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Optimising process flow in manufacturing: a study on standardisation and equipment capacity

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Abstract: The main goal of a manufacturing company is to make a profit, which requires efficient in-house processes and smooth process flow. The key tools for increasing productivity and optimizing production are process standardization, workflow efficiency, and the application of the theory of constraints (TOC). Process standardisation leads to the standardisation of workflows and the elimination of variability. TOC focuses on identifying bottlenecks in the process and optimizing them, resulting in cost reduction, increased productivity, and improved enterprise profitability by enhancing process flow. The presented paper describes a case study aimed at analysing selected processes at robotic welding workstations in a selected industrial enterprise. The aim of the paper is to identify opportunities to improve production efficiency at robotic welding workplaces, focusing on standardization of work procedures, more efficient use of production equipment capacity, and improvement of the remuneration system, which has a direct impact on workflow efficiency, process optimization, and the financial performance of the enterprise. The results of the research point to a lack of standardisation of working practices, low utilisation of the equipment capacity (30% below the planned value) and limitations in the remuneration system that hinder the achievement of the full productivity potential. The combination of inefficient use of equipment and working time increases financial costs and limits profitability. An effective bonus system can increase employee motivation, support productivity improvements and contribute to cost reduction. To address these issues, the implementation of standardised work practices, optimisation of equipment utilisation and effective workforce management are needed.

1 Introduction

The main goal of every enterprise is to make a profit. In order to achieve this, it is necessary to establish the right and efficient processes across various areas. All processes within a company are interconnected and essential, whether they relate to production, ergonomics, logistics, material flow, or even remuneration and flow of management of financial. Effective supply chain management also plays a crucial role in ensuring smooth operations and optimizing resource utilization. Continuous process improvement should lead to enhanced workflow efficiency, resulting in greater operational effectiveness in terms of productivity, cost reduction, increased competitiveness, and, most importantly, improved profitability. Without regular profit generation, an enterprise cannot sustain itself. Increasing the enterprise's profitability is possible through the implementation of various philosophies, theories, and tools, all of which are closely linked to optimizing internal company processes to reduce operating costs and maximize productivity and profits.

An enterprise, like any other system, is made up of interdependent activities and processes, forming a complex process flow. The analogy is a chain—to increase the strength of the chain, it is necessary to strengthen its weakest link. Strengthening any other link has no effect on the overall strength and represents a loss. The only way to improve the entire system is to identify and optimize the weakest link, which requires a focus on all flows within the enterprise. To effectively enhance flow management, it is first necessary to standardize processes, eliminating unnecessary variations and inconsistencies. Standardization does not aim to establish the ultimate best practice but rather to unify workflows, creating a solid foundation for continuous process flow improvement. These tools are also used to eliminate the process variations and possible wastage that occur, which are a very common cause of reduced profitability in companies. Unless a standard is in place, too much variation occurs in the

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process, and it is almost impossible to improve such a process [1-3]. One of the metrics to improve processes in an enterprise is the Theory of Constraints - TOC. Theory of Constraints is concerned with uncovering bottlenecks in a business and its profitability. In manufacturing, TOC focuses on identifying bottlenecks and by analysing of the material and information flow [3,4]. TOC can also help to identify and improve ergonomically challenging tasks within the manufacturing process, leading to higher efficiency and reduced absenteeism [5]. TOC also influences the reward system by motivating employees to achieve goals. A properly set reward system leads to increased productivity and employee engagement [6]. Lost EBITDA (Earnings Before Interest, Taxes, Depreciation and Amortization) and lost wages are related to a well-set reward system. EBITDA and lost wages are among the key indicators that need to be analysed in process improvement. Removing constraints in processes improves performance, which directly affects EBITDA. Lost wages, which result from inefficiencies, are also reduced when workforce and process utilization are improved [7].

2 Theoretical background

Modern manufacturing process management requires a systematic approach to optimising activities, identifying constraints and improving productivity. In this context, process standardisation and more efficient capacity utilisation of production facilities are key tools to improve production efficiency and resource management. The following section describes the basic concepts related to the presented paper. In addition to these concepts, the chapter also describes an analysis of the number of publications that focus on topics such as process standardization, process optimization, theory of constraints and more efficient use of the capacity of production facilities. The analysis of the number of publications is processed using the Web of Science - WOS citation database, in order to demonstrate the relevance and topicality of the given problem solution.

2.1 The process, its standardisation and the theory of constraints

The term process can be understood as the transformation of inputs into outputs, with a clearly defined beginning and end, according to defined regulators and using allocated resources, with a strong customer orientation. The individual activities within the process are important, but none of them as a stand-alone are meaningful to the customer if the whole process does not lead to the delivery of the desired output [8]. Process standardization creates processes that are consistent or permanent. The same operations or tasks are performed in the same manner and procedure [9]. Standardization helps in companies to create efficient processes and thus reduce costs. In its essence, standardization works as a guide that defines the procedures and flow that should be followed to achieve the desired results in a specified time [1,10]. Process standardization has many benefits, which mainly include eliminating work randomness and confusion, reducing operating costs, increasing productivity, and improving process automation [11]. Standardization is also important within the theory of constraints because it allows organizations to define best practices and performance standards. By implementing standardized workflows, organizations can reduce variability and optimize performance in bottleneck areas [12].

Theory of Constraints is a concept that is closely related to business process management and focuses on the identification and elimination of "constraints" or bottlenecks in a process [13]. Constraints are defined as any factors that limit the performance of the overall system and prevent the achievement of higher levels of efficiency or productivity [14]. If we have a work activity that has multiple steps, not every step can be performed equally efficiently. The lower performance of any step causes a bottleneck in which work accumulates waiting to be processed and moved to the next step. At the same time, if the next steps beyond the constraint are more efficient, they do not receive enough work and go partially idle, thus h optimising material flow and information flow aving unnecessary downtime. As a result, the productivity of the entire work chain suffers from the constraint in one step [3,15,16]. When we analyse the process, we are likely to find that there are several constraints in the process. The challenge is to find the constraint that limits the efficiency of the process the most and solving it will have the greatest positive impact on the productivity of the entire process. It is important to analyse the process and find out where the constraint arises, i.e., where the most work accumulates, and which part of the work process does not keep up with the rest [17]. In general, constraints can be found in several places: in production resources - insufficient machine capacity, inefficient use of equipment capacity, lack of staff, lack of finance, lack of materials/parts for production; in marketing - you can have a perfectly fine-tuned production process, but if there are just few orders, it does not help to the enterprise; in time; in people's attitudes; and in management, directives and organization [3,17].

In the next part of the paper, we will focus on TOC, which has been widely applied to manufacturing process improvement, standardization and rewarding, and is also closely linked to financial analysis. TOC focuses on identifying and removing bottlenecks in the production process. By analysing the material and information flow, organizations can increase equipment capacity and reduce costs and improve production efficiency [18]. In Lean manufacturing and Industry 4.0 [19], TOC is applied to improve overall productivity and efficiency. By improving and automating processes using Industry 4.0 technologies, it has been possible to increase productivity by 20-30% compared to traditional practices [4,20]. In the context of TOC, it is also important to analyse the normalization in manufacturing - the recalculation of the norm, which must

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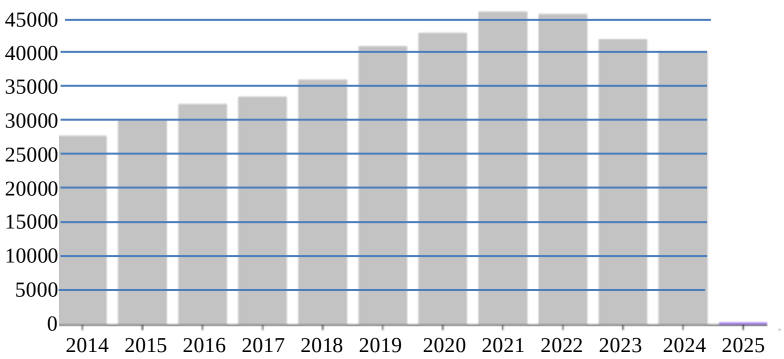
take into account the actual capacity constraints. TOC helps in defining realistic and achievable standards, leading to more efficient planning and optimization of processes [21]. Standard setting is crucial for measuring of efficiency and resource allocation in manufacturing. In the context of TOC, standards adapt to process improvements after bottlenecks are removed, resulting in higher accuracy and fairer evaluation of worker performance and reward systems [22,23]. TOC in the context of reward emphasizes the need to align employee goals with the goals of the organization. If a constraint that slows down production is removed, there will be an increase in efficiency, which can be linked to performance bonuses and improvements in the reward system [23]. The reward system should be set to motivate employees [24]. In assessing the financial impact of production constraints, the lost EBITDA and lost wages are also analysed. If the constraint causes lower output, this has a direct impact on reduced EBITDA, which means untapped potential profit. Once the constraints are removed and the production rate is increased, an EBITDA increase of more than 10-15% can be achieved [25]. Similarly, lost wages, which reflect inefficient use of working time, are reduced when restrictions are removed, leading to a fairer distribution of financial rewards. Constraint theory [26,27] provides a powerful framework for optimizing production processes and improving efficiency in different areas of the enterprise [28,29].

2.2 *Literature review*

As part of the theoretical background analysis, we also focused on examining the number of publications that focus on topics such as "process and optimization", "standardization", "theory of constraints" and "capacity utilization rate" in the WOS - Web of Science citation database from 2014 to 2025 (Figure 1).



Publication Years	Record Count	% of 416 276
2025	371	0.089
2024	39973	9.603
2023	41770	10.034
2022	45534	10.938
2021	45844	11.013
2020	42765	10.273
2019	40790	9.799
2018	35896	8.623
2017	33389	8.021
2016	32260	7.750
2015	30032	7.214
2014	27652	6.643

Figure 1 The topics: "processes, optimisation, theory of constraints, equipment capacity" in world database WOS in the years 2014 – 2025 (Own processing)

The aim of the analysis was to show the relevance of the areas. Figure 1 shows an increasing trend of articles in the different databases until 2023. The year 2024 is not yet complete, but we assume an increasing trend in that year as well.

The second point of the analysis of the theoretical background was the bibliometric analysis performed using VOSviewer software [30]. That database uses files also created in the WOS citation database. For this analysis a dataset was created from the database, focusing on the keyword "processes, optimisation, theory of constraints, equipment capacity. A total of 416 276 documents were found.

Documents were converted into an MS Excel file and processed in VOSviewer (Figure 2, Figure 3).

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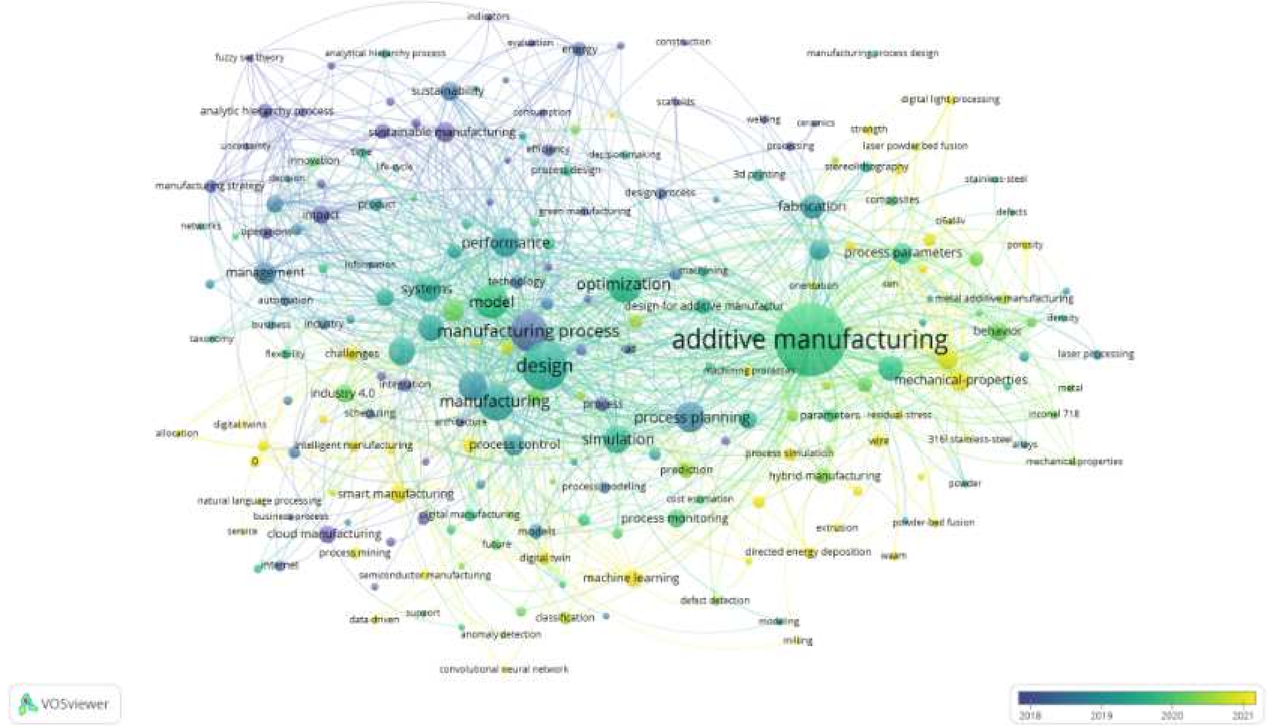

Figure 2 Bibliographic analysis – keywords: "processes, optimisation, theory of constraints, equipment capacity" in WOS in the years 2014 – 2025 (Own processing)

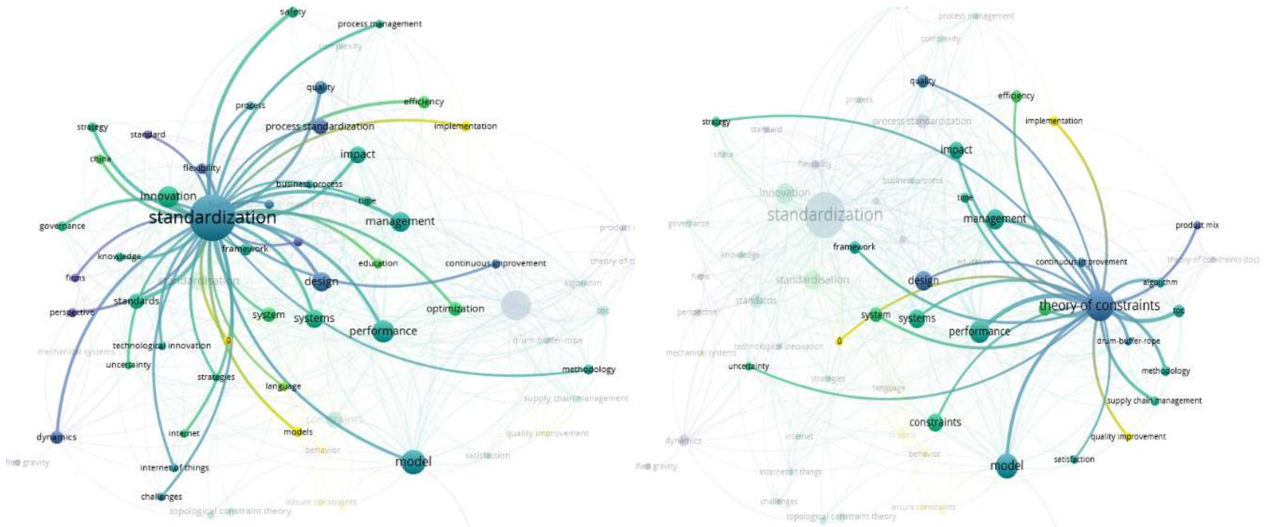

Figure 3 Bibliographic analysis – keyword: "standardization and theory of constraints (details)" in WOS in the years 2014 – 2025 (Own processing)

3 Methodology of research

The paper used a case study as one of the basic research methods of qualitative research. A case study is *"an idiographic investigation of a single individual, family, group, organization, community, or society and its main purpose is description; attempts at explanations are also acceptable"* [27]. The case study was chosen to examine selected enterprise processes in depth because it allows for detailed information to be obtained about specific practices in the enterprise under analysis. In the presented paper, a case study of an organization is described in which the robotic welding workplaces are analysed in detail.

3.1 *Qualitative research using a case study*

- **Research questions**: Three research questions have been identified in the presented paper:

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- **RQ1:** How does the low level of standardization affect the efficiency and quality of production in robotic welding workplaces?
- **RQ2:** What factors contribute to the underutilisation of production equipment capacity and what are their implications for production flexibility and product delivery times?
- **RQ3:** What are the main causes of financial losses in robotic welding workplaces?

- **Aim of the case study**: The aim of the present case study is to identify opportunities to improve the efficiency of the production process, with a focus on standardisation of working procedures, more efficient use of the capacity of production facilities and improvement of the remuneration system, which will have a direct impact on the optimisation of the processes and financial management of the company.
- **Characteristics of robotic welding workplaces**: As part of the research, 7 robotic welding workstations were analysed to produce column footing products. Two of the seven workplaces are dedicated only to the production of semi-finished products and the remaining five workplaces are also dedicated to the production of finished products. Each of these five workstations is staffed by one operator for the production of the semi-finished product and one operator for the production of the finished product.
- **Selection criteria:** The process selected for the research was the production of a product of the column footing group, which is produced in two steps, that is, the production of the semi-finished product and the production of the finished product. In this production process, the analysis of work instructions at the robotic welding workstations, standard calculation, equipment utilization and productivity analysis, remuneration system and basic financial analysis of the enterprise were carried out. These listed areas represent key processes for robotic welding workplaces and provide the necessary data for a thorough efficiency analysis.
- **Data collection methods, instruments and timeframe**: Multiple data collection methods were used in the research, which lasted 11 months:
  - Observation of operators in the workplace, which gives insight into the work habits of employees and work efficiency;
  - Interviews with operators at robotic welding workplaces;
  - Document analysis: production documentation, financial statements, shift foreman reports;
  - PDCA cycle tool, which we have chosen as an effective tool for incremental improvement, through which we can measure bottlenecks and improve them incrementally;
  - KAIZEN philosophy to identify and implement improvements.
- **Data analysis**: The research used the MachineTrack software solution, which is able to track and record the real equipment usage in robotic welding workplaces.

3.2 Description of the company and the robotic welding workplace (RW)

The analysed company supplies a wide range of products such as precast concrete bolted joints, reinforcing elements and interlocking steel beams for thin ceilings. Currently, the analyzed robotic welding workplaces produce the products of the column footing group (for the purpose of this article they are referred to as: product X and product Y). These are used in the manufacture of precast reinforced concrete columns which, together with anchor bolts, form the basis for bolted connection solutions. With this solution, it is possible to replace the conventional cup solution, which in many cases can bring considerable savings and there is also the possibility of reusing the columns. Another key advantage of such columns is the smaller footprint while handling the same load. Both products (X and Y) are manufactured in two steps, namely the production of a semi-finished product called "SFP" and the production of the finished product.

4 Results and discussion

The following chapter analyses selected processes in manufacturing, focusing on standardisation, standard calculation and equipment availability determination, remuneration and financial analysis.

4.1 Analysis of the production processes for the representative product "X"

Within the analysis of the production processes, the most sold and therefore also produced product "X" from the group of column footings will be analysed and described. The production consists of two steps, first the semi-finished product and then the finished product. Due to the need for the welded plate to cool naturally before bending, these two steps are not coordinated in any way and there is usually a large quantity of already welded semi-finished products in stock, as the production of the semi-finished products proceeds faster than the production of the finished product. The volume of orders is therefore greater than the capacity of the RW facilities. However, during the analysis it was not possible to determine by how many percent the orders exceeded this capacity during the period in question. It is for this reason that one workplace was allocated on a 24-hour basis only to the production of product "X" and, where possible, if an additional workplace became available, this product was also produced on two workplaces simultaneously. This was also possible because two sets of fixtures were available on the workplaces. However, the production process itself was not unified in any way and it could be said that each of the operators had his own way of preparing and producing the

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products. The stacking of the fixture products was admittedly dictated by the fixture itself, and thus the manufactured pieces were stacked correctly. However, the way in which the operators transferred the pieces to the place varied. The same was true in the process of making the semi-finished product "SFP" as well as in the process of making the finished product or the bending part of the product. At the time of the analysis, the company's internal rule was that only 1 operator was dedicated to the production of the semi-finished product and only 1 operator was dedicated to the production of the finished product. Probably the most common production method was one in which the worker tried to unload and reload the product in the shortest possible time. In doing so, however, he often made unnecessary movements and performed unnecessary handling of the load. For example, in the production of the "SFP", instead of removing and directly placing the weldment on the pallet of finished products, the worker first placed the piece on the ground in order to release the fixture as soon as possible. In this way, he removed all the welded "SFP" from the fixture and proceeded to load the parts destined for the welding of the new "SFP". Only after they had been placed and secured in the fixtures did he put the already welded pieces on the pallet with the finished "SFP". However, this was wasteful in terms of handling the load. Similar wastage was also visible during the observation in the production of the finished products. Workers were mostly preparing the material ahead of time or putting it aside for a period of time when it was not necessary. Thus, it was necessary to check whether the procedures and rules for production were clearly built. Significant differences then also occurred in the output, i.e. the number of pieces produced per shift. The more skilled operators were able to produce more pieces of product per shift, the less skilled less so. Standards were set before the analysis period, but their achievement was not regular. It could be said that a smaller group of workers were able to achieve them, but not all. It was therefore clear that they were achievable, it was just that the method of production was probably not sufficiently and correctly standardised.

4.2 Analysis of work instructions at RW workplaces - standardisation

At the time of the research, one workflow was in place for all RW workplaces and for all products that were produced at the workplaces, regardless of whether it was for the production of a semi-finished product or for the production of a finished product. It was available as an internal document in the quality section of the ERP system used by the company and also at the RW workplaces. The last update of the document part that specified the production process was made in 2012. Having analysed the entire workflow, we can assess that each of the employees working at the RWworkplaces followed this workflow, although each of them has their own way and sequence of actions they follow. The procedure did not specify the individual tasks separately, nor was their sequence developed in detail. The part of the workflow focusing on the actions to be performed for the production of the products consisted of only three simple steps: fit the fixtures, unload the fixtures and place the pieces on the workbench, check the pieces, repair if necessary, place on the pallet and return to step one. The developed workflow did not provide a single standard of product manufacture from a process point of view that could be worked with in the future and could be improved over time. In the absence of a single standard for the workers to follow and adhere to, there were too many variations and unforeseen problems or constraints that were difficult to predict and influence. Another shortcoming of the workflow is that it was applicable to all types and sizes of products, whether finished or semi-finished. At the time of the analysis, it was a rule that for certain types of products two workers were assigned to production and for others only one.

4.3 Calculation of the standard and usability of the equipment

In order to analyse the individual processes in the following parts of the paper, it is first necessary to analyse the calculation of the standards that determine the quantity of products that need to be and are planned to be produced in one working shift.The times involved in the calculation of the standards may vary slightly depending on the workplace for which the standard is calculated. Therefore, we will set a recent robotic welding workplace as a representative example. For this workplace, the times given below are valid. The individual times have been accurately measured and recalculated and have been found to be correct on analysis.

1. **Shift length -** total duration of one shift - 8 hours.
2. **Break time -** total duration of breaks - 50 minutes.
3. **Time required for consumables change -** total time required for welding spike change during one work shift - 5 minutes.
4. **Cleaning time and TPM (Total Productive Maintenance) -** time to clean the work area at the end of the shift and activities associated with TPM - 15 minutes.
5. **Welding nozzle cleaning time per shift -** total time required for continuous manual cleaning of the welding nozzle on welding robots per work shift - 16 minutes.
6. **Failure rate -** one of the KPIs is 95% availability of robotic welding equipment. This KPI has been met for a long time and thus a failure rate of 5% is assumed.
7. **Tact in minutes -** the production tact of one cycle of the RW equipment. If the machine cycle tact is shorter than the operator cycle tact, i.e. the time required to load and unload the machine, the operator cycle tact is given as the tact, and 1 min. is added as the time required for resting.
8. **Number of pieces per tact -** the number of pieces of products in one welding cycle.

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For the calculation of the norm, we have all the input data except the tact and the number of pieces in the tact. These had already had their values determined and when re-measured, the tact and pieces were found to be correct, with the tact measured at 9.25 minutes and 6 pieces being welded in one cycle. The actual calculation then begins by recalculating the time required to produce one piece of product (as expressed in equation (1)).

$$Production\ time\ 1\ pc = \frac{Takt\ time}{Number\ of\ pieces\ in\ a\ measure} = \frac{9.25}{6} = 1.54\ min/pc \quad (1)$$

The quantity of pieces (equation (2)) produced in 1 hour is calculated:

$$Number\ of\ pieces\ per\ 1\ hour = \frac{1\ hour}{Production\ time\ 1\ piece} = \frac{60}{1.54} \cong 39\ pcs/h \quad (2)$$

The net working time in hours (equation (3)) is then calculated, taking into account the failure rate:

$$Net\ working\ time = \left(8 - \left(\frac{50}{60}\right) - \left(\frac{5}{60}\right) - \left(\frac{15}{60}\right) - \left(\frac{16}{60}\right)\right) \times 0.95 = 6.24\ h \quad (3)$$

Calculate the quantity of pieces for 1 shift, expressed equation (4):

$$Number\ of\ pieces\ per\ shift = 39 \times 6.24 = 243\ pcs/shift \quad (4)$$

The resulting standard is therefore equal to the number of pieces per shift and in the case of product "X" this is 243 pieces per shift.

The planned availability on the RW workplaces is calculated as the ratio of net working time to the duration of the working shift and is given in% (equation (5)):

$$Planned\ utilization = \left(\frac{Net\ wrking\ time}{8{-}hour\ shift}\right) \times 100 = \left(\frac{6.24}{8}\right) \times 100 = 78\% \quad (5)$$

The analysed company has been using a software solution for a long time, which is able to monitor and record the real usage of the equipment at the RW workplaces. The system was called MachineTrack. The period monitored was 11 months (6 milestones), i.e. eleven months of data on how much time the equipment produced, how much downtime it had and how many breakdowns there were. The analysis showed (Figure 4) that the equipment was used at 48,92%, which corresponds to a time of 3,91 hours per 8-hour shift. The real utilisation is therefore 30% lower than it should be when achieving 100% of the standard on the equipment. Only the shifts on which production was planned were monitored. Thus, weekend shifts and shifts that were not scheduled are not counted in Figure 4.

Milestones	Availability	Technical Availability
M1	53,7	95,16
M2	54,13	95,08
M3	53,32	97,56
M4	54,54	96,55
M5	46,18	97,89
M6	46,04	96,77
Average of the observed period	48,92	97,07

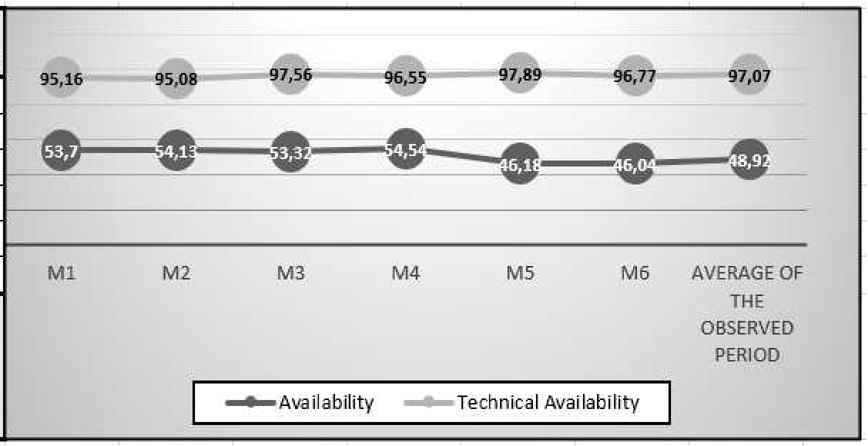

Figure 4 Utilisation and failure rate of RW equipment (Own processing)

4.4 Analysis of the remuneration processes

In addition to the hourly rate, workers employed at robotic welding workstations had the opportunity for increased earnings if they achieved sufficient performance on the job. This performance was measured in terms of the number of pieces produced per shift, as a percentage of planned pieces/produced pieces (equation (6)). The formula for calculating the productivity was as follows:

$$Productivity = \frac{Planned\ production}{Actual\ production} \times 100 \quad (6)$$

The bonus system had different levels set, with productivity thresholds being graduated and when a certain level of productivity was reached, the worker was rewarded with the appropriate amount of financial resources when the salary was paid. The different levels along with the values a worker could earn are shown in Table 1 - Part A.

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Table 1 Productivity and bonus system (Own processing)

A – Bonus system		B – Conversion of productivity to equipment availability		C – Proposal for a change to the reward system	
Productivity	Bonus	Productivity	Equipment Utilization	Productivity	Bonus
< 50%	20 EUR	50%	39.0%	< 70%	0 EUR
50% - 55%	40 EUR	55%	42.9%	70% - 75%	80 EUR
55% - 60%	60 EUR	60%	46.8%	75% - 80%	160 EUR
60% - 65%	80 EUR	65%	50.7%	80% - 85%	240 EUR
65% - 70%	120 EUR	70%	54.6%	85% - 90%	300 EUR
70% - 75%	160 EUR	75%	58.5%	90% - 95%	360 EUR
75% - 80%	200 EUR	80%	62.4%	> 100%	440 EUR
80% - 85%	240 EUR	85%	66.3%		
> 85%	280 EUR	90%	70.2%		
		95%	74.1%		
		100%	78.0%		

As shown in Table 1-A, remuneration started as early as the 50% of the norm threshold. If we analyse the norm for product "X", which is 243 units per shift, then if a worker produced 122 pieces per shift, he was credited with a productivity value of 50% for that shift in addition to his hourly wage. The monthly remuneration is calculated as an average of the whole month and an aliquot amount is paid based on the actual number of days worked on the job. Thus, if a worker achieved 50% productivity every day, he would receive a reward of 20 EUR at the end of the month. If his average was 66%, which is 160 pieces "X", he would receive a remuneration of 120 EUR per month. In contrast, the upper limit of the bonus system is set at 85% and above. Here, the worker has the possibility to receive a 280 EUR bonus per month if he exceeds this threshold. However, at this threshold, workers have no incentive to reach 100% productivity and thus achieve the planned quantity of units produced, as they only need to stay at the 90% threshold. The workers were able to keep track of the productivity themselves on a screen in the production area, where this information was also continuously updated during the month.

In the analysis of the remuneration processes, the data from the equipment availability and the data from the reports of the shift masters, who recorded the productivity achieved for each worker, were compared, while the observation period remains the same as in the equipment availability section. The average productivity value, when converted to equipment availability, should be approximately equal to the actual availability for the period under review. The formula for converting productivity into equipment availability is as follows (equation (7)):

$$Converting\ productivity\ to\ equipment\ availability = \frac{\left(\frac{Net\ working\ time}{Productivity\ achieved}\right)}{\left(\frac{8}{100}\right)}\ [\![\%]\!] \qquad (7)$$

Table 1 - Part B shows the conversion of the productivity achieved from 50% and above into plant availability. The average productivity obtained from the shift foremen's reports was 86,71% for the period under review. This means that after the formula conversion, the equipment availability should be 67,63% (as expressed in equation (8)). However, in the previous analysis, it was found that the equipment utilization was 48,92% during the period under review (Figure 4). Again, we can back-calculate this figure to the actual productivity achieved using the formula:

$$Converting\ equipment\ availability\ to\ productivity = (Converting\ equipment\ availability\ to\ productivity) \times \left(\frac{8}{100}\right) = \left(\frac{48.92}{6.24}\right) \times \left(\frac{8}{100}\right) = 62.71\ [\![\%]\!] \qquad (8)$$

After converting the equipment availability into real productivity, we get a value of 62.71%. The difference between the reported productivity and the real productivity was 24%. A summary of this data is given in Table 2.

Table 2 Conversion of productivity to plant availability and back conversion to productivity (Own processing)

Productivity	Equipment Utilisation
62.71%	48.92%
86.71%	67.63%

As the analysis revealed, one important aspect of performance is the company's remuneration system, which at the time of the analysis did not sufficiently motivate workers to achieve full productivity in the workplace. For this reason, the company proposes to change both the boundaries of each level of remuneration and the amount at each level. The proposed change is shown in Table 1 - Part C.

4.5 Financial analysis

One of the most important analyses during process improvement is financial analysis, because the goal of every enterprise is to make a profit. In this analysis we will discuss the lost EBIDTA, lost wages, but also the overall loss due to inefficient processes.

Lost EBITDA: The above analysis can also be used for financial analysis of the process at RW workplaces. As already defined, the real availability was 30% lower than it would have been in achieving 100% of standards. We have financial data from the company's finance department on the products sold that are produced at the RW workplaces. The data are for a period when sales were high and production was directly to order, not to stock. It is clear from the results that the main reason for this was the under-utilisation of the facilities and if they were used more it

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would also be possible to produce and sell more products. It is therefore possible to calculate EBITDA as one of the fairly accurate indicators of financial performance. The total EBITDA for the period under review for the products manufactured at the RW workplaces and sold was 2 972 206 EUR. Furthermore, the data necessary to calculate the EBIDTA, such as invoiced amounts, direct, indirect, fixed and variable costs, sales margin, etc., were also available. On the basis of these data, it was possible to calculate what EBITDA would have been achieved in the event of higher equipment utilisation and thus higher staff productivity. The calculations have been made starting from an increase of 15% and are summarised in Table 3.

Table 3 EBITDA conversion table for productivity increase (Own Processing)

Increase	Number of units	EBITDA (EUR)	Difference (EUR)
TOTAL	402 055	2 972 206	
15% increase	462 363	3 535 337	563 131
20% increase	482 466	3 723 047	750 841
25% increase	502 569	3 910 757	938 551
30% increase	522 672	4 098 467	1 126 262

The difference between the EBITDA achieved and the EBITDA with the increase in utilisation can be considered as the EBITDA foregone that would have been achieved if productivity had been increased.

Lost wages - In addition to the lost EBITDA, the lost wages paid to workers for time they did not actually work should also be treated in the financial analysis. In the section where equipment utilization was analyzed, it was found that the average time worked per 8-hour shift was 3,91 hours. In order to achieve the required productivity, 6,24 hours were required. The difference in this case is 2,33 hours. This means that 2,33 hours of the 8-hour shift were unworked and unused wages were paid for this time. For privacy reasons, this part of the analysis has been carried out on the basis of information from the Human Resources Department. The average cost per employee was 25 000 EUR/year. During the year, an average of 34 employees worked at the RW workplaces. The resulting amount of wages paid is therefore 850 000 EUR /year.
Table 4 shows the individual figures for the different degrees of productivity loss and also the difference in wages paid, which can be considered as an indication of the foregone staff costs.

Table 4 Foregone personnel costs (Own processing)

Decrease in productivity	Wages paid (EUR)	Difference (EUR)
TOTAL	850 000	
15% decrease	722 500	127 500
20% decrease	680 000	170 000
25% decrease	637 500	212 500
30% decrease	595 000	255 000

Total loss - The total loss for each level of decline can be quantified as the sum of lost EBITDA and lost wages per employee. The individual amounts are summarized in Table 5. These losses include the cost of weekend labor. The latter was mainly due to the fact that it was not possible to produce sufficient quantities during the working week. In doing so, however, additional costs are incurred, which arise from the law and which are paid by the company under analysis even in excess of the law at a higher percentage than is necessary.

Table 5 Total loss at different levels of productivity loss (Own processing)

Decrease in productivity	Difference (EUR)	Difference (EUR)	TOTAL
15% increase	563 131	127 500	-690 631
20% increase	750 841	170 000	-920 841
25% increase	938 551	212 500	-1 151 051
30% increase	1 126 262	255 000	-1 381 262

5 Conclusions

There is a lot of waste that is overlooked on robotic welding workplaces. Overlooking is also aided by increased inventories of input material and semi-finished products, which can disrupt logistics and obscure real problems. In the event of an issue, these excess materials can replace rejects, allowing production to continue without addressing the root cause. A positive finding is the system for calculating standards, where all planned and necessary downtime during production is taken into account, ensuring a balanced process flow. The set standards are achievable and also consider possible minor equipment failures. If the equipment is tacted too fast, the norm is adjusted based on the operator's clock, allowing for sufficient rest between cycles, contributing to more sustainable human flows in the workplace. As a positive assessment for the company, there is sufficient room for future process improvements, as well as increased capacity and profit, even without the additional cost of purchasing new equipment or making other costly investments. The main shortcomings can be considered as:

- Low level of standardisation in the workplaces, especially in the area of work instructions. Workers carry out different tasks in different ways. This way of production makes it significantly more difficult to identify and correct process deficiencies.
- Under-utilisation of equipment capacity. Utilisation was found to be 30% below planned capacity. This has a negative impact on both production flexibility and delivery times for finished products.
- A pay system based on stepped productivity provides clear incentives for employees to improve performance, but does not sufficiently support the achievement of maximum productivity potential. Setting an upper limit on rewards at 85% of productivity creates a barrier to motivating

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employees to go beyond this and achieve the planned production of 100%.
- Financial losses due to under-utilisation of equipment capacity and incorrect use of staff time.

The above findings can be generalised as they have major negative consequences for production, which can be summarised as follows:

- The lack of standardisation of workplace procedures, particularly in the area of work instructions, causes a high degree of variability in the performance of individual tasks. This significantly complicates the systematic analysis of processes, the identification of the root causes of deficiencies and their subsequent elimination. In addition, the lack of a uniform standard weakens the implementation of improvement measures and makes it impossible to ensure consistent production quality.
- Inefficient capacity utilisation of production facilities compared to their planned output results in a significant reduction in overall production productivity. This inefficiency leads to limitations in the flexibility of the production process, which means that the company is unable to respond adequately to changes in demand, unexpected variations in production or the need to shorten delivery times. Such a situation weakens the ability to compete in the market.
- The combination of inefficient capacity utilisation of production facilities and misallocation of employee time generates significant financial losses. These losses result from increased fixed costs per unit of production, unproductive staff time and unused potential of production facilities. These inefficiencies not only reduce the overall profitability of production but also limit the ability of the enterprise to allocate resources to innovative and strategic projects.
- Optimal remuneration not only increases employee motivation, but also directly contributes to the achievement of production plans, cost reduction and the long-term competitiveness of the enterprise. When designing bonus systems, it is necessary to create reward structures that promote continuous productivity improvement without introducing disincentive ceilings. The bonus system should be set up in such a way that employees have a clear incentive to achieve and exceed targets, while ensuring that targets are realistic and fair. The transparency of performance information provided by the production system should be supported by feedback and opportunities for further productivity improvements.

To address these shortcomings, it is necessary to implement standardised working practices, optimise the use of equipment and manage the workforce effectively and use effective remuneration.

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