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ANALIZA SYSTEMU LOGISTYKI WEWNĄTRZZAKŁADOWEJ

Streszczenie: Artykuł poświęcono problemom związanym z analizą system logistyki wewnątrzzakładowej z użyciem oprogramowania komercyjnego 'Plant Simulation'. Stwierdzono, że istnieje możliwość zarządzania oraz rozmieszczania pół-produktów, zaprojektowania sprzętu, który pozwoli na przemieszczanie tychże obiektów, ustalenie dróg transportowych dla pojazdów autonomicznych (AGV). W pracy, omówiono także jak zaprojektowano i zbudowano model symulacyjny do zobrazowania transportu wewnątrzzakładowego.

Słowa kluczowe: logistyka, wyposażenie w AGV (pojazdy autonomiczne), symulacja, oprogramowanie 'Plant Simulation'

ANALYSIS OF THE SYSTEM OF INTERNAL LOGISTIC

Abstract: The article is devoted to questions related to the analysis of internal logistics system design using Plant Simulation software. The analysis made it possible to solve the problem of disposition and location of the store of intermediate products, design of handling equipment, transport route for AGV equipment. The analysis was used in the design of the simulation model, which is also presented in the article.

Keywords: logistics, AGV equipment, simulation, Plant Simulation.

1. Introduction

The current requirements for the transformation of enterprises to the conditions of future intelligent plants place increased demands on the level of automation also in Slovak manufacturing companies. In order for the company to be able to maintain

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its competitiveness and economic success even in these new conditions, the company must follow trends and developments in industry. Therefore, today's companies are on the road to automating the entire plant and optimizing production processes in operation. In this way, all production and logistics processes taking place in the company are improved. [1]

1.1. Plant Simulation

Nowadays, with a very rapid increase in the performance of computer technology, it is possible to observe a very massive advent of techniques and methods, which until recently were the highness of only very powerful computers with the necessary team of highly qualified specialists. One such technique is computer simulation. [2]
Plant Simulation allows simulation to verify and analyse the suitability of the proposed variants for a given plant operation. Analysis tasks are performed by experimenting with a simulation model by inputting input data, thus imitating the dynamics of system states. One of the main advantages of the simulation is the ability to simulate processes in a user-requested time. Simulation of the required real time in computer simulation takes only a few minutes. After running the simulation run, it gives several reports based on which it is possible to verify the validity of the required main objective of the simulation. Through the models it is possible to find the optimal solution under the specified constraints within a short time. [4, 5]

2. Current state of storage

Storage in the company where the new material storage design has been implemented is organized in a way of interchange storage, which is suitable for storing many assortment items. Storage for storing cartridges with different types of semi-finished products. [3]

Figure 1. Stock current status [Authors]

Depending on the nature of the stored material and the storage means used, the storage (Fig. 1.) is a stack type of storage. The advantages of such a type of storage are high flexibility and low investment costs. But at the same time, it has several drawbacks

such as the lack of direct access to all items, low mechanization and automation options without a complete storage reorganization.
Half finished products are stored in several small storage located in several locations in operation.

2.1. Transport in service

Operation operates in three-shift mode. So, the working time of 1 change equals 480 minutes of which, according to the Labour Code, the worker is entitled to a 30-minute break.
In the plant, the transport of materials, half finished products are carried out by 12 workers: one is a wheelchair cutter; one is wheelchair rolling and ten are wheelchair ready. Ready-to-wear wheelchairs have similar routes and will therefore be divided into two basic types:

- Worker 1 will include staff in charge of KMPU 1 to 7 and 13 to 17 and 20.
- Worker 2 will include staff in charge machines KMPU 8 to 10 and 11 to 19.

An analysis of all the operations taking place in the plant was performed. All activities were divided among workers who carry out these activities. From the analysis, the duration of transport (Tab. 1.) was determined by individual workers for one working shift. Time consumption

Table 1. List of indicators [Authors]

Worker	Working time (min)	Break time (min)	Total runway duration in min		
			min.	max.	average
Wheelchair cutter	480	30	305	437	396
Wheelchair rolling mill			348	423	403
Worker 1			380	447	414
Worker 2			374	440	407

The total runway duration has shown the time consumption of operations logistics staff (Fig. 2-3).

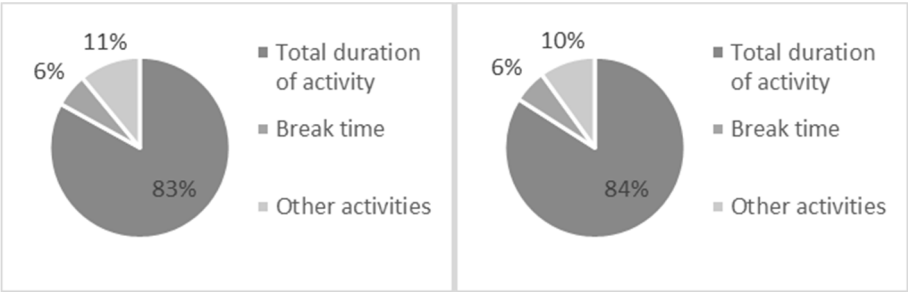

Figure 2. Time consuming of wheelchair cutter and wheelchair rolling mill [Authors]

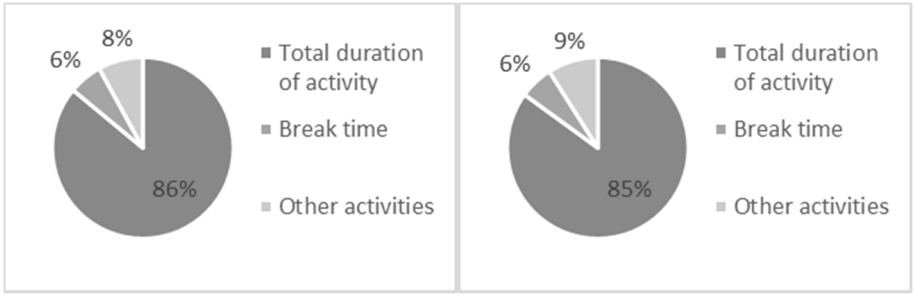

Figure 3. Time consuming of Worker 1and Worker 2 [Authors]

Based on the analysis of the movement of logistics employees of the assigned operation, sections of the aisles that are most heavily loaded (Fig. 4.) and which are bottlenecks in operation from the perspective of inter-operational transport have been identified.

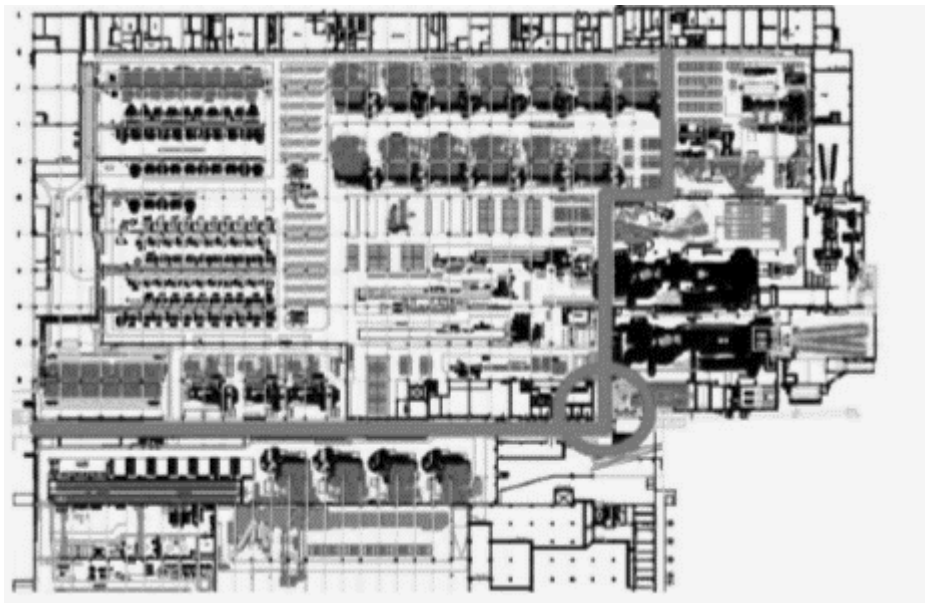

Figure 4. Traffic aisle congestion [Authors]

Overloaded is mainly the highway, which connects the old hall and the new hall. Also, a problem is the aisle beside the elevator, which is unidirectional and at the same time the mixture is transported to all workplaces through this elevator.
Based on the analysis, a new transport system was designed and subsequently verified using a simulation model.

3. Proposal of location and disposition of semi-finished storage

The solved operation is in the old hall, so the layout of workplaces and storage was considered with the characteristics of this hall. For the above reasons, the stocking

of semi-finished products is currently carried out in several small storage, which are in several locations in operation (Fig.5.).

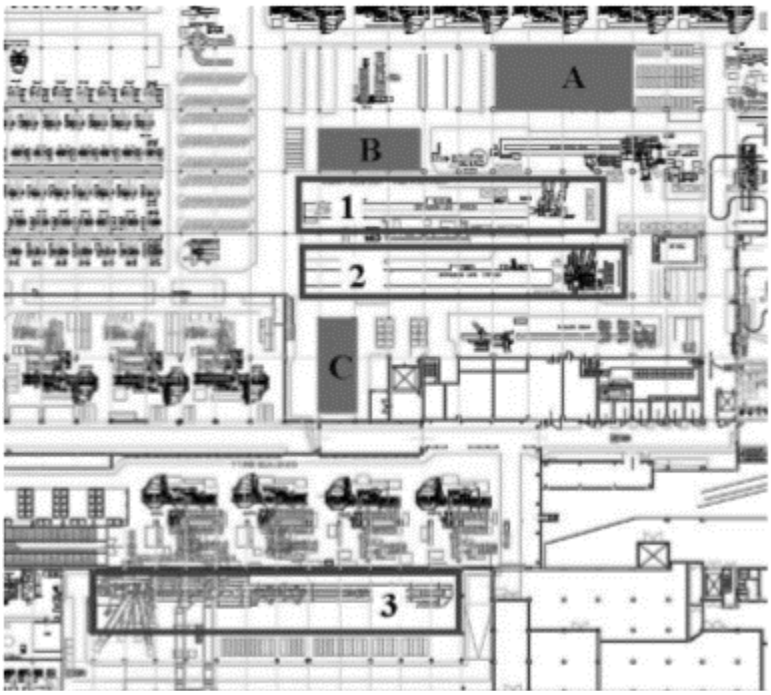

Figure 5. Current stock status, A to C concurrent storage; 1 to 3 – extruders [Authors]

When designing an automated storage, it is assumed that the storage will be in one city (Fig. 6.). In this way, a part of the space that can be used for further adjustments and improvement of the layout is also released.

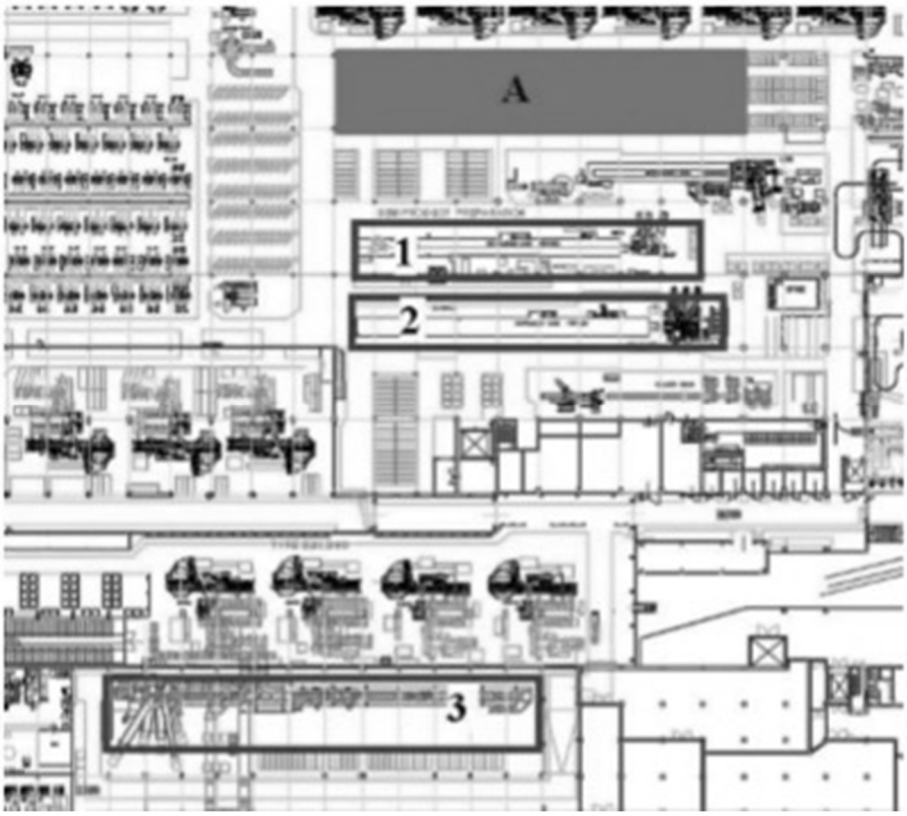

Figure 6. Disposition after storage automation, A - Disposition after storage automation; 1 to 3 – extruders [Authors]

3.1 Characteristics of automated stock of semi-finished products

An optimized storage management is represented by an organized storage (Fig. 7.), strict storage controls, determination of the necessary batches for the reloading activity. Flexible organizational flows are provided by electronic data collection, which also affects inventory policy and storage operations.
An optimally working storage should meet the following conditions:

- The site condition, i. as much material as possible in as little space as possible.
- The condition of time, i. faster access to goods anywhere, anytime.
- Condition of money, i. material flow = capital flow.

Using an automated system will save a lot of time in the company's logistics processes. Thanks to time savings, the economic benefits of automated systems are clearly visible compared to the manual variant. Automated solutions are a real alternative to manual solutions.
The running times are significantly shorter, the error rate during storage and picking is significantly reduced, the goods are still available, and the automated storage

system requires much less storage space and space. A permanent inventory is performed using a computer-controlled system.

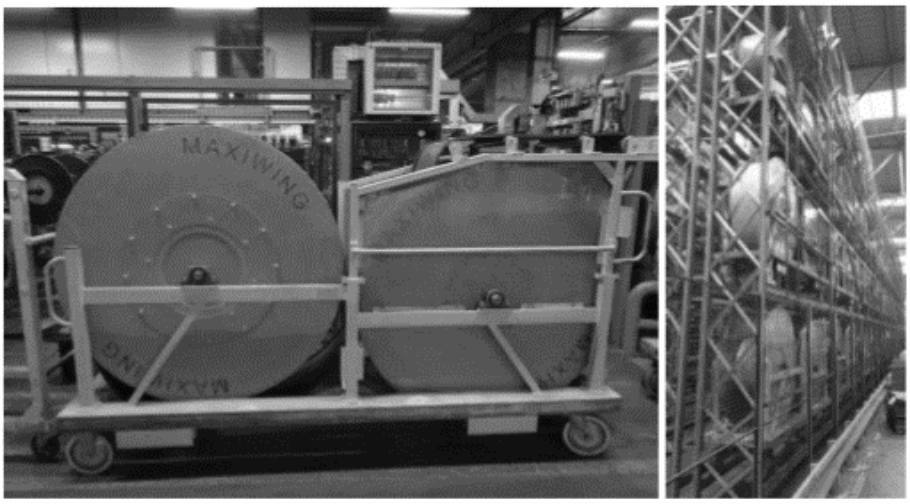

Figure 7. Handling units [Authors]

As a closed system, the automated storage also has the advantage of preventing unauthorized persons from accessing the goods.
Since the stock material can easily deform, it is best to store it in handling units (Fig. 7.)

The handling units will be stored in storage equipment - rack.
The racking system is the key to achieving optimum performance when handling and storing goods. Increasing the efficiency of storage using the racking system will make the handling of goods more transparent and thus improve not only the material but also the financial flow of the company.
Shelf system advantages:

- Direct access to all products.
- Free allocation of storage location.
- Possibility of random selection of storage location.

The racks will be 3-storey and the total planned storage capacity is 300 cartridges.
The automated storage includes crane-lift devices designed for automatic storage. They move along the aisles along the rails and carry out the storage and removal of goods. The storage transporters (Fig.8.) are controlled by the control software which coordinates all their movements.

Figure 8. Crane-lift equipment [1]

Advantages of crane-lift equipment:

- Automation of operations for goods receipt and delivery.
- Enables managed and constantly updated inventory management.
- Manual processing errors are excluded.
- Possibility to adapt to special working conditions.

3.2. Handling equipment for the transport of semi-finished products

About the objective of automation of production and logistics processes in operation, an AGV truck was designed as a handling device for transport of semi-finished products in production. Its main task will be transport of semi-finished products between automated storage and extrusion machines. Basic requirements for the parameters of the selected AGV equipment

- 1,000 kg load capacity – the load capacity of the device has been determined with respect to the maximum weight of one full shipping cassette, which is 950 kg.
- Average speed of 6 km / h – the speed of movement was determined about the safety of the transport system operation, prevention of collisions and possible injuries of workers
- The size of the AGV equipment itself was determined about the requirement of good functioning even in narrow spaces.
- Enough battery life.

3.3. Transport routes for AGV equipment

With regard to the arrangement of the machines and the location of the automated storage (Fig. 6.), Two basic variants of the routes for the transport of the semi-finished product to the storage are possible.

These two variants were processed into simulation models using data processed in the analysis of transports and taking into account the rules for material movement in operation, which were subsequently used in design verification and selection of the most suitable solution variant.

Route 1

The route length is 195 m. (Fig. 9.) The route passes through the main highway in the production hall (1), the section next to the mill (2) is also problematic. This section of the track is already quite overloaded. In terms of outputs from lines 1 and 2, the route is designed optimally.

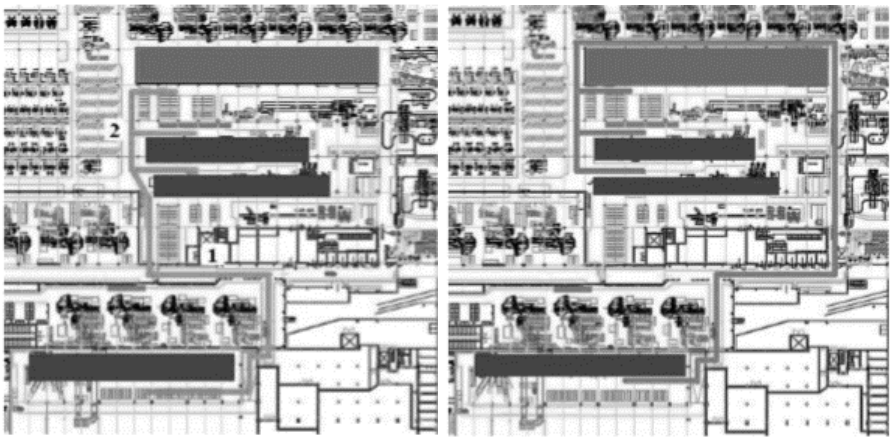

Figure 9. Route 1and Route 2 [Authors]

Route 2.
The route length is 251 m. (Fig. 9.). The route also has a section that passes through the main highway. As this section is located next to the elevator, it is overloaded by other means of transport. another limitation in this section is the one-way lane.
Both alternates are realistic in the present or soon due to the technological and organizational possibilities of the company and will therefore be verified using computer simulation means.

3.4. Simulation models

During simulation of variant 1 (Fig. 10.), it was considered with the specified parameters and conditions and at the same time it was specified that only one trolley could be located on one section of the route. The truck has come to a halt when the truck is closer to the other truck than 5 meters away. The truck can accelerate or slow down as needed. At the same time, the simulation model also considered a limited amount of inventory next to the machines, which cannot be more than one piece.

Figure 10. Simulation of variant 1 and variant 2 [Authors]

The simulation of variant 2 (Fig. 10.) was considered with the same parameters, conditions and limitations as for variant 1. The individual variants thus differ from each other by the situation of the transport route itself, its length and the utilization of individual sections of the transport route. These differences were then reflected in the simulation models of the variants.
The simulation of both route variants was carried out under the conditions described in the previous point. Plant Simulation software, part of the Siemens Tecnomatix package, was used to verify the application. The simulation software was chosen with regard to it is suitability for the simulation of production and logistics systems.

4. Conclusion

The simulation not only verified the individual variants of the transport routes, but also showed the optimal capacity of the automatic storage, which was designed for 300 pcs. Altogether 22 simulation runs were realized for individual variants of transport routes. One simulation lasts 7 days and 8 hours to start up. Based on their results, statistical data were processed to compare both variants of the solution (Tab. 2.).

Table 2. Results of simulation experiments - comparison of variants [Authors]

Parameter	Variant 1	Variant 2
Total efficiency: Machine 1 Machine 2 Machine 3 AVG (average)	 66.000 % 66.000 % 60.000 % 75.750 %	 66.000 % 66.000 % 60.000 % 58.625 %
Waiting time (average)	24.250 %	41.375 %
Running 1 AVG per 1 change (average)	1011 m	1198 m
Quantity of transports cycles made 1 AGV per change (average)	150 cycles	102 cycles
Number of AGV trucks	3 pieces	4 pieces
Route length	195 m	251 m

Simulation experiments confirmed the quantity of trolleys determined by static capacity calculation. Simultaneously, the average utilization of AGV trucks and the necessary capacity of the automated storage were determined on the basis of the simulation. With a storage capacity of 300 pcs, the storage works steadily and without waiting for a free space

The benefits of introducing an automated storage include centralizing the storage of the entire tread stock range, as well as optimizing the utilization of the area and capacity of the new storage. The proposed solution allows to place a larger amount of material on a smaller area. At the same time, the free space can be used to store storage for other types of material items. The proposed automated storage improves the transparency of inventory in operation, which allows to increase the accuracy and speed of stock picking and storage processes.

Benefits of implementing AGV equipment:

- Accuracy and safety of operation.
- Possibility to work 24 h / 7 days without human intervention.
- Absence of material handling infrastructures.
- Update without overall downtime.
- No errors at destination.
- Greater accuracy in inventory management.
- Low operating costs.

Based on the processing of the simulation results and after consultation with the project team of the company, the variant of the transport route No. 1 has been selected. This variant has a shorter distance compared to the second variant; the route lies on less loaded sections of transport aisles. A smaller number of trucks is required to put the variant into operation, which reduces the cost of system deployment.

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