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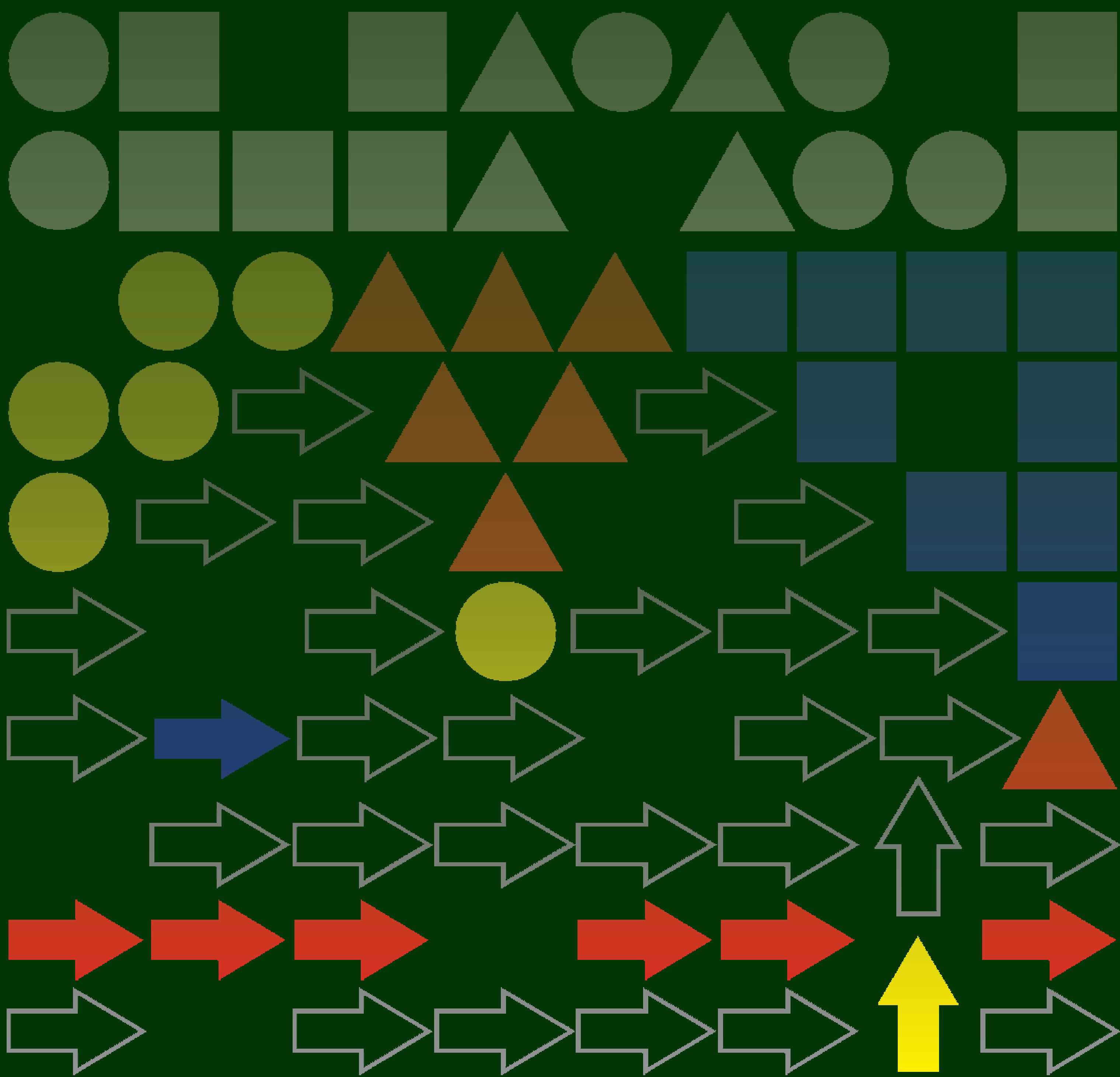

CONTENTS

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SIMULATION PROCESSES IN COMPANIES USING PLM AND TECNOMATIX PLANT SIMULATION SOFTWARE

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Keywords: PLM, digitalization, Tecnomatix Plant Simulation, simulation processes.

Abstract: This paper aims to demonstrate the use of simulations in the process of improving production processes. With the help of simulations, it is possible to test the efficiency of production in the virtual world, various variants of simulations. The advantage of simulations is the fact that it is possible to make simple and especially cost-effective changes to the production process and thus make it more efficient to the required level. 3D modeling of production halls is already an integral part of improvement. At the same time, this article points out that PLM positively affects the improvement process itself. The final simulation is aimed at improving the production process.

1 Introduction - PLM software

At this time, in a time of pandemics, businesses must increasingly strive to remain competitive in the market. The constant process of developing new technologies, modernizing processes, eliminating the heavy manual work that advanced robots do instead of people, are all commonplace in modern businesses. Manufacturing companies are constantly improving the quality of products, improving their properties to provide customers with even greater benefits than before. Such a company must emphasize PLM, which must have a higher level of software resources. PLM software deals with the entire life course of a product, from its intangible state, ie the idea, through user use, to its wear and tear. PLM software gives companies a clear overview of products, their features, and customer value. For a company to improve the production process, it must constantly improve the processes. The digitization process is used for this. Thanks to digital simulations, it is possible to make changes without stopping production, which brings a huge advantage.

PLM software serves as a tool using which manages the company's product portfolio, from the initial idea to wear and tear and disposal. With PLM, we manage the product portfolio of one product and all the company's products in the most efficient way possible. The entire range is managed, from individual parts to complex products. PLM is primarily product-oriented. Products form the so-called heart of society, they are a source of profit, and that is why PLM and its implementation in processes are so important. Products are what indicate the quality of the company, it creates a positive advertisement for the company and the product is what the customer buys.

PLM software serves as a tool when, of course, set to the maximum level, it will certainly mean increasing product revenue, reducing product costs, maximizing the value of the product portfolio, and, last but not least, increasing the value of the product for the customer and shareholders.

Product lifecycle management consists of 5 phases. At each stage, the product is in a different form. During the imagination phase, the product is only on a theoretical level as an idea of the people. The product is assigned properties such as color, shape, materials used, functionality, etc. At the end of the implementation phase, the product is no longer intangible but is already a real result of the production process. At this stage, the product is ready for use by customers. When the owner uses, the product enters the next phase, when it loses value and usefulness. In the last phase, the product is disposed of (Fig. 1).

Of course, companies are different, so the product life cycle is different in each industry.

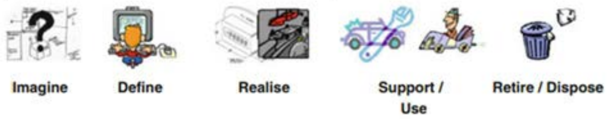

Figure 1 5 product life cycle phases

As Kirk Carlson states in his article Today's Future, over time, PLM has also evolved. Today we encounter the term PLM 4.0. It is the software with which the company can monitor the Digital Thread, which connects the Internet of Things (IoT), the digital twin of the product as with the product itself, the factory, and the customers. With the advent of the digital age, information began to accumulate and the cloud must be interconnected with business processes.

Figure 2 shows the structure of PLM 4.0. The core of the structure is PLM 4.0. There is another layer attached to this core, in which questions are asked about how to design a product, how to plan up to the question of how to sell. With the last layer of the PLM 4.0 cell, which contains elements such as AR / VR, linked Internet of Things, and monitoring products, the rest of the cell of the just mentioned digital thread connects.

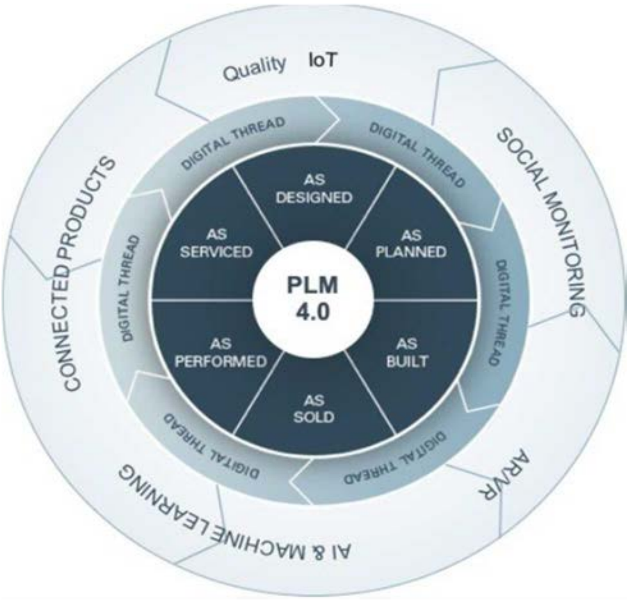

Figure 2 PLM 4.0 cell structure

1.1 Product Data Management

The production of products is associated with a lot of data needed to realize production. Therefore, a system called Product Data Management (PDM) is introduced in companies, which has a basic role, namely product data management. It is one of the most important elements of a PLM environment. Using PDM software, a company can manage product data created during a product lifecycle. It provides the necessary information at the right time in the right place. Information is an integral part of the life cycle. The introduction of PDM is a source of strategic control, thanks to which information is fully available and for everyone who needs it.

As Merja Peltokoski states in her studies, PDM is a necessary complement to PLM. PDM helps designers easily identify a part, making it easier to create a datasheet design and assignment to PDM (Fig.3).

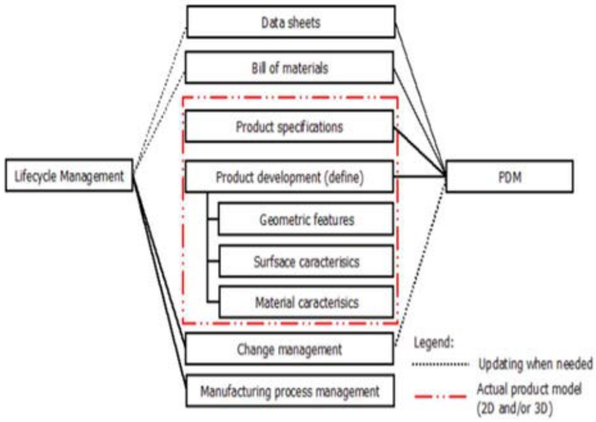

Figure 3 Features that are included in PDM and PLM

1.2 Tecnomatix Plant Simulation

Plant simulation is a program in which it is possible to create a digital form (digital twin) and then create a simulation of the work process and thus optimize production and logistics systems and processes (Fig.4). It is an important link in optimizing material flow, resource utilization, and logistics across all businesses, from the smallest to the world's giants. SOVA DIGITAL states that the correct creation of digital processes in the Tecnomatix Plant Simulation environment brings an increase in productivity by up to 34%, better alignment of workers, simulation of new layouts, increased production line throughput by 12%, optimized logistics, and last but not least by 27%. However, these statistics are only illustrative and it is necessary to realize that the results differ according to the degree of incorporation of the simulation. The Tecnomatix Plant Simulation program offers 2D simulation as well as 3D production simulation.

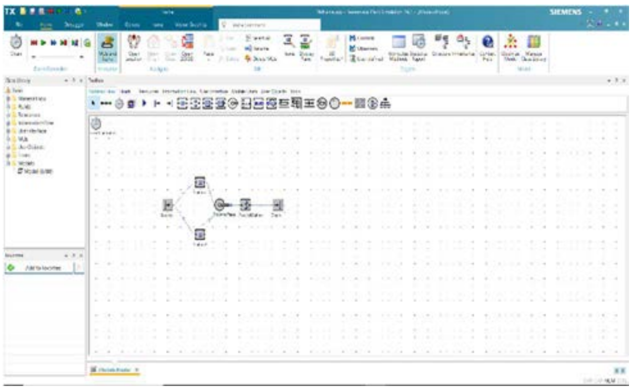

Figure 4 Tecnomatix Plant Simulation simulation environment

2 Production process simulations and material flow optimization

The basis for the whole simulation was to get acquainted with the problem of the company. In this case, it was inefficient transport between workplaces. Transport in the company was provided by transporters and the production machines themselves. Transporters represent a certain degree of automation, but in this case, this involvement of transporters is disadvantageous, because the transporter comes to the workplace, fulfills its capacity, and then to the destination. However, it runs halfway empty, which negatively affects production statistics (Fig.5).

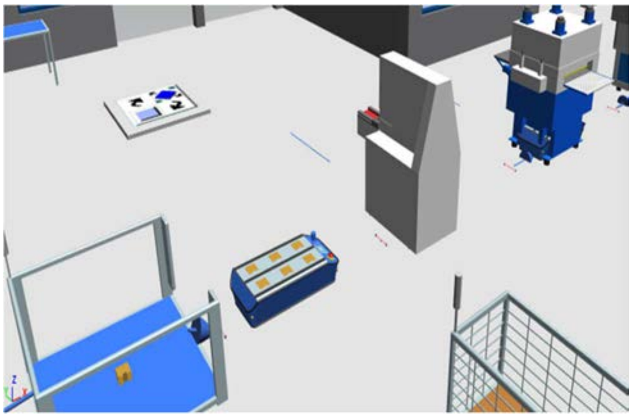

Figure 5 Transport of entities using transporters

Another problem of the company was the unsatisfactory rate of production processes. This was caused by inefficient transport of material or semi-finished products. The manufacturing process was made up of different operations and machines, each with different time requirements to operate. The downtime was most significantly recorded at 3 workplaces: laser cutting, polishing, and grinding (Fig 6).

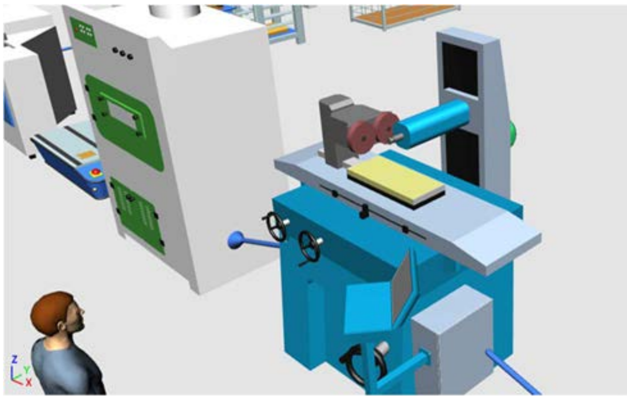

Figure 6 Accumulation of entities in the grinding workplace

When creating a digital model, it is necessary to initially define entities, which represent inputs to production. The basic entity for this production process was the transition boards. The company imported them from subcontractors and subsequently prepared them for 1x1 meter dimensions.

The next important step is to define the production machines, their capacity, time requirements to perform the necessary operations, personnel production capacity, length of working time, the definition of entities that are based on workplaces. With a given type of production, waste is also generated and it is also an entity that must have a defined location. At the end of the production process is the output, which is the finished product, waiting to be transported to the customer.

Figure 7 shows a 2D view of the manufacturing process. The program clearly defines processes, outputs, and inputs, paths for operators and transporters.

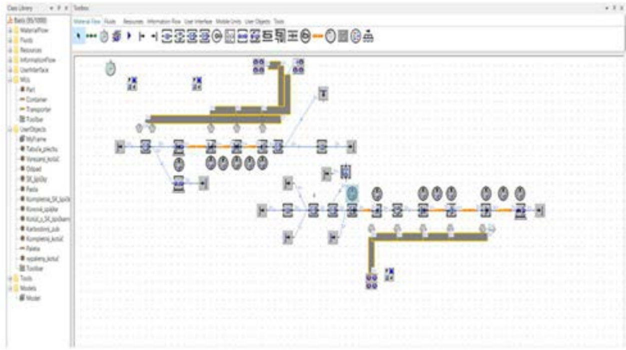

Figure 7 2D digital model

When creating a 3D model (Fig. 8), the look is more important so that it is clear to the customer what process he is currently following. The Tecnomatix Plant Simulation library contains some digital machine models. But in this case, it was not enough. Therefore, there is a need to create digital machine twins in 3D modeling programs. Autodesk Inventor Professional was chosen to create the models. Once the models were in their final form, it was easy to insert them into the Plant Simulation environment.

Figure 8 3D model of a digital company

The advantage of connecting the 3D modeling program with the Tecnomatix plant Simulation program is that the customer can define exactly what the models should look like. When the dimensions are configured correctly, it is possible to monitor the extent to which the production hall will be filled and how much space is unused, which provides additional options. Figure 9 shows a 3D model of a rolling and polishing machine.

Acta Simulatio - International Scientific Journal about Simulation
Volume: 7 2021 Issue: 3 Pages: 13-18 ISSN 1339-9640

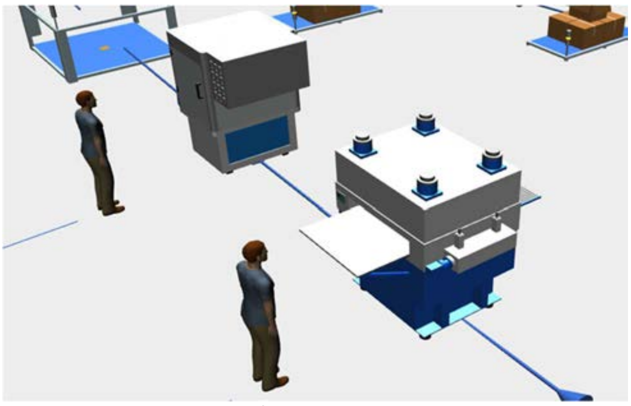

Figure 9 3D model of a rolling and polishing machine

3 Solving deficiencies in production using simulation

Just as the original 3D and 2D model of the production process was created in the Tecnomatix Plant Simulation program, so the modernized production process was processed in this program. In the modernized digital model, I focused on the shortcomings defined in the production hall's original model to minimize them, respectively. completely removed. Fig. 10 is a 2D model of a modernized production line.

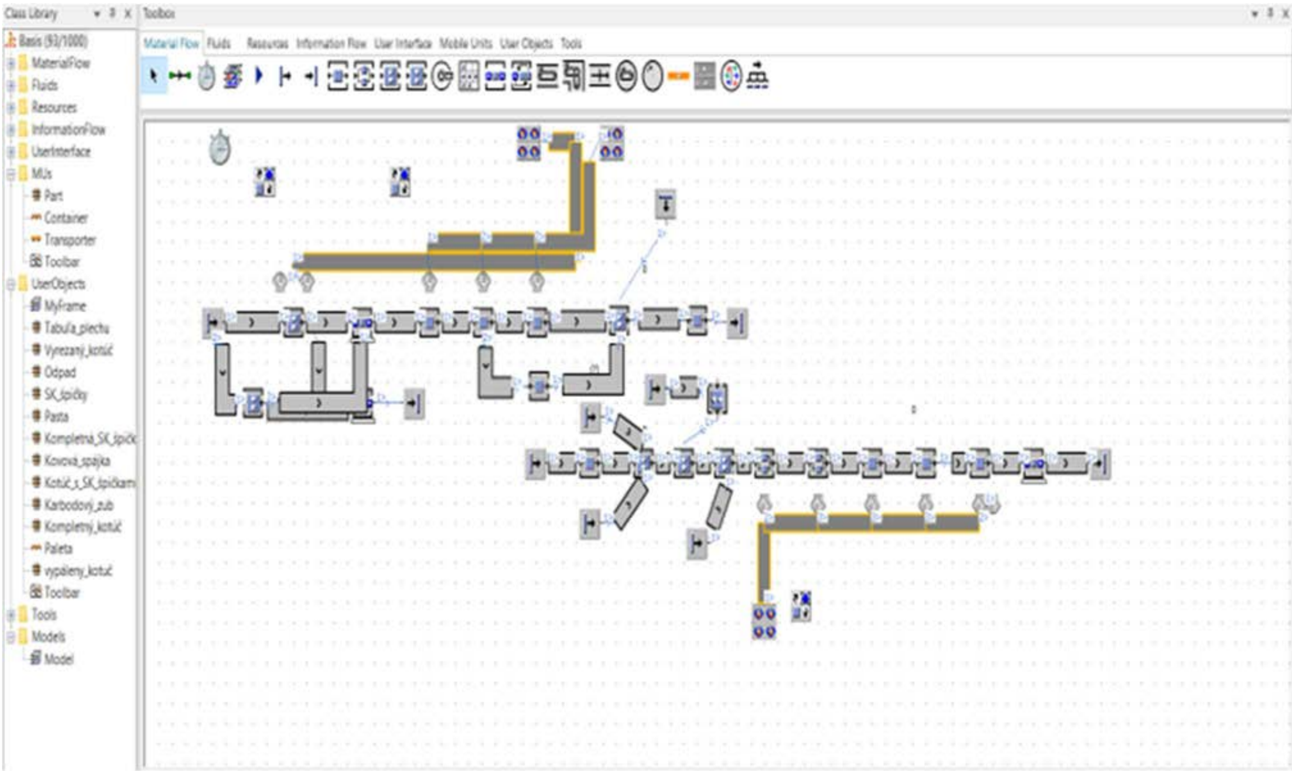

Figure 10 2D model

The problem with the transfer of individual components, the transfer of which was provided by workers or transporters, resulted in a significant decrease in the production of complete discs. Therefore, in the production process, we removed conveyors and transfers with the help of workers and replaced them with conveyor belts (Fig.11). The advantage of conveyor belts over conveyors is that the conveyor belts do not have to travel empty because they work continuously and have no end. Also, the advantage of conveyor belts is that the speed can be regulated and thus the production process can be made even more efficient. Conveyor belts connect the entire production line and contribute to improvements in the number of resulting components.

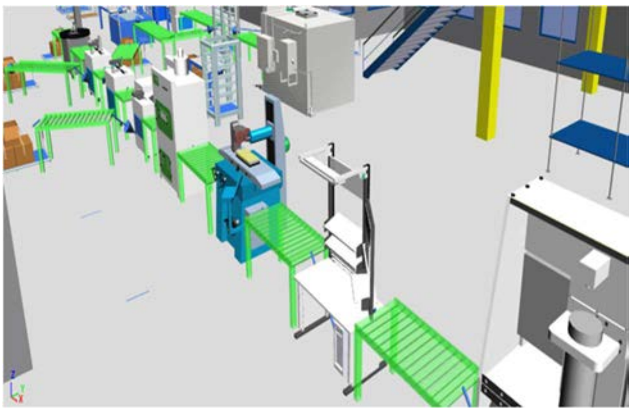

Figure 11 Conveyor belts in the production process

Acta Simulatio - International Scientific Journal about Simulation
Volume: 7 2021 Issue: 3 Pages: 13-18 ISSN 1339-9640

Another problem was the low efficiency of certain production processes, which was also reflected in the final statistics of the production process. We have already partially eliminated this problem by introducing conveyor belts into the production process. But that did not provide a complete improvement. Therefore, I solved this problem by adding machines that have experienced low production efficiency (Fig. 12). The addition of machines increased efficiency, which was reflected in the resulting statistics. Although it is a costly solution in terms of procurement and increasing the price of energy, the result is expected to be a return on resources to optimize production.

Figure 12 Laser cutting process optimization

The effectiveness of these solutions is shown in Table 1.

Table 1 Statistical comparison between processes before improvement using simulation

Laser cutting		
	Primary workplace	Improved workplace
Number of inputs	72	105
Working share	4%	5.64%
Working time	38:24.0000	37:12.0000
Downtime for one product	0.45%	0.03%
Polishing		
	Primary workplace	Improved workplace
Number of inputs	211	384
Working share	66,18%	81,90%
Working time	39.9925	38.5420
Downtime for one product	0.48%	0.21%
Grinding		
	Primary workplace	Improved workplace
Number of inputs	416	704
Working share	74.16%	80.67%
Working time	34.5748	41.2987
Downtime for one product	0.25%	0.16%

4 Conclusions

The work process simulation yielded sufficient results and indicates that the process has significantly improved thanks to the simulations in the Tecnomatix Plant simulation program. The number of outputs per shift has increased and this opens up the possibility for the company to accept orders in larger quantities. Of course, the company has spent considerable funds on the purchase of new machines, but the return on money is expected in the coming years. The simulation model is clear to the customer, so he can find out about the availability of any changes in the simulation model. Ultimately, the simulation can be applied throughout the product life cycle. The simulation also prevented production interruptions, as the modernization process took place in a simulation environment, so there was no need to stop production, which did not prevent the company from producing products.

Acknowledgment

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COLLECTION OF PRODUCTION DATA FOR THE POSSIBILITY OF CREATING A SIMULATION MODEL USING RTLS LOCALIZATION TECHNOLOGY

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Keywords: RTLS, localization system, data, simulation
Abstract: This paper deals with the collection of production data using elements of a specific localization technology in real time for later use and subsequent possible verification via the TX Plant simulation software platform. The paper defines terms such as RTLS system and its main parts, topology, coverage and hardware part of localization technology.

1 Introduction

In today's modern world, engineers are increasingly focused on full-fledged data collection. In many ways, it is not just about production data based on material flow values and the like. Values such as movements of machines, equipment but also workers are also taken into account. These data are increasingly able to refine our simulations due to more accurate and especially real collected production data. The form of data collection for evaluation and processing of simulations is usually performed by combining software and hardware parts, which ultimately form a unique way for data collection and possibly statistical evaluation, which the simulation program can verify or build on.

2 RTLS technology

Real-time positioning system (RTLS) refers to any system that accurately determines the location of an item or person. RTLS is not a specific type of system or technology, but rather a goal that can be achieved by different asset localization and management systems. An important aspect of RTLS is the time at which assets are monitored, and this data can be used in different ways depending on the application. For example, some applications only need timestamps as the asset traverses the area, while other RTLS applications require much more detailed visibility and require constant updating of time data. The ideal real-time location system can accurately locate, track and manage assets, inventory or people and help companies make informed decisions based on the location data collected [1-3].

Furthermore, it can be said that the RTLS system serves not only to identify the tag, but also to locate it and track the movement in real time. The system determines the location using small devices placed on the objects we track, active RFID tags. RTLS technology is designed mainly for monitoring and determining the position of objects in the interior or exterior (production area, etc.). RTLS is used in many industries with specific applications such as employee tracking and asset tracking. These applications can be found in the manufacturing and mining industries, but are most important in healthcare. The accuracy of this system ranges from meters to tens of centimeters depending on the technology used.

Figure 1 RTLS tags

Volume: 7 2021 Issue: 3 Pages: 19-23 ISSN 1339-9640

We can use several methods to determine the position of the tag in the RTLS system. Most positioning methods are based on the dependence of the distance traveled on the time required to cover that distance.

A method that only works on this principle is called ToA (Time of Arrival). For accurate and continuous measurement, it is necessary to synchronize the time on the receiver and transmitter, which is the biggest disadvantage of this method. The TDoA (Time Difference of Arrival) method eliminated this disadvantage in that, similarly to GPS location, the time differences between neighboring transmitters are based not only on absolute time values. All these methods work with time and are suitable mainly for the exterior, where there is direct visibility from the transmitter to the receiver and a minimum of reflections.

The RSSI (Received Signal Strength Indication) method is based on the signal strength at radio-visible access points. It is based on the dependence of signal strength and distance from the transmitter. The method is easy to apply to spaces inside buildings and to accurately determine the position of the tag, we must know the signal strength of at least three receivers.

3 Parts of the RTLS system

All RTLS applications will consist of several basic components: a transponder, a receiver, and software for interpreting the data from each. The complexity of the system, the technology chosen, and the scope of the application will determine the amount of hardware and software needed to create the ideal RTLS.

Each technology used for RTLS uses its own terminology. Here are some general concepts to help you understand the items and their roles in the system in general.

4 RTLS coverage options

RTLS options and reading ranges vary from one technology and setting to another. For example, the system with the longest reading range, GNSS (GPS), can provide the location of an item in real time anywhere in the world, because the receivers are satellites orbiting the Earth. Other technologies with shorter reading ranges, such as UHF passive RFID, can provide placement in a building or zone. The following are the different levels of coverage achievable with RTLS. It is noted that increased granularity can be achieved with each of these coverage options depending on the technology selected, the number of receivers, the labels, or the type of positioning method chosen.

5 Transponders

A transponder is connected to an item or person to uniquely identify that item or person. A transponder typically receives a signal from a receiver and responds back with its unique ID, but can also transmit an initial signal if it contains an internal power source.

Depending on the type of technology and the purpose of the application, transponders can be:

- Radio Frequency Identification Tags (RFID)
- Bluetooth beacons
- Smart devices
- Wi-Fi tags
- Global Navigation Satellite System (GNSS) / Global Positioning System (GPS) markings
- Ultrasonic markers
- Infrared markers
- Smart devices (depending on mode)

6 Receivers

A receiver is hardware with a power source connected to a network that transmits and receives signals from transponders. The receiver then forwards the collected data to end hosts or databases. In some systems, the receiver may be an existing infrastructure, but in others the receivers need to be purchased and integrated into the application environment.

Depending on the type of technology and the goal of the application, the hardware can be:

- Readers
- Position sensors
- Access points
- Receivers
- Beacons (depending on mode)
- Smart devices (depending on mode)

7 Software

The software in these systems can vary in complexity, from simple software integrated into the receiver's hardware to multiple software instances, such as localization software, middleware, and application software on the host computer. The software can be combined to create the desired system functionality. Three main types are used in RTLS applications:

- Firmware - software that resides on the hardware
- Software or application software - Software that resides on a back-end computer or server
- Middleware - used to connect firmware and application software

Figure 2 Logo of Sewio company

In the case of data collection, in our case the software platform from Sewio is used, which contains all the necessary collection modules [4,5]. Models such as Sensemap, RTLS monitor or SAGE analytics are mainly used.

Acta Simulatio - International Scientific Journal about Simulation
Volume: 7 2021 Issue: 3 Pages: 19-23 ISSN 1339-9640

Four examples of real-time data collection:

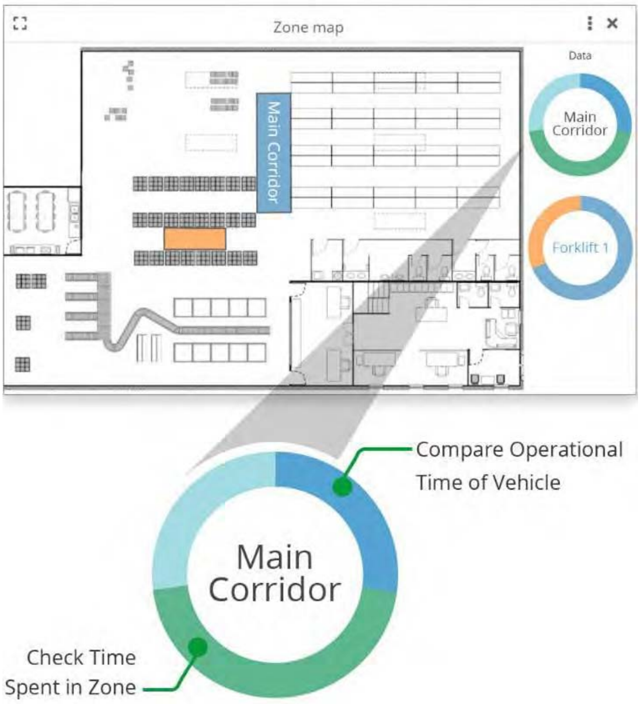

Figure 3 Vehicle time spent in the area

By setting up virtual zones (they can be unlimited) above the devices, it is possible to measure the time spent by vehicles or other assets in those zones. This collected information can be classified into days or individual work shifts.

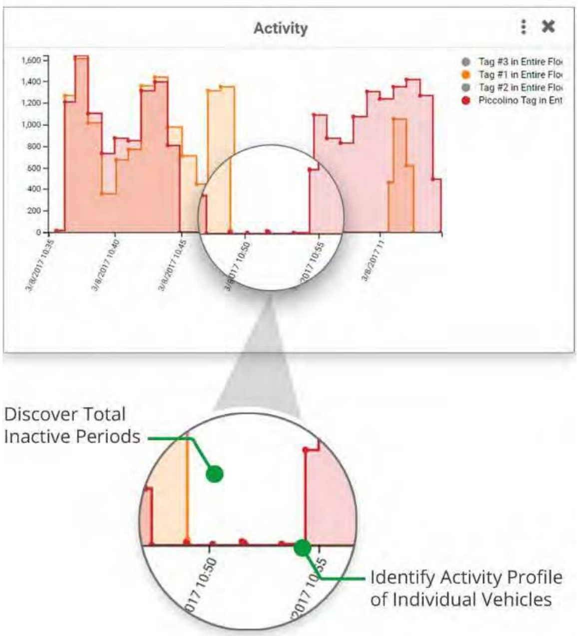

Figure 4 Vehicle activity log

Vehicle activity log can optimize overall fleet utilization efficiency. Elements such as inactive recovery and repair periods are used. Data can be compared with each other.

Figure 5 Heatmap

Heatmaps in general can provide a relatively high level of process clarity in the sense that it is able to detect the distribution and density of in-house operations as well as vulnerabilities that ultimately cause delays.

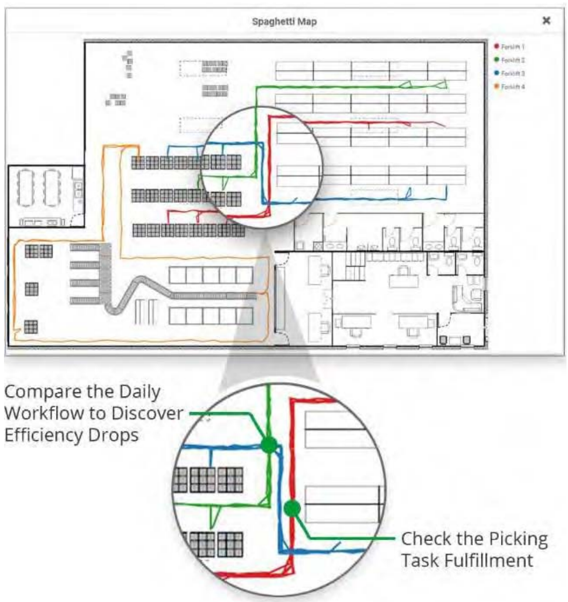

Figure 6 Spaghetti diagram

In this case, the purpose of the spaghetti diagram is to determine the continuity of the material flow for the possibility of further process optimization and to identify inefficiencies in work arrangements, also by wasting transport and unjustified reductions in activity.

The collection of working data for the purpose of creating a simulation model begins in the initial part with the layout, installation and configuration of the hardware and software part of the localization RTLS system. It is necessary to insert a CAD model or layout of the given monitored area from which the data will be collected. If the dxf file is not available. (CAD), the Planner software module allows you to use other file formats such as pdf. In any case, the advantage of CAD files is the possibility of a more sophisticated 3D model if required. In the RTLS studio software, this layout is inserted and its dimensions are also determined, based on which the data will be collected in real parameters. Data is collected based on customer requirements.

In the examples below it is possible to see four examples resp. types of data collection that can be transformed as a basis for creating a simulation, in other words, possible verification of measurement results. For the purpose of linking the collected data and the simulation software in our case TX Plant Simulation, a common excel table is used as the output, which is fully compatible with this software platform [6-10].

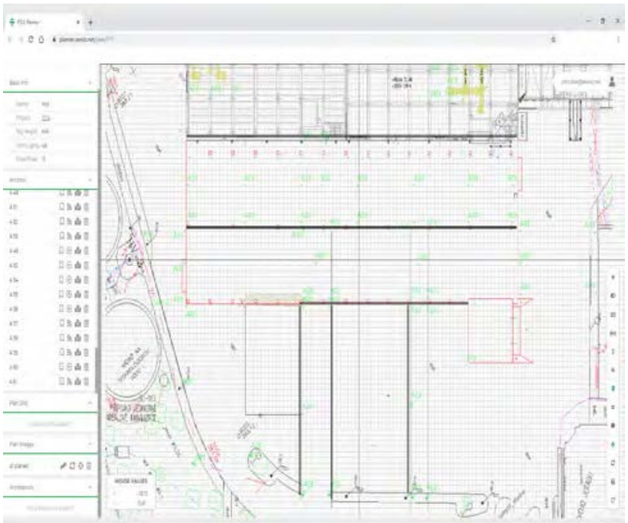

Figure RTLS Planner

8 Conclusions

The idea of Smart Factory today does not bypass any modern enterprise. The process of digitization is becoming faster and faster and it is important to continue this trend and not lag behind the competition if the company wants to be competitive. In this sense, the collection of production data seems to be one of the most important stages in creating this concept. The importance appears only in the optimization of material and production flows, but also in better transparency of production and the overall operation and life of the company. The creation and connection of this model is provided by localization technology in conjunction with the TX Plant Simulation software platform.

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