**OPTIMIZATION OF TECHNOLOGICAL JIGS FLOW IN AUTOMOTIVE USING SOFTWARE MODULE TECNOMATIX PLANT SIMULATION**
Miriam Pekarčíková; Peter Trebuňa; Marek Kliment; Milan Edl; Ladislav Rosocha

# OPTIMIZATION OF TECHNOLOGICAL JIGS FLOW IN AUTOMOTIVE USING SOFTWARE MODULE TECNOMATIX PLANT SIMULATION

**Miriam Pekarčíková**
Technical University of Kosice, Faculty of Mechanical Engineering, Institute of Management, Industrial and Digital Engineering, Park Komenskeho 9, 042 00 Kosice, Slovak Republic, EU,
miriam.pekarcikova@tuke.sk (corresponding author)

**Peter Trebuňa**
Technical University of Kosice, Faculty of Mechanical Engineering, Institute of Management, Industrial and Digital Engineering, Park Komenskeho 9, 042 00 Kosice, Slovak Republic,
peter.trebuna@tuke.sk

**Marek Kliment**
Technical University of Kosice, Faculty of Mechanical Engineering, Institute of Management, Industrial and Digital Engineering, Park Komenskeho 9, 042 00 Kosice, Slovak Republic,
marek.kliment@tuke.sk

**Milan Edl**
University of West Bohemia, Faculty of Mechanical Engineering, Department of Industrial Engineering and Management, Univerzitni 8, 301 00 Plzen, Czech Republic,
edl@fst.zcu.cz

**Ladislav Rosocha**
Technical University of Kosice, Faculty of Mechanical Engineering, Institute of Management, Industrial and Digital Engineering, Park Komenskeho 9, 042 00 Kosice, Slovak Republic,
ladislav.rosocha@tuke.sk

*Abstract:* Production must be adapted to the needs of the product structure while meeting the economic requirements of low cost. As processes will be monitored, managed and optimized in near real-time, decentralization of decision-making processes will also increase. Due to the heterogeneous structure of the value chain, its complexity is increasing, reorganized, causing changes to the system as a whole and will require the creation of appropriate infrastructures. Mastering the value chain dynamics is largely translated into logistics. This paper deals with the optimization of the flow of technological jigs at the workplace of the paint shop in a company that is oriented to the automotive industry. The design of an optimal solution will be verified using the selected software module Tecnomatix Plant simulation. Description and analysis of monitored flows of technological preparations are realized in the workplace Painting. The simulation model of the original state was created and by testing alternative solutions the solution of inter-operational transport was chosen, which is optimal. The use of software support in the analysis of variant solutions is of great importance especially in terms of speed of verification and achievement of results from the tested variants.

## 1 Introduction

The authors [1] in their study "Industry 4.0 and the Current Status and Future Prospects on Logistics" focuses on clarifying the impact of the Industry 4.0 concept on logistics. Under Industry 4.0 they understand the introduction of CPS, IoT, IoS and Smart Factory. Although the concept of Industry 4.0 is only at the beginning of its development and it is not known how it will be reflected in practice, its impact on logistics is still uncertain, the authors note its enormous importance and potential of use especially in the field of logistics. Regarding the introduction of these technologies, the authors argue that "Industry 4.0 can, by its very nature, become a reality only if logistics can provide production systems with the required inputs at the right time, quality and in the right place" [1].

Logistics in large halls must be precisely planned to save time, increase efficiency and thus reduce costs and increase production. The whole material flow must, therefore, be one perfectly functioning system. The growing competitive environment, which forces companies to reduce production times, inter alia, leads to continuous improvement in inter-operational transport [2,3].

The goal by making the logistics model is to simplify the mapping of complex logistics systems in order to gain knowledge, that can be transferred back to real system without interrupting current flows. In general, the simulation model of real logistics system is simplified through abstraction and idealization. The abstraction allows the real elements, relationships, and attributes omitted in order to concentrate on the essential system

**OPTIMIZATION OF TECHNOLOGICAL JIGS FLOW IN AUTOMOTIVE USING SOFTWARE MODULE TECNOMATIX PLANT SIMULATION**
Miriam Pekarčíková; Peter Trebuňa; Marek Kliment; Milan Edl; Ladislav Rosocha

components. The idealization, however, allows you to view these components in the created simulation model, but in a simplified form [4-6].

For example, as stated in the case study, when simulating a assembly line in automotive, not all part positions that are installed in the vehicle are shown. This abstraction leads to that the simulation model used remains manageable and controllable. At the same time, the real component is represented by idealization in a software-specific component without, for example, displaying the geometric dimensions more precisely in the model. With both approaches, it is first necessary to decide which system components are mapped or how they are simplified. Which specific selection decision is made can, however, only be made in individual cases and always goal-oriented [7-9]. The higher level is the direction to the digital enterprise, i.e. through the creation of a digital twin, it would be possible to create a fully valuable system in a virtual environment with the possibility of virtual set-up and process optimization without interfering with the real system, and through digital twin, technologies to implement them directly into the real system [10-14].

Currently, there are programs to solve such problems that save time in designing workplaces and logistics. TX Plant Simulation is a software tool that allows engineers to create digital models and simulations of both logistics and manufacturing systems. It offers a wide range of modules to monitor the individual production process [15-18].

It is these software programs, automation, and robotization of production processes that represent the fourth industrial revolution. Companies, as well as individuals, are constantly striving to design, develop and implement new ways of production, simplification, optimization, and rationalization. In the world we know today, it is unimaginable that simulation programs, models, robots and other advanced technologies are not used in pre-production phases such as planning, design, and production. Robots and production automation itself are slowly replacing human activity, thus avoiding errors in the production process. All of this takes human society to the next level and creates a world of technology [19-26].

The case study below analyzes the workplace painting in a company focused on the automotive industry, simulates the current state and concludes with a proposal for a solution for inter-operational transport. Tx Plant Simulation was used to create a simulation model of current material flows in the workplace painting.

## 2 Material and Methods
### 2.1 Description of used software Tecnomatix Plant Simulation

Tecnomatix Plant Simulation support discrete-event simulation. It shows the state changes of the model components at certain points in time, not continually over time. When certain events take place, certain model components change their state and thus control the simulation. This software considers these events in a discrete way, step-by-step. The main advantage is that TX Plant Simulation skips the time between the events. In addition, TX Plant Simulation is an object-oriented application, that allows child objects to inherit properties from a parent object [15]. Different and very complex systems and business processes can be represented realistically and with high accuracy. The object-oriented, graphic and integrated work environment has increased user acceptance. Working with objects that are inherited has great advantages:

- adjustments are made much faster,
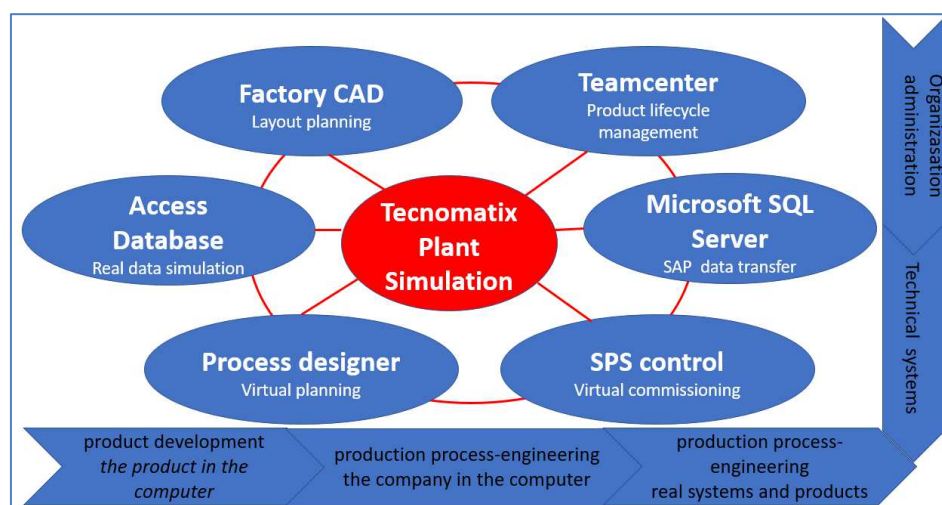- parameter changes are made more securely in the entire model.



*Figure 1 Company-wide simulation with TX Plant simulation and integration example [7]*

**OPTIMIZATION OF TECHNOLOGICAL JIGS FLOW IN AUTOMOTIVE USING SOFTWARE MODULE TECNOMATIX PLANT SIMULATION**
Miriam Pekarčíková; Peter Trebuňa; Marek Kliment; Milan Edl; Ladislav Rosocha

The extraordinary functionality in the creation of models, as well as the easy modification and maintenance of created models in TX Plant Simulation have made the universal and productive use this tool possible. The data exchange during the simulation run and the complete control of TX Plant Simulation by other programs (e.g. PPS, ERP system, etc.) are important for integrated solutions. Via the existing interfaces, TX Plant Simulation is open for individual extensions and fulfils all practical integration requirements. TX Plant Simulation integrates with many other software systems, (Figure 1).

Throughout the automotive manufacturing process, processes in the paint shop are among the most technologically demanding, as they include various processes based on the chemical, thermochemical, physical and technological properties of the materials used, such as: paint, paint, putty, bodywork, chemicals used in individual processes, etc.

### 2.2 Layout Workplace Position Painting Module

Throughout the automotive manufacturing process, processes in the paint shop are among the most technologically demanding, as they include various processes based on the chemical, thermochemical, physical and technological properties of the materials used, such as: paint, paint, putty, bodywork, chemicals used in individual processes, etc.

The workplace of the paint removal process consists of two parts. This is from an enclosed and ventilated area, where there are three paint removers, a sump for working with a high-pressure device, and a place for blowing with compressed air. In this part of the workplace, the operator inserts resp. removes rotary baskets from paint removers. Here, the paints are removed after each painting process. This workstation is closed in order to prevent the odor spread of the chemical varnish medium present in the varnish modules during the varnishing process. Therefore, during insertion respectively. When removing the rotary basket from the machine, the worker must use personal protective equipment (face mask for respiratory protection, protective shield, chemical gloves, rubber boots, chemical coat, protective headphones).

In the case study, an analysis of the flow of auxiliary technological products and an analysis of the current working positions that perform the manipulation with the given technological auxiliaries was created. The bodywork in the painting process passes through specific workplaces to obtain a final look. Bodies move along the conveyor system with a length of 7.5 km. This system also includes a 360 ° rotary immersion system, which is used in degreasing and pretreatment processes. By means of these processes, the body is free of dirt and grease, and at the same time in the subsequent cataphoresis process a protective layer is applied. There are 80 robots integrated

in the entire painting process, which are used to apply sealant and paint. The paints used in the coating process are water-dilutable and therefore do not significantly pollute or damage the environment. The process of applying paint and varnish is flexible, so the company offers several colors for each model. The amount of color shades for each model is described in Table 1.

*Table 1 Quantity of colors for individual models in the company*

| Model | Number of shades |
|-------|------------------|
| A | 13 |
| B | 14 |
| C | 10 |

Analysis of the current state is focused on the flow of auxiliary technological jigs, which are not part of the final form of the automobile body, as parts or components, so that they do not create the added value of the product. These preparations are designed to facilitate the work of operators, but also robots in robotized workplaces. The types of preparations analyzed have a fixation, support, and auxiliary function.

The fixatives are mainly used to fix the front and rear doors and the front and rear bonnets during degreasing, pretreatment and cataphoresis processes. Thanks to these products, the opening of the individual body parts is prevented since 360 ° rotation occurs during these processes.

Supporting products are used mainly during the movement of car bodies between individual workplaces of the paint shop, but also in production halls (from the welding shop to the paint shop, from the paint shop to assembly). Supporting agents are also important during the process of applying the sealant to the inner body. These pro Auxiliaries perform various functions. Whether they simplify opening the front resp. hold the door open while moving between workstations, or help keep the door open during the process of applying the sealant to the inner part. Some of these formulations also undergo a coating process. Jigs that pass through this process must, after removal from the manufacturing process, be removed by stripping in the stripping module operated by the operator at position no. 1.

The work positions analyzed in this chapter are handled by external company workers who carry out the transport and supply of individual workpieces with preparations, operate the stripping module and perform other work and handling activities described in the workflows.

### 2.3 Process Flow on workplace painting

In Table 2, the individual preparations which enter the production are described. The table shows in which workplaces the products enter and exit the production. The last column of this table shows which operator is in charge of transporting the product to the workplace.

**OPTIMIZATION OF TECHNOLOGICAL JIGS FLOW IN AUTOMOTIVE USING SOFTWARE MODULE TECNOMATIX PLANT SIMULATION**
Miriam Pekarčíková; Peter Trebuňa; Marek Kliment; Milan Edl; Ladislav Rosocha

*Table 2 Overview of jigs at the workplace painting*

| No. | Jigs' name | IN | OUT | Notice | Operator´s manipulation | |
|---|---|---|---|---|---|---|
| 1. | front hood support (from welding) | Welding area | Preclean | - | Op.3 Preclean - Welding area | |
| 2. | rubber stop rear bonnet | Welding area | Preclean | - | Op.3 Preclean - Welding area | |
| 3. | door fixation | Welding area | JIG Station | paint removing the preparation over the weekend | Op.3 JIG Station - Welding area | |
| 4. | door hinge screws | Welding area | Assembly | ASSY-Paint removing module | Op.2 Paint removing module - Welding area | |
| 5. | fixing the front and rear bonnet | Preclean | JIG Station | Washing the jigs over the weekend | Op.3 JIG Station - Preclean | |
| 6. | magnet into the door | JIG Station | Sealer | - | Op.3 Sealer - JIG Station | |
| 7. | long bonnet support (front and rear bonnet) | JIG Station | Deadener Pad | - | Op.2 Deadener Pad - JIG Station | |
| 8. | artificial roof preparation | JIG Station | WAX | - | Op.2 WAX - JIG Station | |
| 9. | plastic door stop | JIG Station | Assembly | Single use | - | |
| 10. | tailgate opening jig | Sealer | WAX | WAX - Paint removing module | Op.1 Paint removing module - Sealer | Op.2 WAX - Paint removing module |
| 11. | fuel tank cap holder | Deadener Pad | WAX | WAX - Paint removing module | Op.1 Paint removing module - Deadener Pad | Op.2 WAX - Paint removing module |
| 12. | front bonnet opener | Deadener Pad | WAX | WAX - Paint removing module | Op.1 Paint removing module - Deadener Pad | Op.2 WAX - Paint removing module |
| 13. | front bonnet support | Deadener Pad | WAX | Outsourcing | Op.2 WAX - Deadener Pad | |
| 14. | fixation strip | WAX | Assembly-Door off | - | Op.1 Assembly -WAX | |
| 15. | pin under the front bonnet | WAX | Assembly-T220 | - | Op.1 Assembly -WAX | |
| 16. | panoramic roof pin | Sunroof | Assembly-Door off | - | Op.1 Assembly -Sunroof | |

In the following Figure 2 is a schematic diagram of the input resp. input circuit output of preparations to/from production. The solid circle marks the mounting of the fixture on the automobile body. Removing the jig from the automobile body is indicated by an empty circle. The full arrow is characterized by the transport resp. moving the mounted fixture on the body during the manufacturing process. Dashed arrows indicate routes of jig which after disassembly continue to the paint removing module for the paint removing process.

Color differentiation of individual arrows is created for the transparency of entry and exit of individual jigs according to workplaces where the jigs are mounted respectively. removed from the automobile body. Numbers by the full and empty circles are denominations of individual jigs from the Table 2.
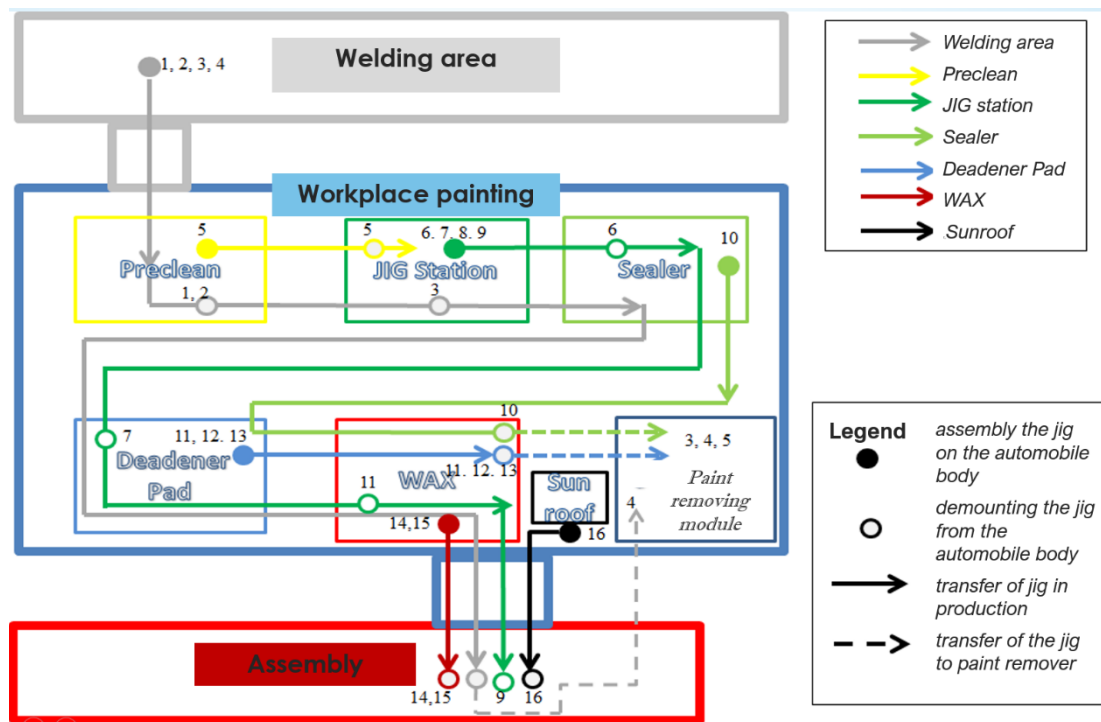
*Figure 2 Scheme of jigs cycle*

In Figure 3 are show the automobile body and the individual jigs whose color differentiation serves to illustrate the entry of the jigs into the individual workplaces. The locations where the jigs are mounted on the automobile body are indicated by arrows.
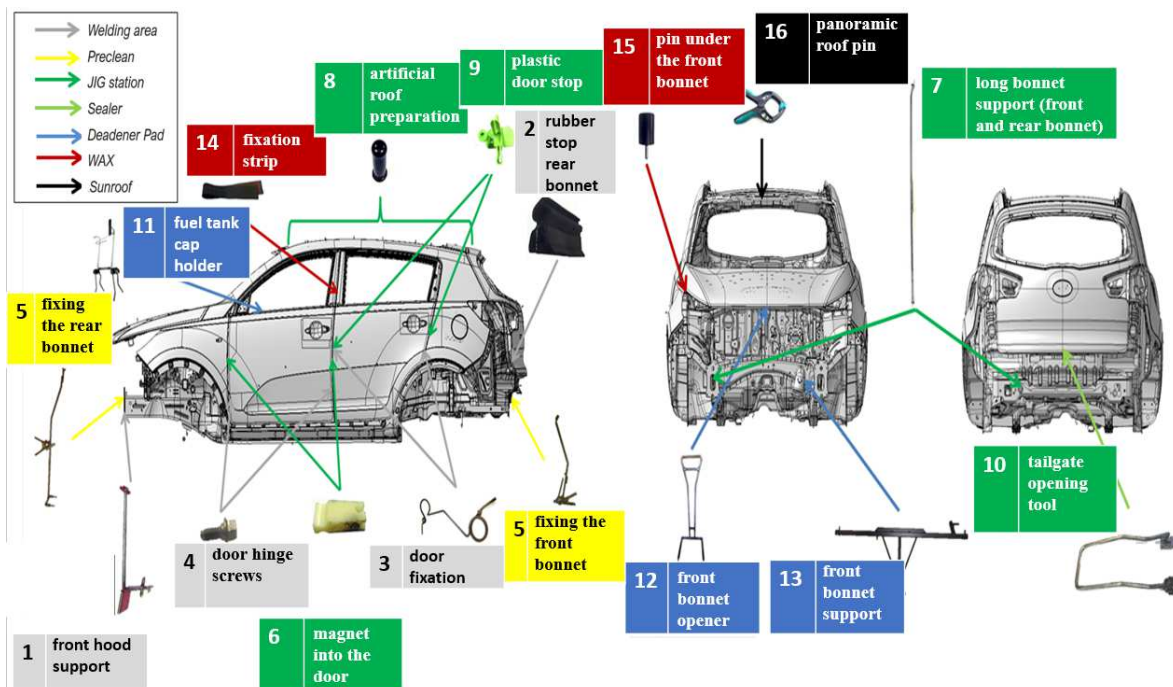


*Figure 3 Placing the jigs on the automobile body*

Acta logistica - International Scientific Journal about Logistics
Volume: 7 2020 Issue: 2 Pages: 111-120 ISSN 1339-5629

OPTIMIZATION OF TECHNOLOGICAL JIGS FLOW IN AUTOMOTIVE USING SOFTWARE MODULE
TECNOMATIX PLANT SIMULATION
Miriam Pekarčíková; Peter Trebuňa; Marek Kliment; Milan Edl; Ladislav Rosocha

### 2.4 Creation of simulation model of material flow of technological jigs on position: Paint removal module

The worker in this position carries out the preparation of supporting and fixation products for production, their removal or the operation of the removal equipment of the products and their subsequent logistics for individual workplaces. At the same time, he is in charge of transporting some types of jigs from assembly to paint shop.

Paint removal of the formulations is carried out in rotary baskets into which the formulations are stored according to the prescribed procedure. After the stripping process has been completed, the operator must subsequently rinse the preparations with water using a high-pressure device. After rinsing the cleaning medium, the worker must remove the residual water preparations by blowing with compressed air to ensure their dryness. The final rinse and blow-off process of the formulations is performed to remove residual amounts of cleaning medium

that can cause contamination of the body surface and hence quality problems.

In addition to the preparation of support and fixation products for paint removal and for the operation of the paint module, this work is also in charge of the product logistics. The varnished, rinsed and dried preparations are sorted and stored by the worker and are prepared to handle trolleys according to the type of preparation. It then delivers these product trolleys to Deadener Pad and Sealer. During the varnishing process, this worker also takes care of the logistics of some types of fixtures (fixation tapes, pegs under the front hood and pegs on the panoramic roof) from assembly workplaces to paint shops workplaces.

**Movement worker on position: Paint removal module**

The job description of the employee in this position is not only the operation of the workplaces of the Paint removal modules but also the transport of individual products to the workplaces. The routes along which the worker transports the individual jigs are mapped in Figure 4.
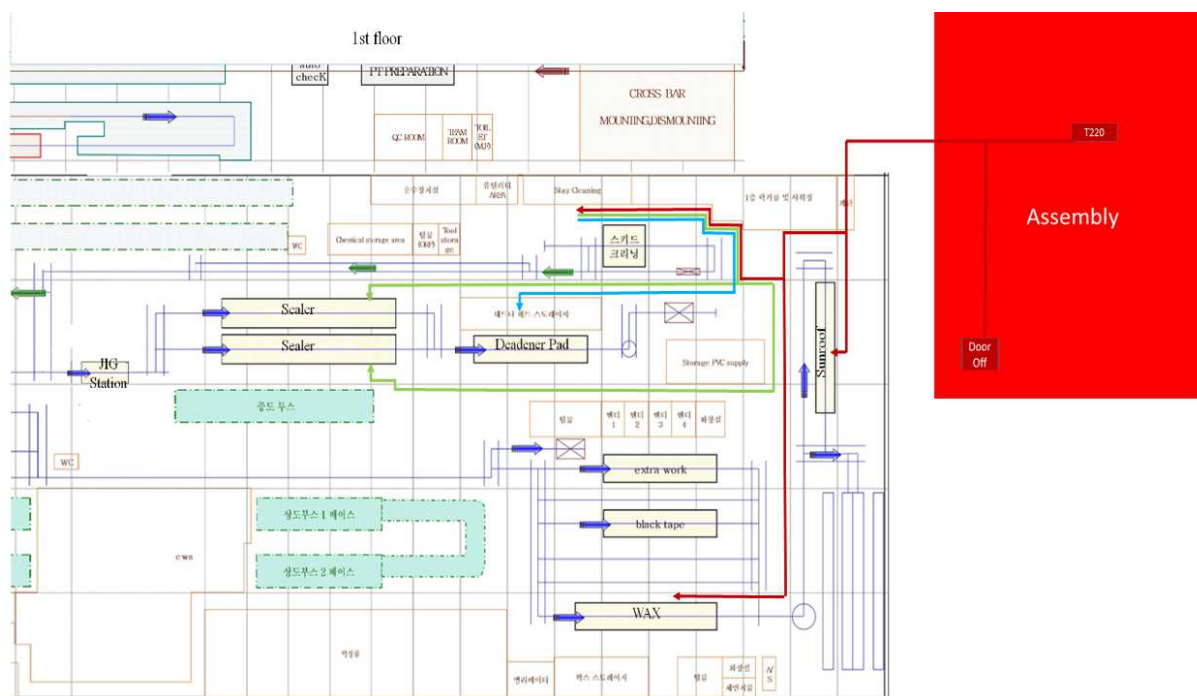


*Figure 4 Motion map of worker on position: Paint removal module*

After completing the preparatory work, inserting the fixtures and operating the paint remover, the worker collects and transports the fixtures (panoramic roof pin, fixation strip and pin under the front hood) from the Assembly Offices (Door off, T220) to the workplace Painting, first to Sunroof and then to WAX. After unloading at the WAX site, the worker returns to the paint module. The worker's movement along this route is marked in red.

After the removal process has been completed and the painting preparations are sorted into prepared handling

trolleys. The transport route for the Deadener Pad is marked in blue. The transport route to Sealer is indicated in green.

### 2.5 Suggestion of optimal solution of the flow of technological jigs in the examined company.

From the results of observation, data collection and analysis of logistics workers in the workplace painting about and subsequent creation of simulation models of individual manipulation workplaces, re-design of these

**OPTIMIZATION OF TECHNOLOGICAL JIGS FLOW IN AUTOMOTIVE USING SOFTWARE MODULE TECNOMATIX PLANT SIMULATION**
Miriam Pekarčíková; Peter Trebuňa; Marek Kliment; Milan Edl; Ladislav Rosocha

workplaces was created. This solution is based mainly on observation and analysis.

The re-design of the workstation relates to position no.1 of the painting module and position no.2 of the WAX. The proposed change and optimization are to move the operation:

• Transfer of painting jigs (tailgate opening jig) to Sealer.

This process is removed from the workflow for position no. 1, and is assigned to the worker of position no. 2 WAX. This operation will be a worker at position no. 2 can be carried out after the transport of the preparations from the WAX workplace, which then proceed to the paint removal process. After completion of the previous paint stripping cycle, when the compositions are painted, depleted of the cleaning medium by a high-pressure device, blow-dried and sorted into ready-to-carry carts. Subsequently, the worker at position no. 2 transports the tailgate jigs to Sealer.

The reason for this proposal and optimization of the occupancy worker at position no. 1, which is responsible for operating the paint remover work module, which includes three paint removal device.

At the same time, it is responsible for the correct storage of the products in the baskets. An important activity is also the proper cleaning of paintings products, their drying with compressed air and subsequent sorting into handling trolleys and their distribution to workplaces,

according to the working procedure. Between these operations, he must also transport the jigs from assembly to the workplace painting

When the worker at position no. 2 WAX was observed short downtimes were detected. Assignment of the above operation does not burden the worker at position 2 significantly, because the operation is performed every two hours.

*Table 3 Comparing the current and proposed state after simulation*

| Current status | | Proposed state | |
|---|---|---|---|
| **Traveled Distance** | | **Traveled Distance** | |
| | **Traveled Distance** | | **Traveled Distance** |
| .MUs.Pozicia1:1 | 5294.55m | .MUs.Pozicia1:1 | 4631.05m |
| **Object** | **Number of Entries** | **Object** | **Number of Entries** |
| .MUs.Pozicia1:1 | 39 | .MUs.Pozicia1:1 | 36 |

The proposed change for position no. 1 of the painting module and position 2 of the WAX is shown in Figure. 5. In Figure. 5 is a red highlighted route to the Sealer site that the worker had not previously performed in that position. At the same time in Figure 6 is shown a 3D model of the proposed optimization.
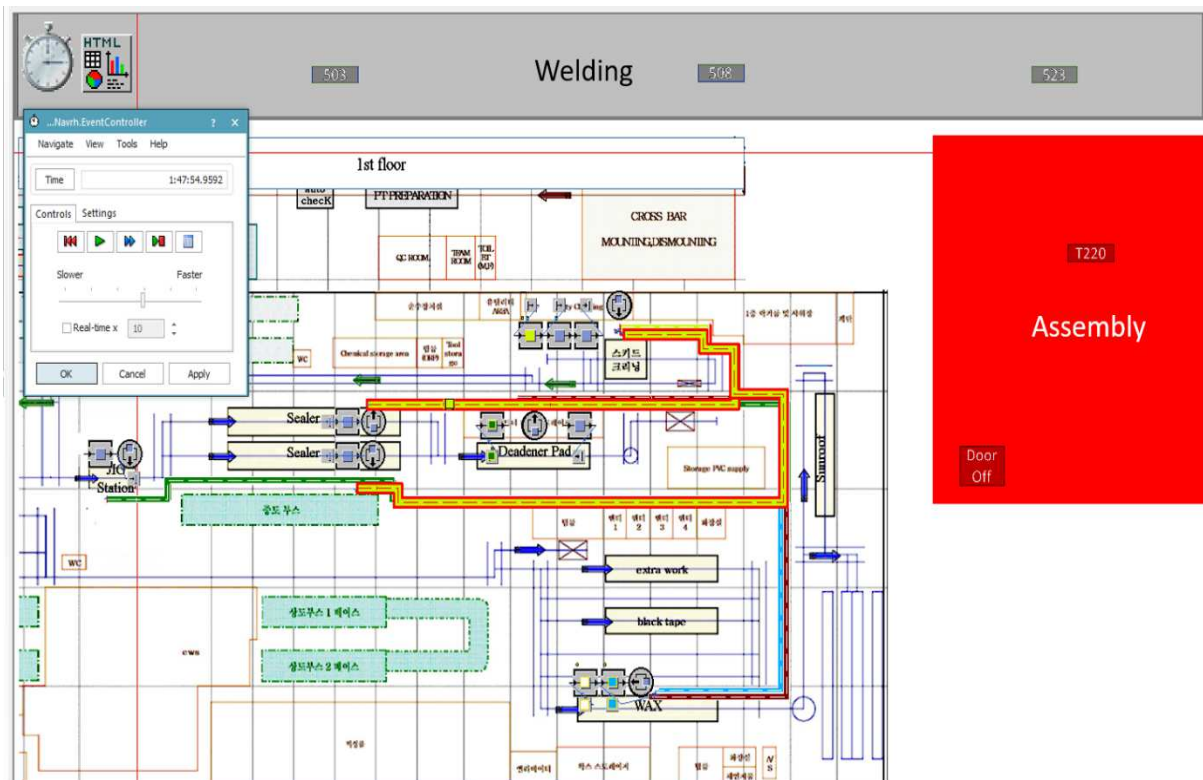


*Figure 5 Optimization Proposal - Position no. 2 WAX*

**OPTIMIZATION OF TECHNOLOGICAL JIGS FLOW IN AUTOMOTIVE USING SOFTWARE MODULE TECNOMATIX PLANT SIMULATION**
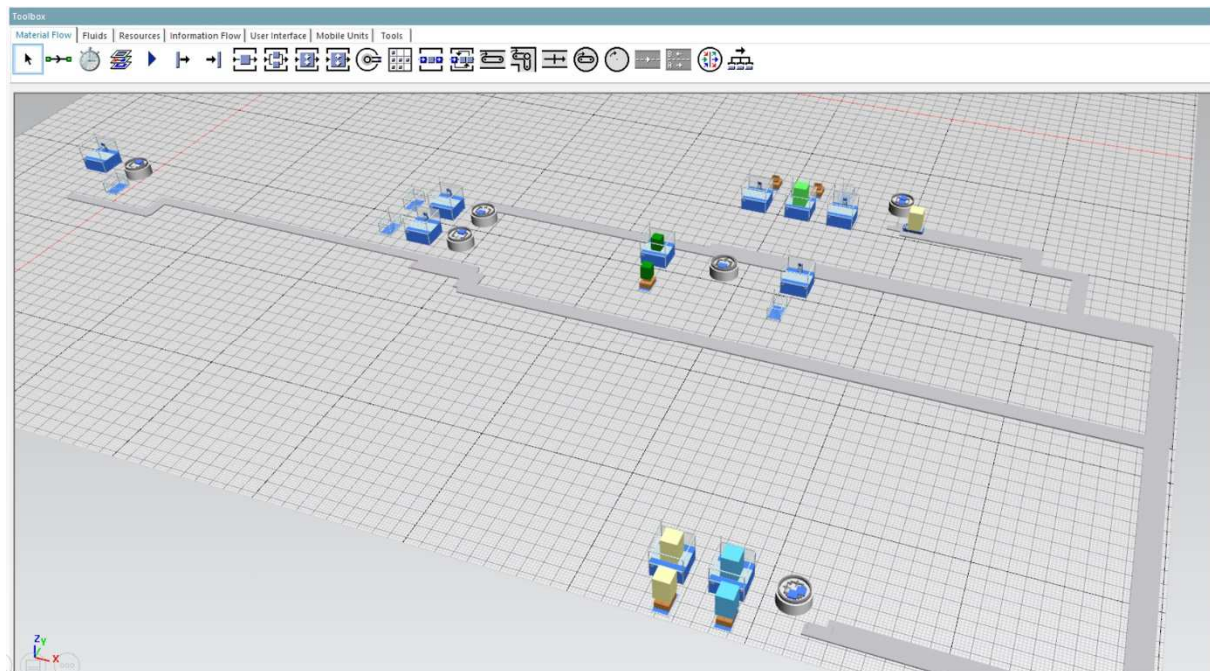Miriam Pekarčíková; Peter Trebuňa; Marek Kliment; Milan Edl; Ladislav Rosocha



*Figure 6 3D model of the proposed optimization*

After elaboration of the optimization proposal and subsequent simulation of this proposal are shown in Tab. 3 taken into account and compared two indicators of the current and proposed state, namely the distance traveled by the worker in position no. 1 during a 12-hour change and the number of inputs to workplaces. The current system will pass 5294.55 meters and the proposed is 4631.05 meters. The difference between these distances is 663.5 meters. The distance that has been shortened to the worker at position no. 1, when transporting the preparations to the workplace, Sealer creates a time reserve. Thanks to this time reserve, the worker can focus on the processes related to the painting process, in particular the processes of rinsing off the painting jigs with a high-pressure device and the subsequent blowing off of the cleaning medium residues. Focusing on this process is very important as this process avoids the possible contamination of the automobile body and hence quality problems.

The second indicator that points to an increase in the necessary time reserve is the number of inputs to workplaces. When comparing the current and the proposed situation, we can point to a reduction in the number of inputs to 36 compared to the original 39.

• Transfer of painting jigs (tailgate opening jig) to Sealer.

## 3  Result and discussion

The use of simulations and the creation of simulation models is nowadays an essential part of modern enterprises for maintaining but also increasing their competitiveness in the market. The use of simulation software facilitates but mainly speeds up the pre-production phase of the process.

In this phase, when planning, designing, resp. re-designing both production and non-production processes is an important factor in time. Simulation programs significantly reduce this time compared to mathematical models resp. experiment during operation. Along with the reduction of time, the costs of introducing new or changes to the original system are also reduced. These two variables can be characterized as important indicators in the introduction of new resp. changes to legacy systems. Before developing a simulation model in this case study, it was necessary to develop an in-depth analysis of the system with a focus on logistics staff. Workers in these positions are responsible for transporting a group of products between the individual workplaces of the painting.

The analysis was created from the results of observation and data collection, in a workplace painting in a company focused on the automotive industry. Part of the analysis is the characteristics of the monitored job positions. The next part of the analysis was the workflow, which is processed in the tables. Subsequently, a table was drawn up of the jigs that the worker transported between workplaces. The next section describes the routes, layouts of workplaces and handling trucks on which the worker transports the jigs. The simulation model of the current system was developed from the knowledge from analysis and observation. The final part is a proposal for the optimization of the current system. Optimization related to position no. 1 Paint removing module from which the process Movement of the painting jigs (tailgate opening jigs) was taken away to the Sealer position. This operation has been assigned to the worker of position no. 2 WAX, thereby reducing the time and physical intensity of position

Acta logistica – International Scientific Journal about Logistics
Volume: 7 2020 Issue: 2 Pages: 111-120 ISSN 1339-5629

OPTIMIZATION OF TECHNOLOGICAL JIGS FLOW IN AUTOMOTIVE USING SOFTWARE MODULE
TECNOMATIX PLANT SIMULATION
Miriam Pekarčíková; Peter Trebuňa; Marek Kliment; Milan Edl; Ladislav Rosocha

no. 1. This proposal is based on observation and in-depth analysis of the current system directly in the company.

The results of the simulation of the current and proposed status were compared based on two indicators, namely the distance travelled by the worker during the change and the number of entrances to the workplaces. When comparing the distance indicator between the current and the proposed condition, a difference of 663.5 meters was made. The difference in the two indicators results in a new time pool that the worker can use to focus on rinsing and blowing processes, which are very important in preventing automobile body surface contamination that results in qualitative errors.

## 4 Conclusions

Current tools for modeling and simulation of logistic processes enable the creation of models, simulation experiments, statistical analyzes, and have a library of predefined entities that can be extended. However, they are not flexible enough to increase the agility of individual entities through the introduction of technological innovation. However, the increasing degree of autonomy of individual elements of the system requires the solution of new problems related to modeling and implementation of autonomous Logistics 4.0. There is a need to apply sophisticated simulation tools that have computational and communication capabilities and can create a digitized image of a real system. This leads to a significant transformation of the so-called hardware logistics to software logistics.

Technological innovations, particular CFS and IoT, create an integration element between decision-making and performance processes that increases the efficiency of bidirectional information flows. There is a need to ensure active and individual communication capability between individual elements of the system. This leads to optimal production adapted to the specific product. The products themselves are looking for their production flow as the distribution of available capacities is subject to a dynamic solution of the products themselves.

## References
[1] HOFMANN, E., RÜSCH, M.: Industry 4.0 and the current status as well as future prospects on logistics, *Computers in Industry*, Vol. 89, pp. 23-34, 2017. doi.org/10.1016/j.compind.2017.04.002
[2] MARASOVA, D., SADEROVA, J., AMBRISKO, L.: Simulation of the Use of the Material Handling Equipment in the Operation Process, *Open Engineering*, Vol. 10, No. 1, pp. 216-223, 2020. doi.org/10.1515/eng-2020-0015
[3] GRZNAR, P., GREGOR, M., MOZOL, S., KRAJCOVIC, M., DULINA, L., GASO, M., MAJOR, M.: A System to Determine the Optimal Work-in-Progress Inventory Stored in Interoperation Manufacturing Buffers, *Sustainability*, Vol. 11, No. 14, pp. 1-36, 2019. doi: 10.3390/su11143949
[4] FEDORKO, G., VASIL, M., BARTOSOVA, M.: Use of simulation model for measurement of MilkRun system performance, *Open Engineering*, Vol. 9, No. 1, pp. 600-605, 2019. doi: 10.1515/eng-2019-0067
[5] ASTASHOVA, J. V., DEMCHENKO, A. I., KATOCHKOV, V. M., UKHOVA, A. I.: *Methodology of Logistics Chain Management: Multi-Object Approach. Sustainable economic growth Education excellence, and innovation management through vision 2020*, 29th International-Business-Information-Management-Association Conference, Vol. 1-7, pp. 405-410, 2017.
[6] RADAEV, A., LEVENTSOV, V.: The methodology for substantianting the materials handling equipment of a unit load warehousing system, *International journal for quality research*, Vol. 12, No. 4, pp. 989-1016, 2018.
[7] KLUG, F.: *Logistik-management in der Automobilindustrie: Grundlagen der Logistik im Automobilbau*, Berlin: Springer, 2018.
[8] PRIBULOVA, A., POKUSOVÁ, M.: *Using a simulation programme to predict distortion of cast iron castings*, 19th International Multidisciplinary Scientific Geoconference, pp. 713-720, 2019. doi:10.5593/sgem2019/2.1/S07.093
[9] STRAKA, M., ROSOVA, A., LENORT, R., BESTA, P., SAREDOVA, J.: Principles of computer simulation design for the needs of improvement of the raw materials combined transport system, *Acta Montanistica Slovaca*, Vol. 23, No. 2, pp. 163-174, 2018.
[10] ZUPANCIC, D., BUCHMEISTER B., ALJAZ T.: Reducing the Time of Task Execution with Existing Resources –Comparison of Approaches, *International Journal of Simulation Modelling*, Vol. 16, No. 3, pp. 484-496, 2017. doi:10.2507/IJSIMM16(3)10.394
[11] KRAJCOVIC, M., HANCINSKY, V., DULINA, L., GRZNAR, P., GASO, M., VACULIK, J.: Parameter Setting for a Genetic Algorithm Layout Planner as a Toll of Sustainable Manufacturing, *Sustainability*, Vol. 11, No. 7, pp. 1-26, 2019. doi:10.3390/su11072083,

Acta logistica – International Scientific Journal about Logistics
Volume: 7 2020 Issue: 2 Pages: 111-120 ISSN 1339-5629

**OPTIMIZATION OF TECHNOLOGICAL JIGS FLOW IN AUTOMOTIVE USING SOFTWARE MODULE TECNOMATIX PLANT SIMULATION**
Miriam Pekarčíková; Peter Trebuňa; Marek Kliment; Milan Edl; Ladislav Rosocha

[12] RAJNOHA, R., GALOVA, K., ROZSA, Z.: Measurement of Impact of Selected Industrial Engineering Practices on Companies' Economic Performance, *Inzinerine Ekonomika-Engineering Economics*, Vol. 29, No. 2, pp. 176-187, 2018.

[13] CHROMJAKOVA, F., BOBAK, R., HRUSECKA, D.: *Production process stability – core assumption of INDUSTRY 4.0 concept*, 5th International Conference on Manufacturing, Optimization, Industrial and Material Engineering, pp. 143-154, 2017.

[14] MICIETA, B., EDL, M., KRAJCOVIC, M., DULINA, L., BUBENIK, P., DURICA, L., BINASOVA, V.: Delegate MASs for coordination and control of one-directional AGV systems: a proof-of-concept, *International Journal of Advanced Manufacturing Technology*, Vol. 94, No. 1-4, pp. 415-431, 2018. doi: 10.1007/s00170-017-0915-8

[15] BANGSOW, S.: *Tecnomatix Plant Simulation. Modeling and Programming by means of examples.* Switzerland: Springer, 2015.

[16] STEFANIK, A., GRZNAR, P., MICIETA, B.: *Tools for continual process improvement - Simulation and benchmarking*, 14th International Symposium of the Danube-Adria-Association-for-Automation-and-Manufacturing, pp.443-444, 2003.

[17] IGNACZ, P.: Use of digital tools in logistic and production facility management for effective information flow, *Acta logistica*, Vol. 6, No.4, pp. 141-146, 2019. doi:10.22306/al.v6i4.141

[18] STRAKA, M., MALINDZAK, D.: Algorithms of capacity balancing of printing machineries for Alfa Foils, a.s. planning system, *Acta Montanistica Slovaca*, Vol. 14, No. 1, pp. 98-102, 2009.

[19] STRAKA, M., ROSOVA, A., MALINDZAKOVA, M., KHOURI, S., CULKOVA, K.: Evaluating the Waste Incineration Process for Sustainable Development through Modelling, Logistics, and Simulation, *Polish Journal of Environmental studies*, Vol. 27, No. 6, pp. 2739-2748, 2018. doi:10.15244/pjoes/81062

[20] SANIUK S., CAGANOVA, D., CAMBAL M.: *Control of strategy realization in metallurgical production*, 23th International Conference on Metallurgy and Materials – Metal, 2014, Tanger, Czech Republic, Brno, pp. 1876-1881, 2014. doi:10.15244/pjoes/81062

[21] KOBLASA, F, SIROVA, E., KRALIKOVA, R.: The Use of Process Thinking in The Industrial Practice – Preliminary Survey, *The Journal Tehnički vjesnik – Technical Gazette*, Vol. 26, No. 3, pp. 786-792, 2019. doi:10.17559/TV-20150617135306

[22] BESTA, P., SAMOLEJOVÁ, A., LENORT, R., ZAPLETAL, F.: Innovative Application of Mathematical Methods in Evaluation of Ore Raw Materials for Production of Iron, *Metalurgija*, Vol. 53, No. 1, pp. 93-96, 2014.

[23] FURMANN, R., FURMANNOVÁ, B., WIĘCEK, D.: Interactive Design of Reconfigurable Logistics Systems. *Procedia Engineering*, Vol. 192, pp. 207-212, 2017.

[24] ROSOVA, A.: The system of indicators of distribution logistics, transport logistics and material flow as a tool of controlling in logistics enterprise, *Acta Montanistica Slovaca*, Vol. 15, No. 1, pp. 67-72, 2010.

[25] FUSKO, M., BUCKOVA, M., GASO, M., KRAJCOVIC, M., DULINA, L., SKOKAN, R.: Concept of Long-Term Sustainable Intralogistics in Plastic Recycling Factory, *Sustainability*, Vol. 11, No. 23, pp. 1-27, 2019. doi:10.3390/su11236750

[26] Car Polishing: The process of painting and manufacturing cars. From: http://lestenieaut.sk/proces.html accessed on 2020-04-01, 2020.

**Review process**
Single-blind peer review process.