# Balancing of assembly operations and detailed design of workplace in software environment.

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**Abstract**: The plants are primarily focused on increasing the efficiency of internal processes. The management of production plants therefore needs to know a realistic picture of their current state, risks and opportunities, so that the plant's presence on the market is not jeopardized and they are able to effectively manage internal and external processes. All this will be possible only through the implementation of new technologies and the transformation of existing factories through digitization. This combination must be based on the scheduling currently provided by interactive software scheduling systems. The article deals with the area of using a software solution for interactive evaluation and capacity sizing of production workers.

## 1 Introduction

In current industrial practice, innovative solutions are proposed to improve production and assembly processes or entire production or logistics systems [1]. In order to implement new technologies, companies must be able to combine the use of the latest and most available technologies. The smart solution in the field of production design and evaluation, which corresponds to current industry trends and the Industry 4.0 concept, is the software known as Ceit Table.

Recently, great emphasis has been placed on the development of functions in the field of capacity planning of production workers. Based on these functions, the user is allowed to create a parametric model of production with a link to individual work tasks. When changing the production volume, production technology, measuring or setting procedures, the workloads of individual work positions are recalculated.

## 2 Defining current problems of production manufactory

Management in the capacity sizing of production workers lacks data, information, methods and tools for clear evaluation. The problem is that planning is based on principles that have been in use for more than a hundred

years. In companies, the vast majority of data in electronic form (about 60%) is a problem, however, that the data do not form structural units that could be used for capacity dimensioning and evaluation of production workload.

Some data (approximately 40%) are collected and evaluated at one-day intervals and stored in paper form, operatively used to identify production problems stored in company archives. Their use is very laborious and time consuming.

At present, companies also lack a unified software solution for detailed capacity sizing of employees, which would be based on data from production processes, linked to specific activities of the production process (absence of digital data model of production). The combination of long-defined principles of capacity planning with digitization brings a completely new quality of data necessary for decision-making [2].

The paper deals with own research in the field of using a software tool for capacity sizing of production workers (creation of a parametric data model of production) and evaluation of production disposition. The research is carried out in a company engaged in the production of automotive components. Among the current problems related to the capacity dimensioning of production workers after the analysis of the current state in the company, we include:

- Inaccurate planning due to inaccurate or incomplete data.
- Missing or inconsistent software and evaluation rules, shortcomings in the information flow.
- Human mistakes resulting from an insufficient system of work, missing rules, motivation.
- Oversized, undersized capacities (workers, handling equipment, areas).
- Problematic data acquisition, insufficient validity and outdated data.
- Undefined valid regulations or only partially, missing regulations, insufficient overview of the flow of information.

## 3 How to solve the problem

Best methodological procedures, which were at a high level, were supplemented by new technologies (algorithms) for processing data structures for the needs of capacitive dimensioning. Evaluation and planning of production capacities actually consists in collecting information, processing them, creating analyzes, finding the best design and its verification. It is a classic methodological procedure, but new technological possibilities give it a completely different dimension and added value [3, 4]. A digital data copy of a real system is analyzed with the help of a software tool easier (from the point

of view of labor, the possibility to make a change, etc.) than this analysis would have been done in the past.

Ceit Table software was used for the solution, which was the subject of research in the previous activity. Capacitive dimensioning in the software consists at the very beginning in the processing of input data. The basic input data needed for the analysis of the capacity utilization of workers can be divided into the following categories, data directly related to the machinery:

- Regular activities (activities related to the volume of production).
  - Loading / unloading on a belt, directly into the machine with workpiece clamping, on a pallet.
  - Visual inspection of part machining.
- Semi regular activities (semi - regular activities).
  - After a certain number of pieces, check the sample (hardening process, etc.).
- Irregular activities (activities that do not change with the volume of production).
  - Service activities at the workplace, cleaning, morning consultation with the manager.
- SMED activity (proportion of sorting time per change).
- Autonomous maintenance activities (share of maintenance time per change).

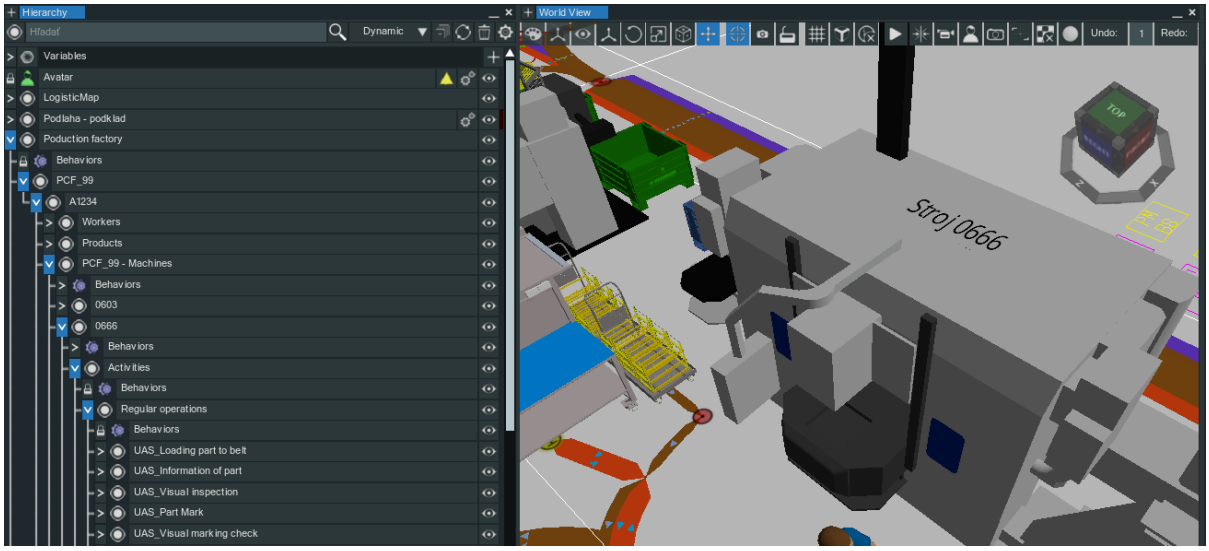


*Figure 1 - Hierarchy of assembled digital model of production disposition*

The creation of a data model of the production system takes place on the basis of the current state, automatic import of data or their manual insertion. After entering and hierarchical assignment of all data (Figure 1), the calculation takes place in the background and its constant updating. Mathematical algorithms connect the structures of individual input data and

generate output data using established rules, from which output analyzes of capacity utilization of production workers are created.

From the collected data, a digital data model is created in the software environment, which is supplemented by a 3D (Figure 2) representation of the production space for a better perception of the interconnections of some data and data structures.

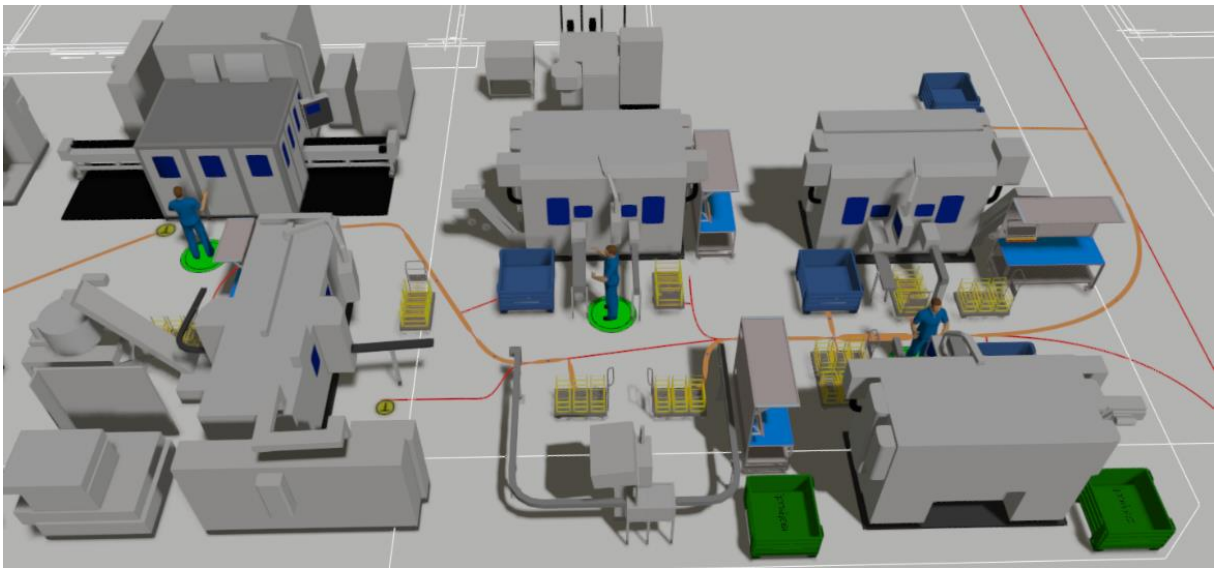

*Figure 2 - Virtual representation of production space in a software environment*

Based on the creation of a digital representation of individual work tasks (with a defined time intensity), it is possible to assign them in the software to job positions on the basis of a technological process, or the knowledge of production managers. It is then possible to quantify the amount of capacity required for multi-machine operation or to evaluate the uneven capacity utilization of production personnel.

After changing any input parameter of the digital data model of production, the created links are recalculated in the software and the user has an up-to-date overview of the impact of the entered changes. The basic parameter that influences the change in the workload of production workers is the production quantity of individual products just determined (Figure 3).

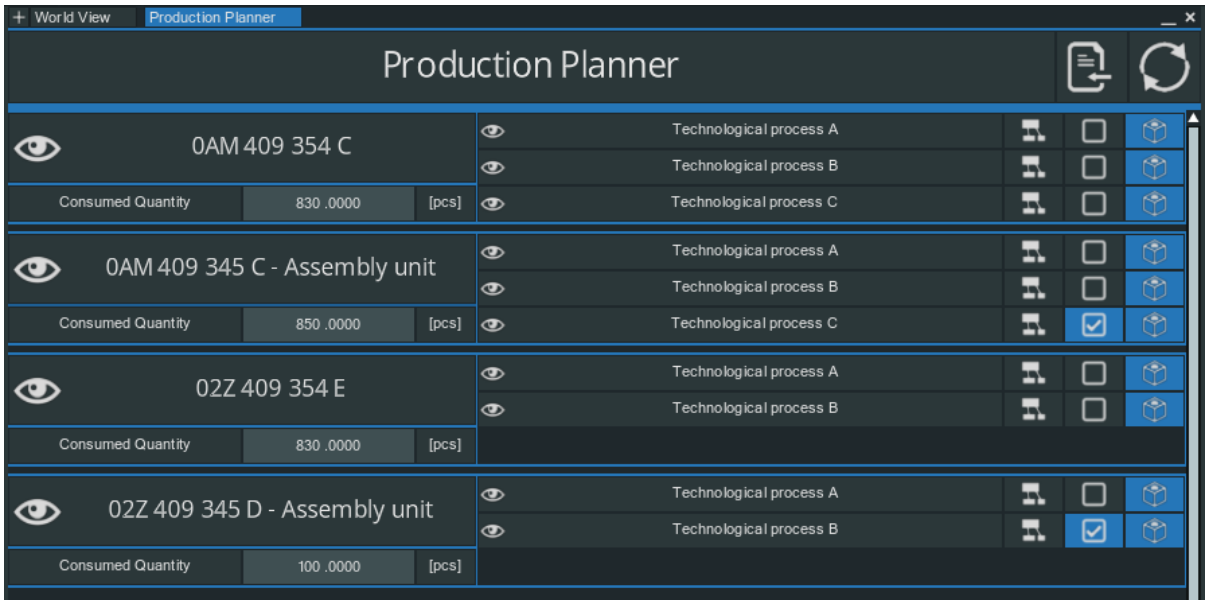


*Figure 3 - Overview of produced quantities of individual product groups*

# 4 Evaluation of the results of practical application

At the production stage, the production workers have the task of machining the supplied raw material in the form of a forging into the form of a finished customer component, which will serve as an input to the assembly of the engine or gearbox.

Manufacturing operations are divided into individual points according to the nature of machining, starting with hard turning and ending with thermo-chemical surface treatment of the machined component.

Workers have prescribed tasks that ensure the smooth running of production. These are measuring operations according to established test procedures. Tool change, subject to adjustment, based on a delta of machining tools. Operations related to the regular inspection of machine parts or operating fluids in the form of prescribed work procedures.

With the help of the tool, we created several variants of the layout of prescribed production operations for individual job positions / workers.

After making any change, the system interactively evaluated the impact and recalculated the resulting parameters of the required capacity of the personnel of the proposed production system. The production system has changed:

- Distribution of operations evenly on individual employees according to the analyzed time consumption of the given operations using the MTM UAS methodology.
- Number of individual workers at individual production workplaces.
- Installation of workplaces (figure 2), placement of material entering the assembly in range zones up to 3 [m] (prevention of losses caused by walking).

- Replacement of machinery, more modern design, automated some operations, automatic detection of material defects after processing.
- Inter-operational manipulation at individual workplaces, use of drop conveyors, storage conveyors, etc.

The results of the analyses confirmed the above-mentioned problems with the capacity dimensioning of production workers (by creating a parametric data model of production) and the evaluation of production disposition.

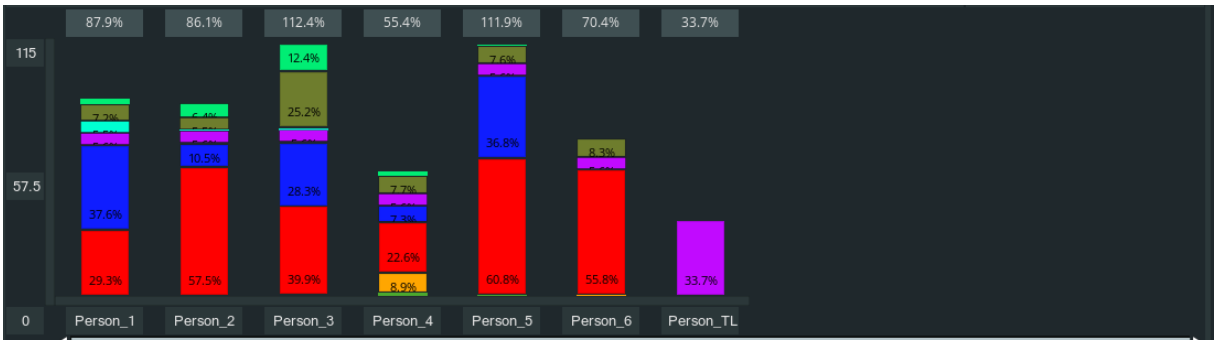


*Figure 4 - Capacity utilization of employees by prescribed activities in valid documentation*

There is a discrepancy between the software evaluation (Figure 4) and the opinion (expert judgment based on experience) of the production capacity planning officer. After the presentation of all input data, the opinion is concluded that there are still activities that are not prescribed by the valid documentation, or are not clearly quantified in terms of frequency / duration.

Table 1 shows an example, the analysis of the capacity utilization of the workers of the production stage by the activities defined by the valid documentation. Subsequently, an increase in capacity utilization by activities that do not have a valid agreed regulation (valid documentation), but from the point of view of the process are necessary to maintain the quality set by the customer (absent in the calculation, it is generating a loss of 28.9% of production staff capacity).

*Table 1 Analysis of capacity utilization of production workers according to valid documentation*

| Rankings: | According to the documentation [%]: | At the discretion of TL [%]: | Difference [%]: |
|---|---|---|---|
| Person 1 | 87,9 | 90,0 | 2,1 |
| Person 2 | 86,1 | 86,1 | 0 |
| Person 3 | 112,4 | 112,4 | 0 |
| Person 4 | 55,4 | 82,2 | 26,8 |
| Person 5 | 111,9 | 111,9 | 0 |
| Person 6 | 70,4 | 70,4 | 0 |

| | | | |
|---|---|---|---|
| Person TL | 33,7 | 33,7 | 0 |
| | | Sum: | 28,9 |

Distribution of individual production operations based on the analysis of them time consumption allowed us to more optimally distribute the tasks of job positions (Figure 5) and thus more evenly utilize individual production workers.

Together with the elimination of waste in the form of: walking between machines, unstable machinery, or incorrect redistribution of mandatory tasks, the proposed changes found that the need for production workers at a particular stage is two less than the number actually allocated for production (personnel records). This represents a significant saving (22% reduction) in terms of staffing needs.

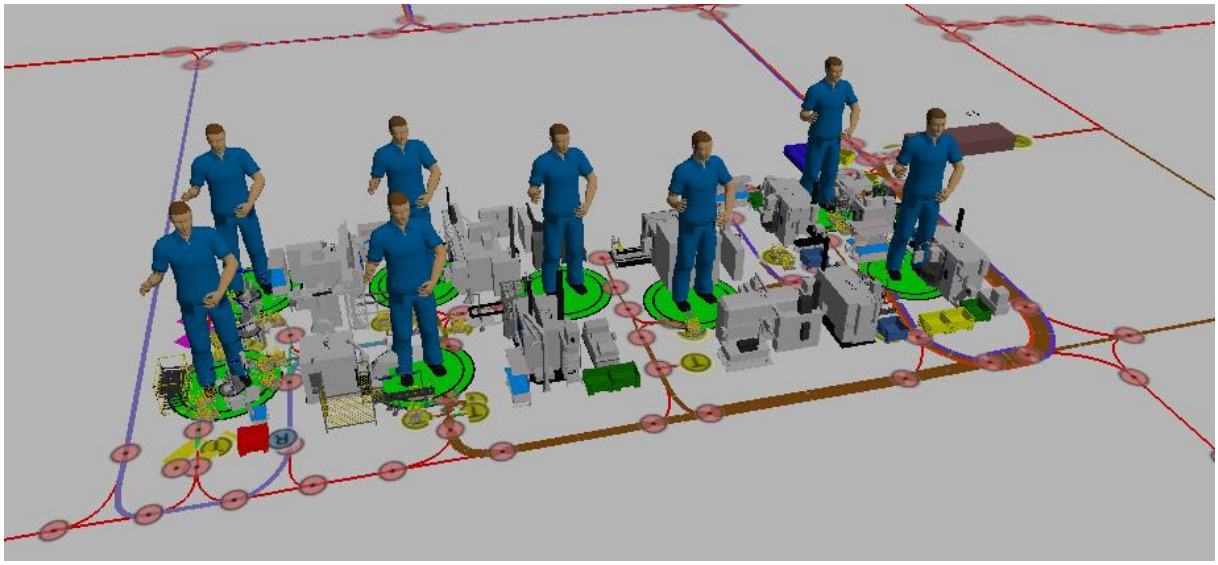

*Figure 5 - Illustrative filling of individual job positions in production*

Based on the mentioned changes and research in this area, it is possible to design production workplaces and capacity utilization of workers more optimally. With the help of a software solution, it is possible to reveal a significant potential for the redesign of existing production systems.

# 5 Conclusion

New functionalities of software solutions are now necessary in creating and evaluating the design of complex production structures. Software solutions that encourage mutual communication and interaction of individual system objects offer an effective tool for creating a design, which can then be changed without demanding changes to each element of the system. Thus, a supportive design tool with interconnected and communicating elements can provide information and feedback in the process of creating change for further decision-making of industry organizations. It helps to reveal a discrepancy

between the design and reality, quantifies the difference, helps to reduce unnecessary losses of the production company.

## Acknowledgments

This work was supported by the Slovak Research and Development Agency under the Contract no. APVV-16-0488.

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