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Milan MARČAN[1], Ladislav PAPÁNEK[2]

Supervisor: Patrik GRZNÁR[3]

WYKORZYSTANIE SYMULACJI KOMPUTEROWEJ W PROJEKTOWANIU AUTOMATYZACJI PROCESÓW LOGISTYCZNYCH

Streszczenie: W artykule wyrażono pogląd, iż symulacja komputerowa jest obecnie bardzo użytecznym narzędziem do projektowania procesów produkcji oraz logistycznych. Opisano jak symulacja komputerowa może być zastosowana do optymalizacji oraz do planowania efektywnego obiegu materiałów co poprawia działanie czynności logistycznych, umożliwia oszczędności oraz zwiększa konkurencyjność firmy.

Słowa kluczowe: symulacja komputerowa, proces logistyczny, Tecnomatix Plant Simulation

THE USE OF COMPUTER SIMULATION IN THE DESIGN OF LOGISTICS PROCESS AUTOMATION

Summary: The article has demonstrated that computer simulation is nowadays very useful for designing production and logistics processes. It presents how computer simulation can be used to optimize and efficiently plan the movement of materials what improves the performance of the logistics, leading to savings and increased competitiveness of the company.

Keywords: computer simulation, logistic process, Tecnomatix Plant Simulation

1. Introduction

Logistics is a key factor for efficient operation in a company. Its aim is to satisfy the customer's requirements in time and under the most favourable conditions. Effective management and optimisation of logistics processes is a very important element that can ensure the success and increase the competitiveness of a company.

[1] Ing., University of Žilina, Faculty of Mechanical Engineering, Department of Industrial Engineering, e-mail: milan.marcan@fstroj.uniza.sk
[2] Ing., University of Žilina, Faculty of Mechanical Engineering, Department of Industrial Engineering, e-mail: ladislav.papanek@fstroj.uniza.sk
[3] doc., Ing., PhD., University of Žilina, Faculty of Mechanical Engineering, Department of Industrial Engineering, e-mail: patrik.grznar@fstroj.uniza.sk

In this context, the use of computer simulation in the design and implementation of automated logistics systems is nowadays an integral part [1, 2].

Computer simulation allows models of logistics systems to be created in a digital environment and subsequently analysed, tested, and optimised, thus providing valuable information about their behaviour in different scenarios without interfering with the real system [3, 4].

The paper describes a case study of automating a manual logistics process using computer simulation and it is divided into the following sections:

- Analysis of the current state.
- Selection of suitable equipment for automation.
- Creation of a simulation model.
- Selection of a suitable solution option.

The conclusion of the paper also describes the economic evaluation of the proposed solution.

2. Description of the case study

The aim of the case study was to create a design for automating a manual logistics process to save costs. The company for which the study was carried out is involved in the production and recycling of plastics.

The logistics process was the transport of finished products from the production lines to the packaging workstations and the subsequent return of the empty pallet back to the line. The required return on investment was 1.5 years. The automation of this logistics process was implemented by deploying an autonomous mobile robot (AMR) system.

Using computer simulation, the following problems were solved in the preparatory phase of the implementation process of the AMR systems:

- Appropriateness of deployment of the AMR system.
- Selection of the most appropriate type of AMR.
- Determining the optimal number of AMRs.
- Determination of the optimal position and number of charging stations for AMRs.

After implementation, it will also be possible to continue to use the simulation model for the purpose of planning and optimization of the logistics process [5].

2.1 Analysis of the current state

In the initial phase of the case study, it was necessary to analyse the current state of the logistics process as well as the workplace where the logistics process was carried out. The manual logistics process was in its initial state carried out by manual pallet truck. The handling units were standard euro pallets with dimensions 1,200x800x144mm and a load capacity of 1,500kg. Based on the observations made, it was found that the average time to load and unload a pallet from or onto a pallet truck was 27 seconds. Based on the observations, it was also found that the average speed of the worker pulling or pushing the pallet truck is 0.8m/s. It was also observed from the analysis that this logistics process is performed by 14 workers per shift, working 3 shifts representing 8 hours each.

The workplace where the logistics process is carried out has been divided into 2 parts – part A and part B. In each of these parts there is a production zone and a packaging zone. Within the packaging zone, there are 3 pallet positions in each part and within the production zone, there are 7 production lines in part A and 8 production lines in part B. A 2-pallet system is in operation in the production lines. Also, as part the analysis of the current state, the production tacts of the individual lines were identified.

For the purpose of the computer simulation, a logistics aisle traversability analysis was performed, which showed sufficient traversability through all logistics aisles.

2.2 Simulation of the current state

Based on the information from the analysis of the current state, a simulation of the manual logistics process was created in the Siemens Tecnomatix Plant Simulation software. From this simulation, the workload of the individual workers was determined, which is also shown, in Figure 1. The simulation revealed that for workers, average waiting time represents 34.68% of the total workload, with an average worker pushing or pulling a pallet truck 13km in a work shift, which can have a negative impact on the overall physical workload of the worker.

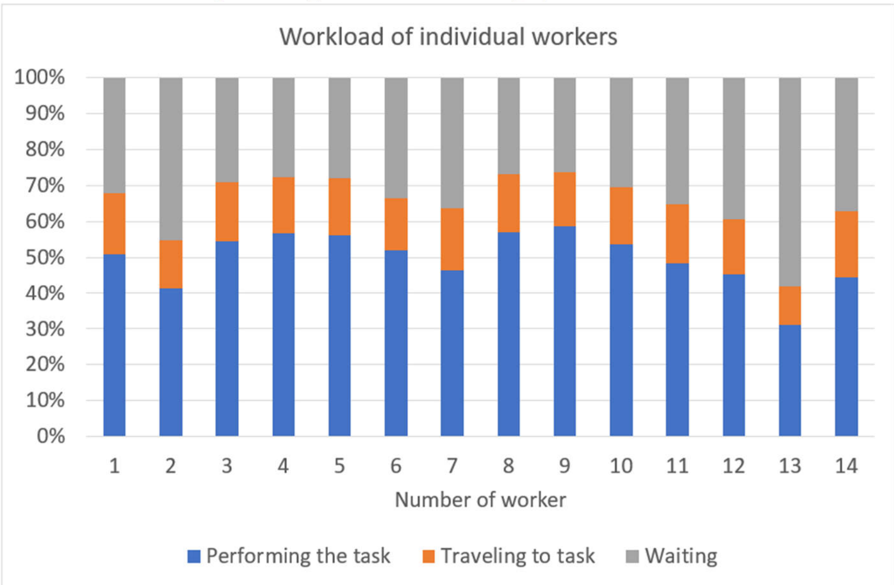

Figure 1. Workload of individual workers [Source: Authors]

3. Selection of the best device for the automation

According to the data obtained from the analysis of the current state, it was necessary to determine the equipment that will be used for the automation of the logistics process. Since this case study was solved in cooperation with Asseco-Ceit a.s. company, AMR equipment for automation of the logistics process will be selected from the portfolio of this company.

Regarding to the workplace and loading and unloading points, forklift AMR system was chosen for automation of the logistics process. Asseco-Ceit, a.s. offers 4 fork AMRs, namely 1500FCB, 1500FS, 1500FSP, and 1500FES. These devices are suitable for transporting pallets placed directly on forks over various distances in industrial halls or warehouses. They are controlled by their own control and monitoring system, are CE certified, and are 5G technology ready. The specifications of the individual AMRs are described in more detail in Table 1. These specifications need to consider the production conditions identified in the current state analysis [6].

Table 1. Technical specifications of AMR devices from Asseco-Ceit, a.s. [Source: Asseco-Ceit, a.s.]

FORKLIFT AMRs				
Name	1500FCB	1500FS	1500FSP	1500FES
AMR type	forked with counterweight	forked with support	fork with support for euro pallets	circumferential fork
Driving directions	forward/reverse, turning on the spot	forward/reverse, turning on the spot	forward/reverse, turning on the spot	forward/reverse, turning on the spot
Speed (m/s)	forward: 2.0; reverse: 0.5	forward: 2.0; reverse: 0.5	forward: 2.0; reverse: 0.5	forward: 2.0; reverse: 0.5
Load capacity (kg)	1,500	1,500	1,500	1,500
Lift	hydraulic	hydraulic	hydraulic	hydraulic
Lift (mm)	4,000/5,000	1,500	300	1,500
Dimensions (L, W, H in mm)	3,645x1,220x3,254	2,386x937x2,554	2,438x900x920	2,968x1,598x2,555
Max pallet dimensions (L, W, H in mm)	length 1,500	width max 1,400 length max 1,500	1,200x800	1,800x2,300x1,600

After evaluating all the parameters and factors, it was found that the AMR 1500FSP is the best suited for the automation of the logistics process, mainly because it is primarily designed for euro pallets, has a small width and sufficient lift.

4. Creation of the simulation model

For the automation of such a logistics process, a very important part is to verify the future state using a dynamic simulation. The simulation will determine the number of AMR devices needed, the number and location of charging stations and will also verify whether automation of this process is even possible and cost-effective. The simulation model was built in the Siemens Tecnomatix Plant Simulation software. There was also used an expansion module for logistics planning developed by Asseco-Ceit, a.s. called CEIT Logistics Library (CLL), which contains an object database, a control interface and a statistical module. The object database contains a complete portfolio of models of the company's logistics technology in 2D and 3D, with objects containing predefined technical parameters such as speed, safety zones, charge/discharge algorithm, predefined animations, etc. The control interface is used to insert and modify individual objects. It contains a database of templates for creating individual logistic commands, control rules for intersections, speed limits, or predefined methods for loading and unloading. The statistics module contains detailed statistical data on individual device utilization, transport delays, maximum transport capacity, battery energy management, Sankey diagram, overall transport efficiency, etc.

The 3D model of the automated workplace logistics process is shown in Figure 2.

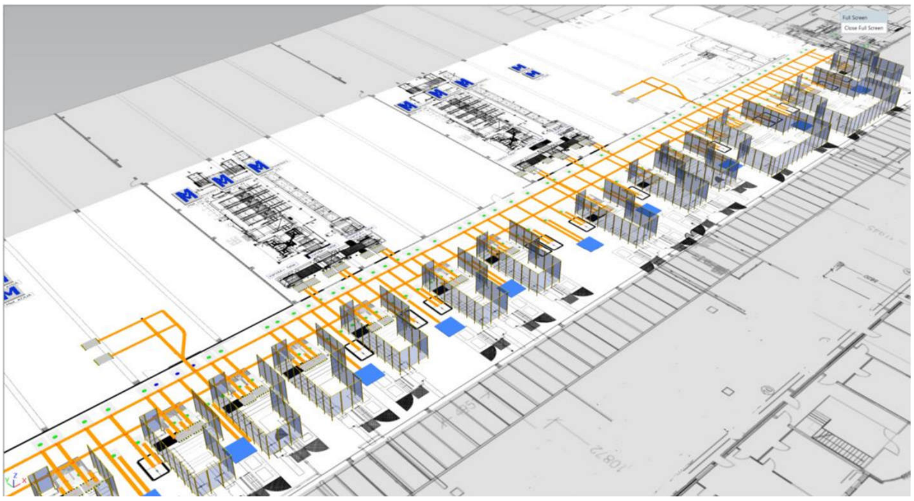

Figure 2. 3D model [Source: Authors]

5. Choosing a suitable solution variant

As part of the case study solution, a number of simulation experiments were created to help determine how many AMR devices are needed for automation, as well as how many charging stations are needed and at what locations. At the end, 3 solution options were picked that best met the production conditions and at the same time the number of AMR devices was not so high that the devices would block each other. In the simulations, the overall utilization of the logistics devices needs to be at 85.00% due to unpredictable situations.

5.1 Variant 1

The first option involved the deployment of 10 AMR devices, with 5 AMRs deployed in part A and 5 AMRs in part B. The number of charging stations and their distribution for parts A and B is the same as the number and distribution of AMR devices.

In this variant, part A was underutilized, where the overall utilization of AMR facilities was 96.39%. Part B was at the optimal level in terms of overall utilization of facilities in this variant, averaging 81.69%. A graph showing the overall device utilization for variant 1 is shown in Figure 3.

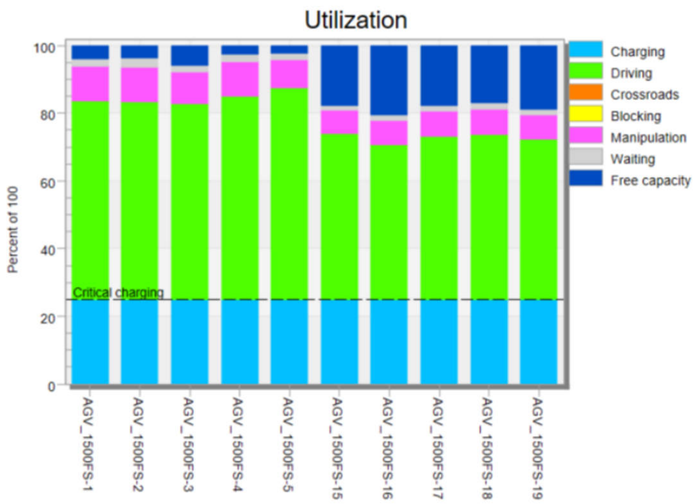

Figure 3. Device utilization – Variant 1 [Source: Authors]

5.2 Variant 2

In the second variant, 9 AMR devices were deployed, with 5 AMRs deployed on Part A and 4 AMRs on Part B. The number and distribution of charging stations here was identical to the number and distribution of AMR devices.

Part A was also underutilized in this variant, with a 96.42% utilization of AMR facilities. Part B was also underutilized in this variant and its overall AMR device utilization was 91.27%. The overall equipment utilization for this variant can be seen in Figure 4.

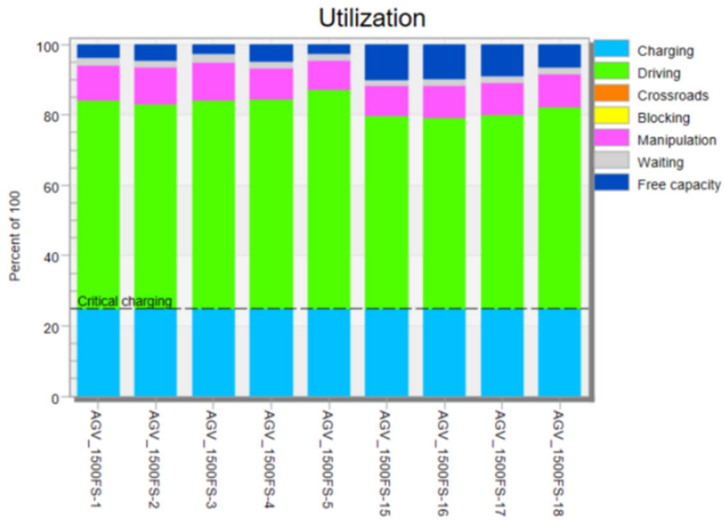

Figure 4. Device utilization – Variant 2 [Source: Authors]

5.3 Variant 3

In Variant 3, 11 AMR devices were deployed, with 6 devices deployed in Part A and 5 devices deployed in Part B. The number and distribution of charging stations here was identical to the number and distribution of AMR devices.

For this variant, the utilization in both parts was acceptable at 85.95% for Part A and 82.76% for Part B. In the case of this variant, the results can also be observed in the graph shown in Figure 5.

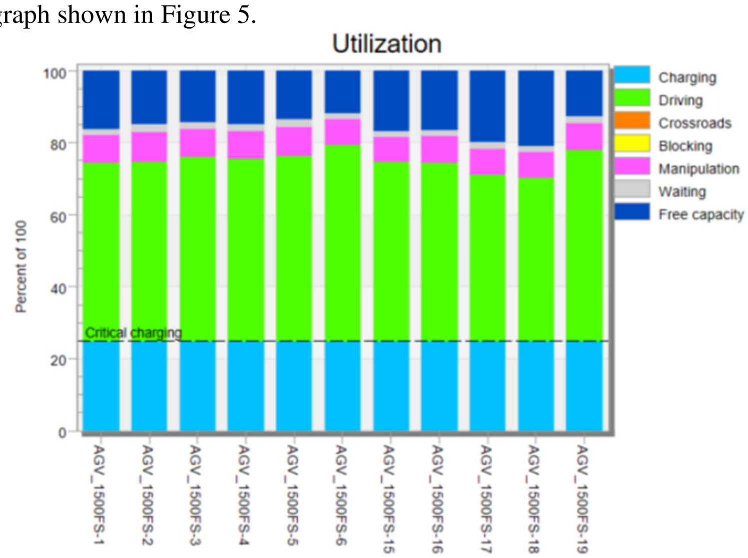

Figure 5. Device utilization – Variant 3 [Source: Authors]

6. Selecting a suitable solution variant

Within the case study, 3 variants of the logistics process automation design were described in more detail. Each of the variants was verified by dynamic simulation, searching for the optimal solution. According to the previous chapter, it can be concluded that variant 3 is the most suitable variant for implementation in terms of equipment utilization. However, the implementation costs, the subsequent annual costs of the logistics system after implementation, the expected annual savings and the expected return on investment also need to be considered. To assess these indicators, a table of expected financial costs and returns has been produced and is shown in Table 2.

Table 2. Economic evaluation [Source: Authors]

	Variant 1	Variant 2	Vartiant 3
Number of AMR	10	9	11
Number of charging stations	10	9	11
AMR cost [€]	680,800.00	612,720.	748,880.00
Charging stations cost [€]	23,300.00	20,970.00	25,630.00
Implementation cost [€]	220,000.00	198,000.00	242,000.00
Total cost of system implementation [€]	924,100.00	831,690.00	1,016,510.00
Total annual cost of system after implementation [€]	919,000.00	913,500.00	924,500.00
Expected annual savings [€]	1,097,000.000	1,102,500.00	1,091,500.00
Expected return on investment [year]	0.84	0.75	0.93

After evaluating the three variants, variant 3 was recommended for implementation even though the cost of implementation of this variant was the highest of all three variants. This option was recommended mainly because of the most appropriate utilization of the devices, but also because the condition of return on investment was fulfilled. The advantage of this option is also the possibility to cover an increase in production of 10.00% compared to the current situation without additional investment.

7. Conclusion

The aim of the paper was to demonstrate the use of computer simulation in the automation of a manual logistics process. Computer simulation is a very useful tool due to the ever-increasing trend of automation, which allows the verification and evaluation of the proposed solutions in a dynamic virtual environment, with minimal financial and time costs.

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