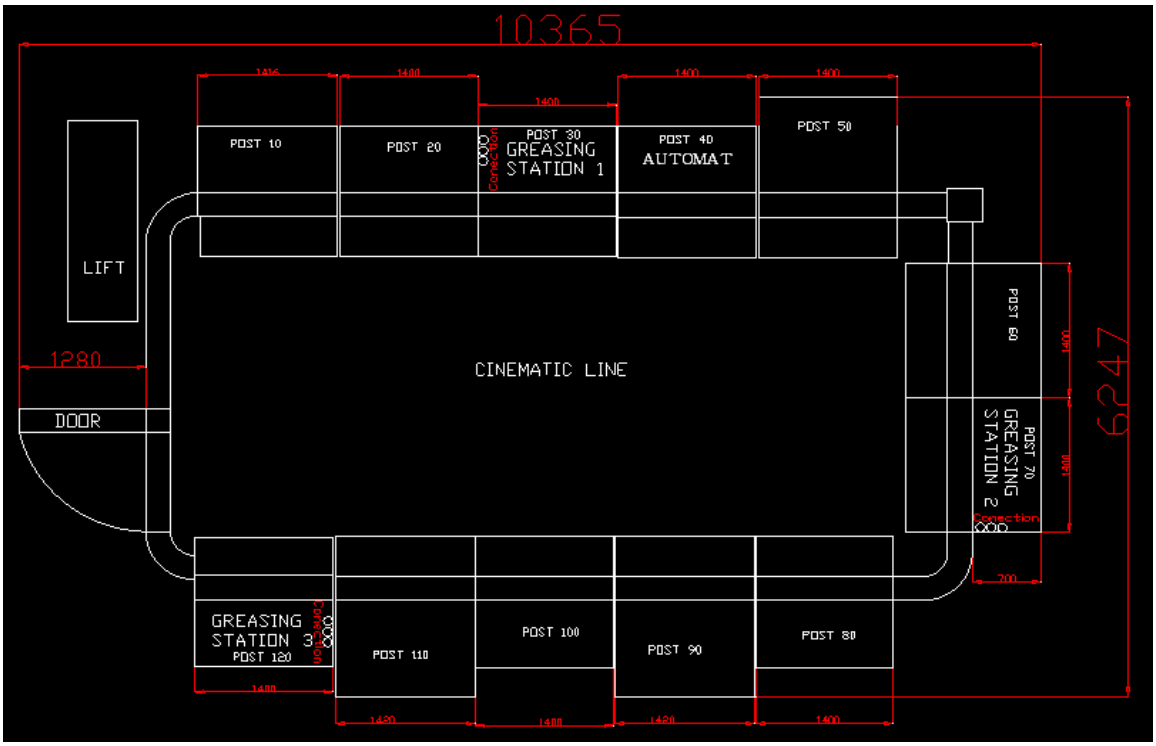


Figure 5. Proposed layout of production line Cinematic

Table 7. Measured CT after implementation of automatic post 40

Version	Side	P10	P20	P30	P40	P50	P60	P70	P80	P90	P100	P110	P120
Mechanical Front	left	5.8	6.1	6.5	6.7	4.2	5.6	6.4	6.7	6.3	6.3		6.6
		5.3	6.7	6.4	6.5	3.4	5.1	6.1	6.1	6.2	6.1		6.3
Mechanical Front	right	5.8	6.1	6.5	6.6	4.2	5.6	6.3	6.7	6.3	6.4		6.5
		5.3	6.7	6.4	6.3	3.4	5.3	6.2	6.1	6.2	6.2		6.2
Mechanical Rear	left	5.8	6.1	7.1	6.6	4.2	5.6	6.6	6.7	6.6	6.5		6.6
		5.3	4.7	7	6.3	3.4	5.1	6.4	6.1	6.4	6.3		4.9
Mechanical Rear	right	5.8	6.1	7.1	6.5	4.2	5.6	6.6	4.7	6.6	6.5		6.6
		5.3	7	7	6	3.4	5.1	6.4	6.1	6.4	6.3		4.9
Electric Front	left	7.2	5.6	6	6.6	5.6	5.8	6.5	6.7	6.5	6.7	6.7	4.6
		6.4	7	5.9	5.9	5	5.1	6.3	5.6	6.3	6.6	6.7	4.2
Electric Front	right	7.2	5.6	6	6.6	5.6	5.8	6.5	6.7	6.5	6.7	6.7	4.5
		6.4	7	5.9	6	5	5.1	6.3	5.6	6.3	6.6	6.7	4.2
Electric Rear	left	5.3	5.6	6	6.7	5.6	5.8	6.5	6.7	6.5	6.7	6.7	4.6
		5	7	5.9	5.9	5	5.1	6.3	5.6	6.3	6.6	6.7	4.2
Electric Rear	right	5.3	5.6	6	6.7	5.6	5.8	6.6	6.7	6.5	6.7	6.7	4.6
		3	6.7	5.9	6.3	4.1	5.1	6.3	5.6	6.3	6.6	6.7	4.2

Tab. 8 shows the number of pieces by production of pre-production units and their average length is 482 pieces per hour, which gives us the average of 3495 pre-production units per 7.25 hour working shift.

Table 8. Hourly capacity after automation of post 40

Production per hour / pieces	Production per working shift / pieces	Longest operation / seconds
493	3576	7.3
493	3576	7.3
474	3435	7.6
474	3435	7.6
480	3480	7.5
480	3480	7.5
480	3480	7.5
480	3480	7.5

Productivity is calculated with 90% efficiency. From Tab. 9 it is clear that 15 working shifts (i.e. three-shift operation in one week), production line will produce 51 525 pieces of Cinematic pre-production configurations. Production line will produce 188 703 pieces of subassemblies at 90 percent efficiency per month.

Table 9. Production capacity of production line after automation of post 40

Maximal value of CT	**7.6**
90 % efficiency/working week/15 working shifts	51 525 pieces
90 % efficiency/ working week + 1 overtime working shift/16 working shifts	54 960 pieces
90 % efficiency/month/ 66 working shift	226 710 pieces

As it was mentioned above, the Iveco production line has to produce 2 610 000 pieces per year, which can be achieved with a production cycle time of 7.6 seconds. The Cinematic production line currently produces 2 250 000 pre-production configurations for the line.

After the implementation of the proposed actions, the Cinematic line will produce 2 751 435 pieces per year at 16 working shifts per week, which is sufficient to cover the customer's needs. The manual station 40 is characterized by the longest operation; the longest time is 8.7 s. After the addition of robotic post 40, the line speeded up and it is 7.6 seconds. In this case it is sufficient situation, because CT is 7.6 and this is lower than TT, which is 7.7.

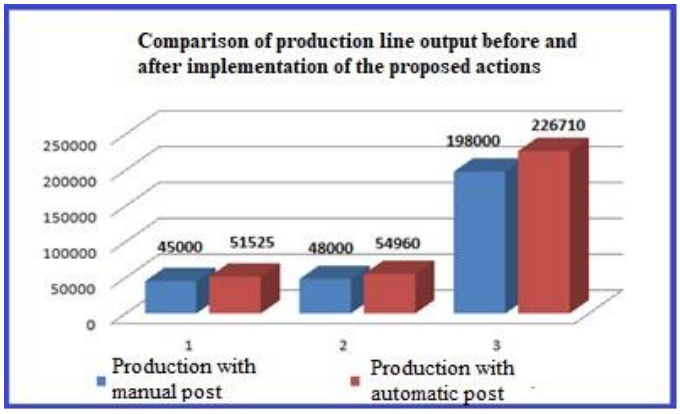


Figure 6. Comparison of production line output before and after implementation of the proposed actions

The increase in hourly production from 417 pieces to 482 pieces was due to the reduction of production line cycles from 8.7 to 6.7, and thus also cause the balancing of posts. Fig. 6 illustrates a comparison of production line output before and after implementation of the proposed actions.

After implementation of the improvements on the Cinematic line, the production ability of Cinematic units is expected to increase by 15% compared to the original production.

The current production ability on the Cinematic production line is on average 417 pieces per hour, i.e. 3027 pieces of Cinematic assembly pieces for a 7.25 hour working shift.

The price of car locks is about 20 – 25 € per piece. With the cycle time of 6.7 seconds after implementing innovations on the Cinematic pre-production line in 7.25 hours and after continuous operation of 250 days, we get output from the production of 2 250 000 pieces on the final lines per year.

4. Conclusion

In this paper we solved the question of the layout improvement and increasing the speed of the slowest post on the Cinematic production line, concretely manual post 40. Then we analyzed the current state of the production line and we prepared a proposal for its improvement.

In the proposal part of the paper, we implemented the automatic post 40 and we proposed the layout change. By changing the post 40 we have improved the cycle time and thus increased the overall output from the Cinematic production line. This was confirmed in subsequent calculations.

After the implementation of the proposal, the company will obtain some concrete improvements, namely the cycle time has decreased from 8.7 to 7.6 seconds, production ability has increased by 15%, balancing of individual posts by reducing bottleneck time, saving the costs of overtime working shifts, reducing the number of operators on the production line from 6 to 5 by adding the automatic post.

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