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LEANING OF PROCESSES AND IMPROVING THE WORKING CONDITIONS OF THE NEWLY CREATED WORKING ZONE

Veronika Sabolová
Slovak University of Technology in Bratislava, Ulica Jána Bottu č. 2781/25, 917 24 Trnava, Slovak Republic, EU, vsabolova4@gmail.com
Dagmar Cagáňová
Slovak University of Technology in Bratislava, Ulica Jána Bottu č. 2781/25, 917 24 Trnava, Slovak Republic, EU, dagmar.caganova@stuba.sk (corresponding author)
Helena Makyšová
Slovak University of Technology in Bratislava, Ulica Jána Bottu č. 2781/25, 917 24 Trnava, Slovak Republic, EU, helena.makysova@stuba.sk

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Abstract: The aim of the article is to propose ways to increase the functioning efficiency of the newly created workplace with regard to the course of the processes themselves, as well as of the working conditions of the affected employees in the selected company, dealing with the production of refrigeration and air conditioning units for automobiles. The automotive market is primarily customer-oriented, to which companies strive to meet and deliver high-quality products that are different from their competition. To ensure this goal, it is necessary to acquire theoretical knowledge in the field of organization and structure of the production process. It is also necessary to analyse problematic points of the newly created working zone on the basis of observations and interviews with employees. The essence of streamlining the workplace and improving the working conditions of employees lies in the identification, analysis and elimination of shortcomings, that have arisen mainly due to dynamic changes and rapid implementation of the working zone in the corner of the production hall. Based on the identified deficiencies, the authors of the paper have proposed corrective actions and have analysed the results of the improved condition.

1 Introduction

Adapting work and working conditions to a person is a necessity for the effective management and improvement of production processes. The company should provide such working environment for the employees that ensures work without endangering their health, without disturbing elements and unnecessary movements [1]. The efficiency of production from an economic point of view depends on appropriately selected production processes and optimal equipment, on the correct layout of the production system, on the quality of work performed, on prices, safety regulations, and technological procedures [2]. Maximum efficiency can be achieved only by reducing resource consumption while increasing production volume [3].

2 Description of the newly created workplace and its shortcomings

The newly created working zone of fluxing (application of the chemical substance flux on perfectly degreased aluminium semi-finished products) with an area of 312 m^2 is situated in a dispositionally separated area of the production hall. There is a machine inside it, through which three types of semi-finished aluminium products pass, all a part of air-conditioning and cooling units of cars and electric cars. The Paintflux device is used to apply a mixture of flux to perfectly degreased semi-finished aluminium products, which are assembled into a certain component and subsequently soldered in an electrically heated furnace at a high temperature of 615 °C. Since soldering technology is very prone to pores, cold joints, undercuts, erosions, and leaks between the individual components, it is necessary to apply flux in exact concentrations per m^2, which could only be achieved by purchasing the Paintflux machine, equipped with a nozzle on the robotic arm. At the workplace, there are also a measuring workplace, waste management, cabinets for personal belongings of employees, work aids, cleaning products, and collection tanks for dangerous waste located. Empty crates, crates with input material, and crates with output material also take up a large area of the workplace. Crates with input and output material are placed chaotically, without a precise system of inventory control and material flow. Like every new production process, it needs to be dynamically improved and systemically managed, precisely because of its initial shortcomings and the growing demands in the automotive industry.

The leanness of production lies in production without unnecessary components, with decreasing time, space, mistakes, and costs in production [4]. Lean philosophy become a very widespread approach to gaining high efficiency in production and logistics processes. The introduction of lean manufacturing has eliminated waste from non-products, excess processes, time losses, inefficient movement of materials and workers, surplus stocks and overproduction. It covers the entire value chain of business [5].

Due to the quick location of this zone in the corner of the production hall, without taking into account the working conditions of each season, material flow, waste management, and the impact of dangerous substance flux into the environment, it is necessary to optimize and systematically harmonize all these points to suit to the requirements of the standards of the automotive industry (OHSAS, ISO 14001, IATF 16 949, VDA6.3, 5STAR). The main impulse for solving the issue was non-compliance with daily production plans. The five employees of this workplace often had to work overtime, or employees from other departments helped them, or they had to also work on Saturdays. Therefore, it was necessary to shorten the daily time needed to flux all semi-finished products.

The need to effectively deal with the location of the workplace was necessary, as employees chaotically and in a disorganized manner managed the flow of material that did not meet the requirements. At the workplace, basic principles were missing for creating and maintaining an organized, clean, and high-powered 5S workplace. Due to the disorganized location of the workplace, semi-finished products were exchanged, which resulted in a loss of the form of unfulfilled daily production plans.

Layout is undoubtedly one of the most important tasks, because it has a direct impact not only on the company economy, but also affects safety at work and social environment of the company. Wrong allocation or layout of the productional and non- productional subjects, storage areas or distribution centres of the corporation can later cause huge problems. There are plenty of ways how to solve different problems with disposition and every single case usually has its own variables which are unique and different from other cases [6].

The creation of the layout itself - the spatial arrangement of the workplace - has a great impact on the overall efficiency of production. A properly designed layout reduces overall production time, eliminates unnecessary movements and transport of material, shortens unnecessary waiting, improves material flour, etc. The purpose is to arrange workstations, machines, equipment, and other necessary equipment so that employees work as efficiently as possible without much effort and unnecessary movements, which has an impact on production and transport costs [7].

One of the other serious shortcomings of the workplace was the direct contact of operators (Figure 1) with the chemical substance flux, which is harmful in direct contact. During the spread of flux to the ends of semi-finished products – manifolds, there was direct contact of the employee with the flux, because the nozzle of the machine could not apply the flux to semi-finished products at a 90° angle. The employee spread the flux by hand with a pressure vessel to the inner ends of the manifolds, with no barrier separating it from the flux aerosol. The employee responsibly used a gas mask and the prescribed protective for the given task. However, from a long-term perspective, a process such as this is ergonomically and safely unacceptable for workplace workers, as the flux enters the environment in the form of fine particles, which can cause health problems in long-term exposure.

Figure 1 Direct contact of operators with flux

The last significant negative aspect is standing work, as standing work in one place with the involvement of both upper limbs predominates among the employees of the workplace. The subsequent consequence of straining the musculoskeletal system of employees is back pain.

3 Methodology

After considering the theoretical knowledge, all shortcomings related to the Paintflux zone were revealed and analysed on the basis of observations and interviews with employees. Interviews with employees and observations were also the basis for streamlining the zone and for improving employees' working conditions.

It was also necessary to shorten the time needed to flux all required types of semi-finished products according to the daily needs of the customers – 716 minutes. Of this, the net production time needed to flux all models was 476 minutes. Non-production time was 240 minutes. The given times were calculated based on measurements of individual Cycle times, where the volume of individual semi-finished products loaded in one minute was measured with a stopwatch.

Cycle time is the time starting when operation begins to the point of time when the operation ends. Cycle time should be considered as a viable option, when an organization is trying to improve efficiency, cost base and customer responsive [8].

Cycle time reduction is of paramount importance in a manufacturing industry as the customer not only emphasizes the quality of the products, but also takes into consideration its timely delivery [9].

The times of the individual activities are shown in Table 1.

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Table 1 Calculations of equipment utilization during one work shift

Paintflux - list of semi - finished products			Daily requirement	Length of frame/semi-finished product (mm)	Gap between frames	Number of products on the frame/belt	Gap + frame (mm)	Paint flux conveyor (mm/min)	Time needed (min)	number/min	Real needed time
BC	J1	ASSY MANIFOLD-B/C D16 X 1 F	70	400	100	30	500	1720	2,1	33	6,36
	J1	ASSY MANIFOLD-B/C & D16 X 1 A	70	400	100	30	500	1720	2,1	33	6,36
	J1	ASSY MANIFOLD-B/C D16 X 1 C	70	400	100	30	500	1720	2,1	33	6,36
	J1	ASSY MANIFOLD-B/C D10 X 1 B	140	400	100	30	500	1720	4,2	33	12,73
	J1	MANIFOLD-B/C D16 X 1 E	70	400	100	30	500	1720	2,1	33	6,36
	J1	ASSY MANIFOLD-B/C D16 X 1 D	70	400	100	30	500	1720	2,1	33	6,36
	J1	ASSY MANIFOLD-B/C & D10 X 1 A	70	400	100	30	500	1720	2,1	33	6,36
	BEV 2013	MANIFOLD ASSY DIRECT CHANGE / RETURN	408	400	100	15	500	1720	14,6	28	43,71
	BEV 2013	MANIFOLD ASSY INLET OUTLET	408	400	100	15	500	1720	14,6	28	43,71
	SP12	MANIFOLD - INLET/OUTLET 1M C	840	400	100	30	500	1720	20,0	42	60,00
		MANIFOLD - RETURN 1M C	840	400	100	30	500	1720	20,0	42	60,00
	SP05 Lower	MANIFOLD - INLET/OUTLET 2M B	165	400	100	15	500	1720	5,9	28	17,68
		MANIFOLD - RETURN 2M B	165	400	100	15	500	1720	5,9	28	17,68
	SP05 Upper	MANIFOLD - INLET/OUTLET 3M D	165	400	100	15	500	1720	5,9	28	17,68
		MANIFOLD - RETURN 3M D	165	400	100	15	500	1720	5,9	28	17,68
CAC	CAC 992	HEADER - INTERCOOLER	560	290	50	10	340	1720	9,3	60	9,3
	Panther CAC	HEADER - INTERCOOLER	2600	170	50	10	220	1720	37,1	70	37,1
	HDT6 CAC	HEADER - INTERCOOLER	240	210	50	7	260	1720	4,1	58	4,1
	Macan F/L	HEADER - INTERCOOLER	800	300	50	10	350	1720	13,3	60	13,3
RAD /LTR	C519 (Ilava 3)	HEDER-RAD CORE INLET 14mm	1520	510	50	10	560	1720	38,0	40	38,0
		HEDER-RAD CORE INLET 18,5mm	1120	510	50	10	560	1720	28,0	40	28,0
		HEDER-RAD CORE INLET C2 LTR 25,25mm	660	510	50	10	560	1720	16,5	40	16,5
change		2 times/1 work shift							20		
starting time									60		
shift cleaning									60		
end day cleaning									50		
break time									50		
	Time required to cover the required volumes								715,4		

Other necessary data for the calculation were the length of the frames which the semi-finished products are stored on, the gap between the frames, the number of products on the frame, conveyor belt speed, the time required to start the machine into operation, the time required to clean the machine during operation, the time required to clean the machine work change, time required to change the model and break time. The only constant statement for all types of semi-finished products was the speed of the belt, which moved at a speed of 1720 mm/min.

The time required to start the machine – **starting time** – includes switching on, starting up, and stabilizing the machine. This time includes heating the machine to a working temperature of approx. 300 ° C, preparing the semi-finished products according to the production plan on a given day, preparing and marking the crates, writing daily verification forms, mixing and filling the flux into the machine, and verifying production before starting.

The time required to clean the machine during shift work – **shift cleaning time** – includes cleaning the nozzles and flux circuits of the machine.

The time required to clean the machine after the work shift – **end day cleaning** – includes the complete cleaning of the flux chamber, circuits, and ducts for the wastewater outlet from residual flux and other impurities.

Based on the stated information and in accordance to terms of the time horizon of one work shift, it was not possible to cover the given volume.

4 Results of the improved working conditions

Each production company must determine its goals individually, so that they correspond to the organizational structure of the company. In order to ensure the main goals of the company, it is also necessary to determine partial goals, which include, for example, minimizing costs or maximizing the use of corporate capacity. The goals that the company sets itself are achieved by eliminating waste in production processes [10].

The issue of the working zone layout was resolved by a new workplace layout, which was necessary to create to eliminate unnecessary movements that operators had made while picking input material, placing manifolds on frames, pre-production, removing final products from the machine conveyor belt, etc. The layout (Figure 2) was designed to ensure simplest possible work for employees, and at the same time, making the workplace safe.

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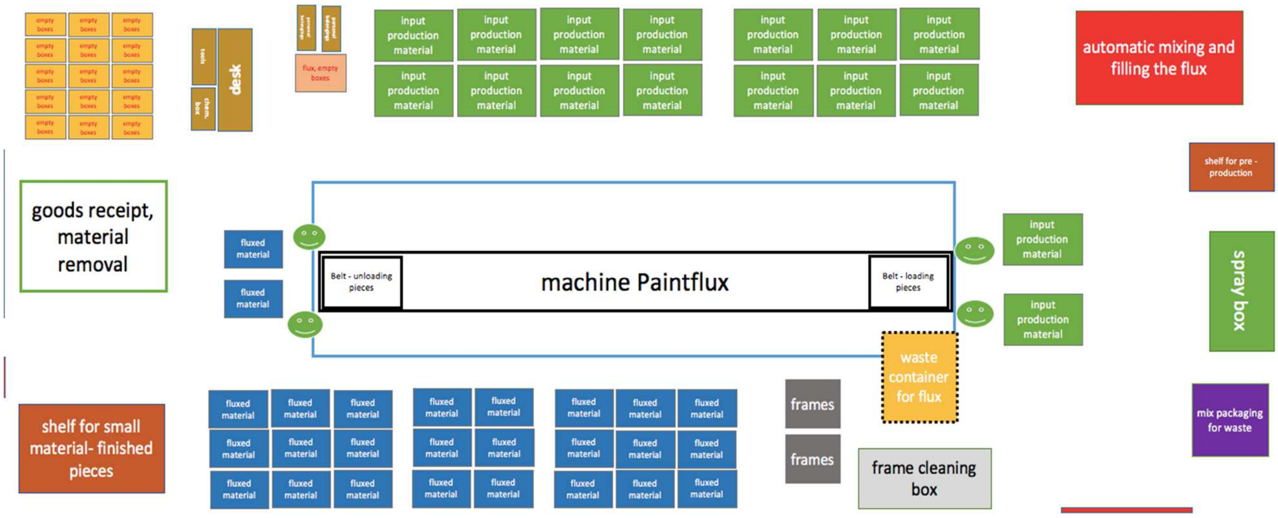

Figure 2 New workplace layout

Figure 3 shows the material flow from the intake to the workplace to the removal of finished pieces by the line feeder for further processing.

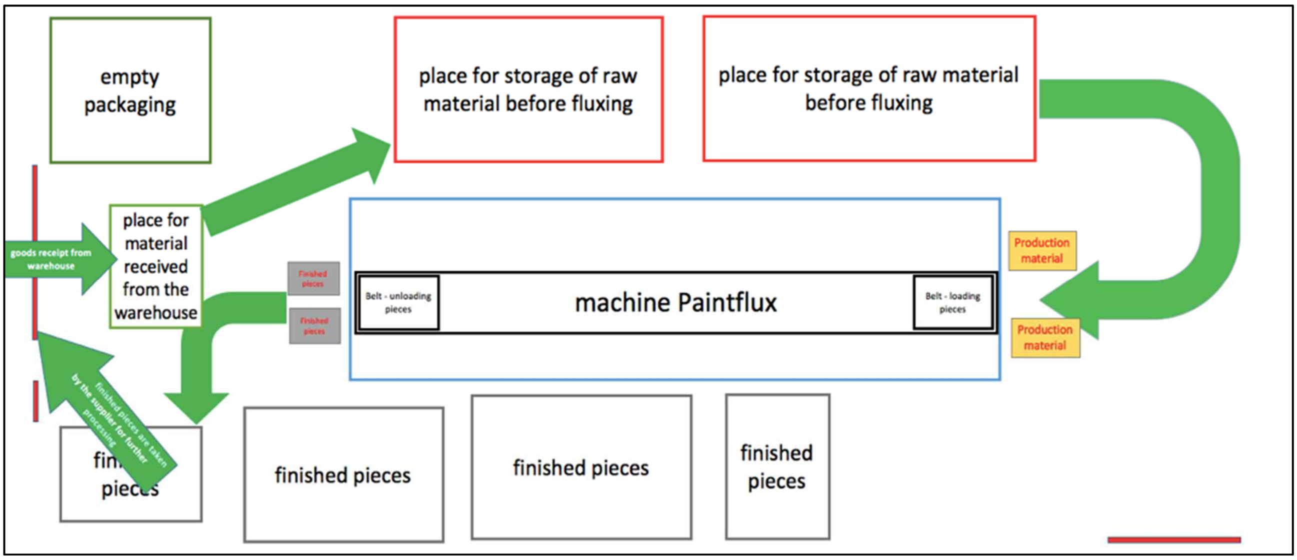

Figure 3 Material flow in the workplace

To ensure daily production plans, it was also necessary to focus on all operations that were not related to the creation of added value. With simple improvements, it was possible to reduce the utilization of the device during one work shift to 411 minutes (Table 2). Net production time was 365.7 minutes from the original 476 minutes. Net production time was eliminated because the manifolds pass through the machine two times. Originally, they had to go through the machine three times for perfect fluxing of circular semi-finished products, but by simply placing manifolds on the frames, employees will now achieve perfect fluxing in less time. This leaning saved approximately 110 minutes. Reduced activities, which originally took 240 minutes, were eliminated by leaning individual activities to 45 minutes.

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Table 2 Calculations of equipment utilization during one work shift after streamlining the production process

Paintflux - list of semi - finished products			Daily requirement	Length of frame/semi - finished product (mm)	Gap between frames	Number of products on the frame/belt	Gap + frame (mm)	Paint flux conveyor (mm/min)	Time needed (min)	number/min	Real needed time
BC	J1	ASSY MANIFOLD-B/C D16 X 1 F	70	400	100	30	500	1720	2,1	33	4,24
	J1	ASSY MANIFOLD-B/C & D16 X 1 A	70	400	100	30	500	1720	2,1	33	4,24
	J1	ASSY MANIFOLD-B/C D16 X 1 C	70	400	100	30	500	1720	2,1	33	4,24
	J1	ASSY MANIFOLD-B/C D10 X 1 B	140	400	100	30	500	1720	4,2	33	8,48
	J1	MANIFOLD-B/C D16 X 1 E	70	400	100	30	500	1720	2,1	33	4,24
	J1	ASSY MANIFOLD-B/C D16 X 1 D	70	400	100	30	500	1720	2,1	33	4,24
	J1	ASSY MANIFOLD-B/C & D10 X 1 A	70	400	100	30	500	1720	2,1	33	4,24
	BEV 2013	MANIFOLD ASSY DIRECT CHANGE / RETURN	408	400	100	15	500	1720	14,6	28	29,14
	BEV 2013	MANIFOLD ASSY INLET OUTLET	408	400	100	15	500	1720	14,6	28	29,14
	SP12	MANIFOLD - INLET/OUTLET 1M C	840	400	100	30	500	1720	20,0	42	40,00
		MANIFOLD - RETURN 1M C	840	400	100	30	500	1720	20,0	42	40,00
	SP05 Lower	MANIFOLD - INLET/OUTLET 2M B	165	400	100	15	500	1720	5,9	28	11,79
		MANIFOLD - RETURN 2M B	165	400	100	15	500	1720	5,9	28	11,79
	SP05 Upper	MANIFOLD - INLET/OUTLET 3M D	165	400	100	15	500	1720	5,9	28	11,79
		MANIFOLD - RETURN 3M D	165	400	100	15	500	1720	5,9	28	11,79
CAC	CAC 992	HEADER - INTERCOOLER	560	290	50	10	340	1720	9,3	60	9,3
	Panther CAC	HEADER - INTERCOOLER	2600	170	50	10	220	1720	37,1	70	37,1
	HDT6 CAC	HEADER - INTERCOOLER	240	210	50	7	260	1720	4,1	58	4,1
	Macan F/L	HEADER - INTERCOOLER	800	300	50	10	350	1720	13,3	60	13,3
RAD /LTR	C519 (Ilava 3)	HEDER-RAD CORE INLET 14mm	1520	510	50	10	560	1720	38,0	40	38,0
		HEDER-RAD CORE INLET 18,5mm	1120	510	50	10	560	1720	28,0	40	28,0
		HEDER-RAD CORE INLET C2 LTR 25,25mm	660	510	50	10	560	1720	16,5	40	16,5
change		2 times/1 work shift							10		
starting time									15		
shift cleaning									0		
end day cleaning									20		
break time									0		
	Time required to cover the required volumes								410,7		

The time required to start the machine was reduced from 60 minutes to 15 minutes by completely removing the warmup of the machine. The waiting was eliminated by having retrained the masters of the other departments to put the Paintflux machine into operation. Every day, during the night shift, the production master now switches on the Paintflux machine about an hour and a half before the morning shift, which is then ready and heated when employees arrive at the workplace.

The time required to clean the machine during shift work was reduced from 60 minutes to 0 minutes by setting aside an adjuster, that ensures that the Paintflux machine runs continuously. The adjuster manually cleans the nozzle of solid and settled residue (exchange for another) during the work of the operators, so there is no need to interrupt production. The flux circuits are cleaned as the model is changing when the gap on the belt between the previous – ending model and the next model is sufficient enough not to affect the adjustment time.

The time required to clean the machine after the work shift was reduced from 50 minutes to 20 minutes by removing the excess cleaning of certain parts of the machine from the automatic cleaning cycle.

The model change time was reduced from 2×10 minutes to 2×5 minutes so that employees do not empty the machine conveyor belt when the model is changing. Before improving this operation, the belt was allowed to empty due to the separation of defective parts (poor flux concentration), and therefore this change took about 10 minutes. From experience of the operators, it was clear that poor flux concentrations are very rare, and therefore other pieces can be loaded immediately after the calibration plates, where you do not have to wait for the belt to be emptied; this replacement only takes 5 minutes. If the flux concentration on the semi-finished product is incorrect (nozzle clogging), operators are trained to suspend the suspicious dose by separating it from the good pieces and adjusting the flux concentration (the flux concentration can be up to three times higher but cannot be lower).

The break time was reduced from 50 minutes to 0 minutes by alternating between five workplace employees for breaks, which allows the machine to produce continuously.

After quantifying the recoverability of the equipment and leaning the production process, it is clear that there is approximately 69 minutes of networking time left, which is used by the employees for pre-supply of the finished products. The pre-supply is produced operatively, which means that the company maintains approximately two days of pre-supplying the parts needed for the next two weekends. These supplies must be available, for example, in the event of a failure of the machine or the individual equipment required for fluxing.

Employees try to prevent possible failures by preventive daily maintenance, regular cleaning, and predictive replacement of sensitive parts with new ones. Sensitive parts are replaced twice a year, before summer and winter shutdowns. Sensitive parts are, for example, membranes on compressors, hoses, V-belts, and so on.

To eliminate the already mentioned direct contact of the flux with employees, a spray box was purchased for the workplace. It is a closed space of 2×2 meters, where the flux is applied with a pressure gun to the inner ends of semi-finished products. The method of applying flux in a spray box consists of manually applying a flux layer by a spray nozzle identical to the nozzle in the flux chamber of the machine, except for those product areas which are not available for flux in the machine chamber. The operator takes the required number of products, puts them inside the box on a turntable, then applies the flux to each side and lets them dry for about two hours. Operators are protected this way from the flux aerosol, which used to be dispersed into the space around them by manually applying flux to the inner ends of the manifolds. The spray box and its method of spraying are shown in the following Figures 4 and Figure 5.

Figure 4 Spray box

Figure 5 Method of spraying in the box

When designing the machine for manual flux application, it was necessary to ensure impermeable isolation of the interior spaces from the external working environment of the employees. After installing the machine at the workplace, it fulfilled its purpose. The flux is now poured by the operators into a pressure vessel located next to the machine, from which the flux is then automatically delivered to the spray gun, by which the application of the flux is applied to the product pieces. This machine also ensures the extraction of the generated steams which accumulate inside the machine into a chimney. Before putting the machine into operation, the accredited health services checked its emissions released into the air outside the company. These emissions were values that were within the allowable limit of 0,3 times (98 mg*m-3 in 160 minutes) the allowable limit, so they do not pose a risk to human activity.

As standing work in one place predominates at this workplace, it was necessary to solve the impact of such work on the musculoskeletal system of employees. During an interview with the employees of the given workplace, it was found out that the pain in their spine and hip joints persisted.

Standing work, together with sitting work, is the most common working position, in which various problems of the motional system arise. It is not only because one's own posture, but mainly to the way a person stands and how long they stand in that given position. The basic position of the production line operator is just working in a standing position, where a larger range of motion expanding higher muscle strength is required. When standing, most of the weight is transferred to the lower limbs. If the work allows it, it is ideal to alternate standing work with sitting work and change stereotypical positions that have a negative impact on human health [11].

This health risk has been reduced by the provision and use of ergonomic anti-fatigue mats (Figure 6) in the standardized size of 600×1200 mm, which is available to every worker in the workplace performing long-term work while standing. Anti-fatigue mats eliminate the danger associated with working in one place.

Figure 6 Application of anti-fatigue mats to the workplace

After the implementation of all proposed and approved changes, significant time savings were achieved, which are shown in yellow in Figure 7 below. The red colour represents the duration of the activity in minutes before improvement, and the green colour after improvement. Numbers from 1 to 8 on the vertical axis represent individual work activities: 1 – the time required to influx the daily demand of the manifolds (TA), 2 – the time required to influx the daily demand of CAC headers (TA), 3 – the time required to influx the daily demand of RAD headers (TA), 4 – model exchange (TB), 5 – starting time (TB), 6 – shift cleaning time (TB), 7 – end day cleaning time (TB), 8 – breaks (TC).

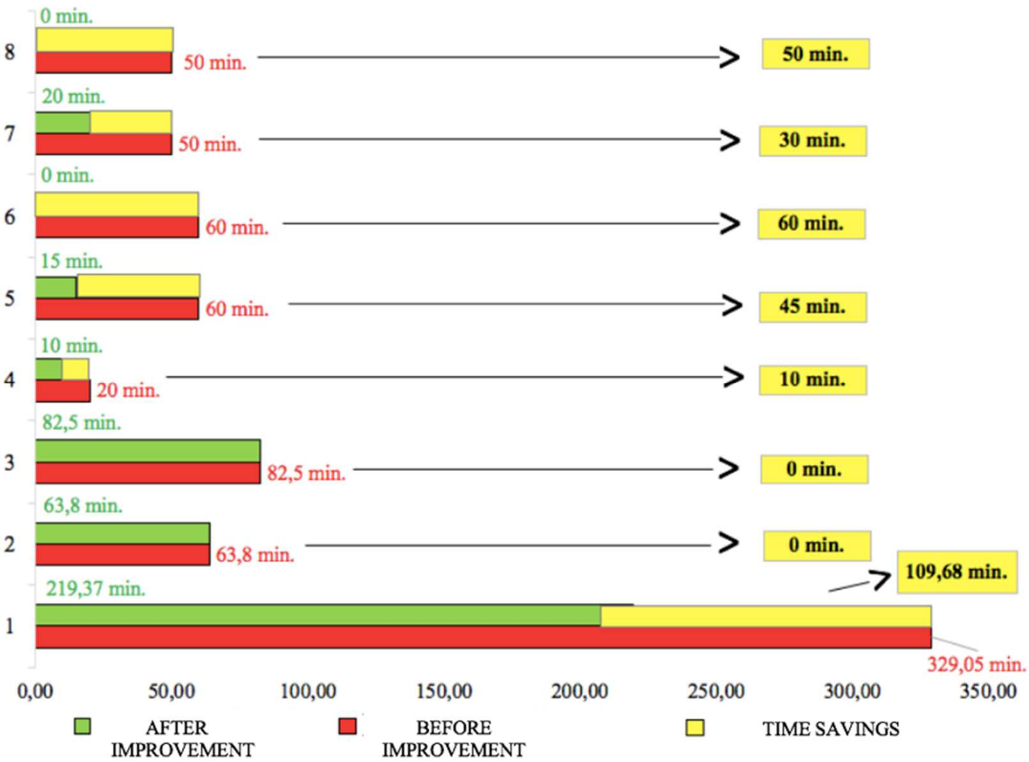

Figure 7 Time savings

From Figure 7, it is possible to read the individual time savings, which together after rounding represent a time of 305 minutes. This time saving ensured that all customer requirements were met while working on one work shift. Also, the new layout gave the workplace a more organized look that suits the 5S standards. The new arrangement must be look after by employees, especially for their safety at work. The layout also meets the necessary standards for material placement and flow (FIFO inventory management system).

After procuring a closed spray box, the problem of direct contact of employees with the chemical flux, which was dispersed in the form of fine particles into the working environment during manual spraying, was also effectively solved.

5 Conclusions

At present, it is a very common phenomenon in organizations to use new tendencies in production processes and their management. It is mainly about increasing customer requirements for quality, shortening delivery times, enforcing market conditions, and product variability. To meet all these aspects, organizations must reduce their downtime, apply new production technologies, and reduce inventory by shortening lead times [12].

Streamlining - lean production and its principles cannot be understood as an exactly defined and closed system. Lean production implementation is most often a reaction to a certain type of problem at a given company. Many lean production ideas originally came from the automotive industry. Lean production makes it possible to achieve the required level of the production system and increase production efficiency accordingly. In countries that have achieved an advanced level of development, the concept of lean manufacturing is recognized as an industrial development strategy that enables market leadership to be achieved. However, as these principles have been gradually developing and expanding to other industrial areas, other methods and instruments have been added and used for improving processes [13-17].

The need to improve the production process in the newly created working zone was based mainly on the need to meet specific customer requirements, and to process semi-finished products in the highest possible quality at reasonable costs. Due to the unreasonable and quick allocation of the workplace in the corner of the production hall, various negative facts came to light over time, which needed to be improved or eliminated.

The workplace modification fulfils the volume requirements of customers after all. After the implementation of all ideas and improvements, compliance with all internal requirements was achieved, including the principle of continuous improvements Kaizen, FIFO inventory management system, and requirements for individual standards such as IATF 16949, ISO 14001, ISO 18000, OHSAS.

References

[1] KOVÁČ, J., SZOMBATHYOVÁ, E.: *Ergonómia*, Technická univerzita, Košice, 2010. (Original in Slovak)

[2] BIELIK, P.: *Ekonomika podnikov*, SPU, Nitra, 2002. (Original in Slovak)

[3] KUPKOVIČ, M. a kol.: *Podnikové hospodárstvo*, Sprint vfra, Bratislava, 2003. (Original in Slovak)

[4] LEŠČIŠIN, M.: *Manažment výroby*, SPRINT, Bratislava, 2008. (Original in Slovak)

[5] PEKARČÍKOVÁ, M., TREBUŇA, P., KLIMENT, M.: Demand driven material requirements planning. some methodical and practical comments, *Management and production engineering review*, Vol. 10, No. 2, pp. 50-59, 2019. doi:10.24425/mper.2019.129568

[6] PEKARČÍKOVÁ, M., TREBUŇA, P., KLIMENT, M.: Digitalization effects on the usability of lean tools, *Acta logistika*, Vol. 6, No. 1, pp. 9-13, 2019. doi:10.22306/al.v6i1.112

[7] HIREGOUDAR, CH., REDDY, B.: *Facility Planning and Layout Design: An Industrial Perspective*, Technical Publications, Pune, 2007.

[8] ARVIND, R., GUNASEKARAN, N.: A literature review on cycle time reduction in material handling system by value stream mapping, *International Journal for Research in Applied Science & Engineering Technology*, Vol. 2, No. 12, pp. 70-72, 2014.

[9] PULKURTE, R., MASILAMANI, R., SONPATKI, S., DHAKE, R.: Cycle time reduction in assembly line through layout improvement, ergonomics analysis and lean principles, *International Journal of Applied Science and Engineering Research*, Vol. 3, No. 2, pp. 455-463, 2014. doi:10.6088/ijaser.030200016

[10] KRAJČOVIČ, M. a kol.: *Priemyselná logistika*, EDIS, Žilina, 2004. (Original in Slovak)

[11] GILBERTOVÁ, S., MATOUŠEK, O.: *Ergonomie*, Grada Publishing, a.s., Praha, 2002. (Original in Czech)

[12] ČAMBÁL, M., CIBULKA, V.: *Logistika výrobného podniku*, Vydavateľstvo STU, Bratislava, 2008. (Original in Slovak)

[13] BESTA, P., VILAMOVA, S., JANOVSKA, K., SVECOVA, E., KUTAC, T., BEZECNY, J.: Utilization of logistics tools in the control of metallurgical processes, 8th Carpathian Logistics Congress on Logistics, Distribution, Transport and Management, CLC 2019, 03-05 December, pp. 97-101, 2019, Prague, 2019.

[14] BURENINA, I.V., BATTALOVA, A.A., BATTALOV, A.M.: Lean production implementation mechanism, European Proceedings of Social and Behavioural Sciences, pp. 140-144, 2020. doi:10.15405/epsbs.2020.03.19

[15] SOUČKOVÁ, I.: *Manažment výroby*, SPEKTRUM STU, Bratislava, 2017. (Original in Slovak)

[16] JUROVÁ, M. a kol.: *Výrobní a logistické procesy v podnikání*, Grada Publishing, a.s., Praha, 2016. (Original in Czech)

[17] SABOLOVÁ, V., MAKYŠOVÁ, H.: *Návrh riešenia na zoštíhlenie procesov a zlepšenie pracovných podmienok Paintflux zóny*, Trnava: STU MTF, 2020. (Original in Slovak)

Review process
Single-blind peer review process.