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MANAGEMENT OF A SIMULATION PROJECT IN A MANUFACTURING COMPANY

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Purpose: The main goal of managing a simulation project in a manufacturing company regarding the optimization of warehouse preparation and placement of galvanized steel profiles using FlexSim software is to improve logistics processes in the warehouse and increase production efficiency. The aim of the research is to develop an effective package addressing scheme and to introduce a special code that will enable precise management of profile storage and will improve the process of completing customer orders.
Design/methodology/approach: The simulation project management methodology is based on several key steps: defining goals and requirements, collecting data and modeling, designing scenarios, performing simulations, and designing an individual addressing scheme for parcels in the warehouse.
Findings: Simulations allow you to find the optimal warehouse layout that ensures effective use of the available space. This, in turn, allows you to increase the storage capacity and better organize the storage of profiles, which translates into minimizing losses and costs. Simulations allow you to test different strategies for placing profiles in a warehouse to minimize the time and effort needed to find them. Optimizing the placement process allows parcels to be located faster and more precisely, which speeds up order picking.
Research limitations/implications: Simulation-based process optimization requires model accuracy and reliability. Imprecise or inaccurate data can affect simulation results and lead to inappropriate decisions. This requires careful data collection and model validation before implementation. Further research may focus on optimizing routes inside the warehouse and optimizing internal logistics. Investigating the best routes and methods of transport will minimize the time your products pass through your warehouse. Research can introduce an element of random events, such as machine breakdowns or fluctuating demand, into the simulation model to better reflect real conditions and increase the reliability of the results.
Practical implications: Improvement of warehouse processes and the introduction of a special code addressing the shipment can significantly reduce the risk of errors and material losses, which contributes to greater accuracy and efficiency of operation and improvement of customer relations.

Social implications: Effective optimization of warehouse and production processes contributes to increased work efficiency. Reduction of redundant activities, more precise management of resources, and more efficient order picking can affect employee satisfaction as well as positively affect working conditions and security.
Originality/value: The key element of originality is using advanced FlexSim software for modeling and simulation of storage processes and producing galvanized steel profiles. Simulations of this type integrated with real data and the implementation of a special package addressing code constitute a comprehensive approach to optimizing the entire process. The results of such a study can have a significant impact on the practice in manufacturing companies, enabling more effective warehouse management, shortening the time of picking orders, reducing costs, optimal use of resources, and improving the quality of customer service. It is an interdisciplinary approach that combines aspects of production management, logistics, process optimization, and the use of advanced IT tools.

Keywords: Simulation project management, process simulation, FlexSim software.

Category of the paper: research paper.

1. Introduction

In today's rapidly changing environment, business success relies on self-improvement, i.e. preparation and implementation of changes under the pressure of time and costs (Griffin, 2017). The implementation of tasks determined by time and financial resources is an area of commitment often referred to in Polish literature as projects. They combine resources, skills, technologies, and ideas to achieve specific benefits (Kopczewski, 2009). Effective project management ensures that benefits or goals are achieved within the budget, within a specific time frame, and by accepted quality standards (Sołtysik, 2016). As research conducted by Polish companies shows, the largest percentage of implemented projects is related to information technology. At the same time, these types of projects are very complicated. Firstly, this is due to the very nature of information technology. Secondly, the human factor plays an important role in the failure of IT projects, which is much greater than in the case of other projects. Information technology is still a relatively young field of science, and its widespread use in economic life began less than 30 years ago (in Poland even later). Contact with information technology often evokes fear and fear of changes in many users due to their psychological conditioning (Dziekoński, 2010). The effectiveness of the company's operation depends on the ability to quickly and frequently adapt to changes in the market (Trocki et al., 2003). In today's competitive reality, the lack of these adaptive skills can lead to market failure for many organizations. Therefore, the organization must have the ability to manage change, which is often an integral part of project management. The implementation of projects usually changes the way the company operates, its structure, and the way information flows and distributes (Williams, 2005). To be successful in a simulation project, you must go through well-defined stages. The process of creating a simulation model consists in mapping the real system in the form of a time model (Wyrozębki, 2007). During the observation of the real system, a model is constructed that reflects its functioning. Each observer may have a different point of view or focus on different features of the system (Wysocki, 2013). Since all of these properties can be important, the simulation methodology must facilitate communication and overall understanding of the simulation project. A non-simulation expert does not have to be directly involved in the creation of the model but can define the purpose of the simulation, run the model, and perform the simulation analysis. The degree of detail of each stage of the simulation project is adapted to the level of complexity of the analyzed system (Figure 1) (Abbasi et al., 2018).

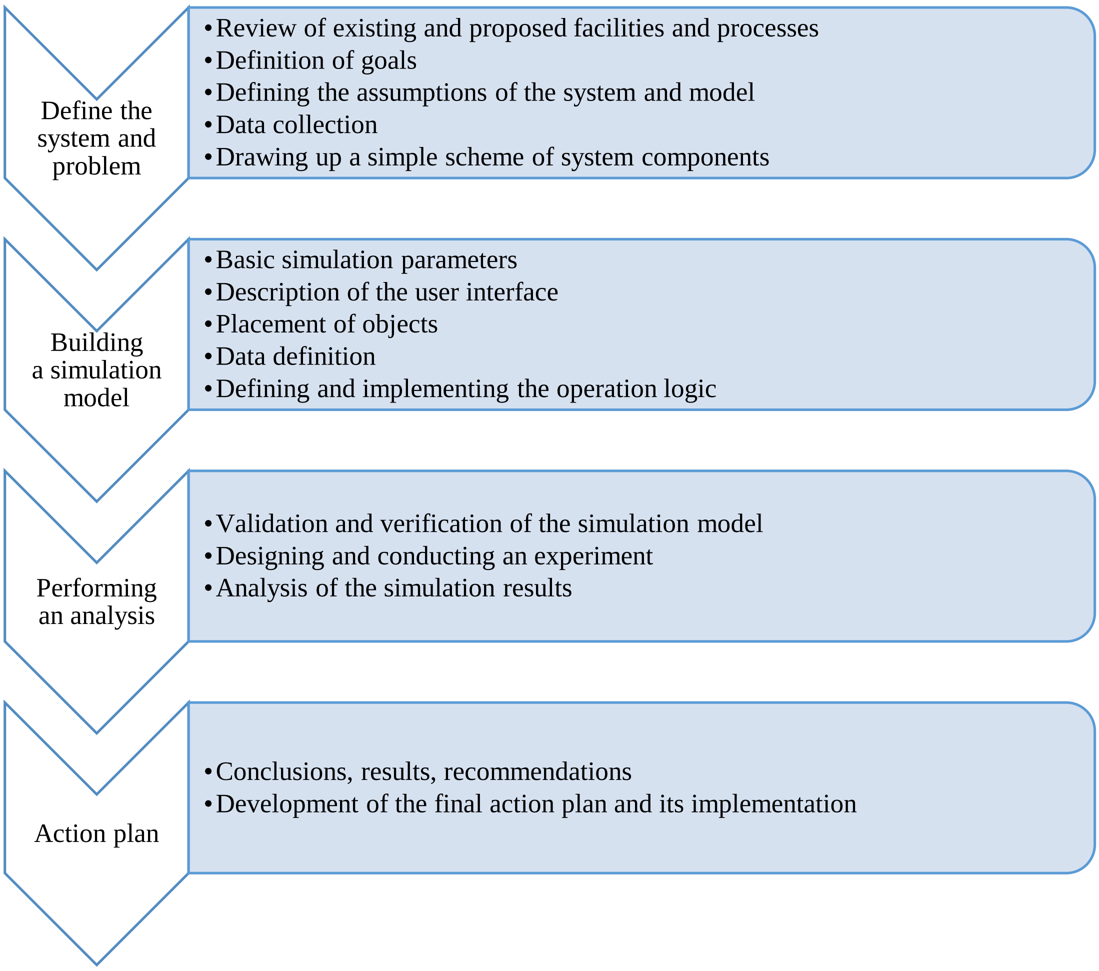

Figure 1. Stages of the simulation project.

Source: Own elaboration.

The simulation project is divided into four stages, depending on the level of detail related to the analyzed system. In the first stage, it is important to understand and plan the project. The second step is to abstract the behavior of the system and present it as a model. In the third step, the simulation model is used for experiments and analysis. The last stage focuses on operation, collecting information and observations from simulation experiments, which are later used to make decisions about improving the operation of the system (Matwiejczuk, 2018). To effectively organize a simulation project, it is worth using a design template that will allow for accurate documentation of all activities performed at each stage. Through reliable documentation, everyone involved in the project will have a common and uniform pool of knowledge about it. The first field in the template is the name of the simulation project that makes sense to the project team and other stakeholders. Simulation model names should include the current version number. Since the simulation project has specific goals, it is useful to include a concise summary of the results obtained that reflects its purpose and essence. In the first stage of the simulation project, an important task is to define the system and justify the implementation of this project (Morris, 2010). In this step, the functional specification is created, which is the definition of the project and the materials associated with it. The functional specification can be used as the basis for an inquiry addressed to external entities that will be responsible for the implementation of the simulation model. At this stage, consultations are carried out with the persons responsible for the problem under study (Trocki, 2019). In addition, familiarize yourself with the buildings and processes that will be represented in the simulation model. If the designed system does not yet exist, you can conduct a study visit to the existing buildings or consult the design and operational documentation. In any case, the people involved should have a good understanding and knowledge of the characteristics and functioning of the system under study (Wirkus, 2013). As you familiarize yourself with your infrastructure and processes, you should do the following:

- It may be useful to carry out a thorough survey of the building during the study visit, even if members of the design team are already working there.
- During the study visit, an inventory should be made of all system components, such as machines, production stations in progress, production parameters, storage locations for tools, and other elements used in the production process. In addition, the product components, details, and subassemblies at each stage of assembly should be listed.
- You should also accurately record all resources in your system, such as conveyors, forklifts, AGVs, maintenance workers, machine operators, cranes, robots, and other resources used in the production process.
- After reviewing all the elements of the system, it is worth taking notes on the characteristic features of its operation. This includes the analysis of special operating logic, task selection, and collaboration between workers, equipment, and other system components.
- Record all acronyms and terminology used to describe equipment, parts, and details. The use of these terms will allow for a better understanding of the model by those familiar with the actual process.
- Before the study visit, it is worth obtaining a plan of the building or making a drawing of the spatial layout yourself during the visit. In the drawing, you can mark individual elements of the system and add appropriate notes. Such supplemented drawings will facilitate the analysis of the spatial layout of the designed system without having to visit the building again. The drawings can also be used as a background for the simulation

model being built by importing them into the simulation program, where they will be the scale for the placed model elements.

- A good way to get to know the system under study is to spend time in the production area and talk to the employees who operate it. Accurate knowledge about the capabilities of the system and the processes implemented in it will allow you to construct the correct model.

Formulating the objectives of the simulation project is a key step, as objectives are an important element understood by management and other stakeholders (Witkowski et al., 2007). Through precisely defined goals, you can manage expectations, and by implementing subsequent stages of the project, you can achieve success in its entirety. Clear and specific goals are criteria for project success (Meredith, 2002). While intentions can be expressed in general terms, objectives should be more specific. At an early stage of the project, it is important to get answers to several questions, such as:

- What is the main purpose of creating a simulation model?
- What value will the simulation analysis bring?
- What elements will be included in the scope of the model?
- What answers are expected from the simulation model?
- What performance indicators will be adopted (e.g. productivity, total production time, resource utilization, delays in the system)?

Precisely defined objectives of the simulation project enable effective monitoring of progress and evaluation of the achieved results. They are the foundation for effective project management and allow you to achieve the intended benefits and optimize the operation of the system.

The defined objectives indicate the performance indicators that will be used for the assessment. It is worth determining in what form the responses to these indicators will be presented. In the project, it is worth taking into account the guidelines for the final report, which will determine its layout and key elements. More detailed issues will be clarified during the project implementation (Pawlewski, 2010).

Simulation has been extensively utilized in various industries for process optimization (Beaverstock et al., 2011). In the context of manufacturing, simulation aids in understanding the dynamic behavior of production systems, identifying bottlenecks, evaluating various scenarios, and making data-driven decisions (Garrido, 2009). Previous studies have shown the effectiveness of simulation project management in improving productivity and resource allocation in manufacturing companies (Beaverstock et al., 2017). FlexSim has emerged as a popular simulation software due to its user-friendly interface, powerful modeling capabilities, and ability to integrate with real-world data (Leks et al., 2015). Several researchers have successfully employed FlexSim in different manufacturing environments, showcasing its potential to optimize complex production processes (Kaczmar, 2015).

2. Methodology

The research begins with the collection of relevant data from the production company's warehouse operations. This includes information on profile types, customer orders, order frequencies, storage capacities, and handling equipment. Real-world data is crucial for building an accurate simulation model that reflects the actual warehouse dynamics.

Using FlexSim software, a detailed 3D model of the warehouse is constructed. The layout includes aisles, racks, shelves, and storage areas, accurately representing the warehouse's physical characteristics and constraints.

Different profile placement strategies are developed and tested in the simulation model. These strategies consider factors such as order prioritization, storage capacity constraints, profile accessibility, and order-picking efficiency.

The simulation model is executed using various profile placement strategies, and the performance metrics are measured and compared. The results of the analysis inform the identification of the most effective profile placement strategy. The simulation analysis provides valuable insights into the warehouse preparation and profile placement process for galvanized steel profiles. The results obtained from testing different strategies enable the production company to make data-driven decisions for optimizing warehouse operations and meeting customer demands efficiently.

3. Using simulation to solve problems

3.1. Characteristics of the production process

The production of galvanized steel profiles starts with the creation of the design tools that will be used to profile the steel. The main raw material for the production of profiles is hot-dip galvanized steel. Steel coils are delivered from the steelworks, each coil weighs about 10 Mg. The sheets have different thicknesses, from 1 to 5 mm, and their surface is covered with a layer of zinc with a thickness of 7 to 30 μm. The sheets are about 1250 mm wide, so they are cut into strips, which are then used to produce profiles. The steel coils are placed on the decoiler of the slitting line. After the sheet is unrolled, it goes to the section with cutting knives. One coil can produce up to 30 tapes of various widths, from 40 to 500 mm. To compensate for different winding speeds, it is necessary to use a loop bottom. At the end of the production line, ready-made tapes are collected, which then go to the profiling line. The first step in this process is smoothing the unevenness of the sheet metal with a straightening machine to ensure a smooth production run. In order not to interrupt production, the strip that ends is welded to the material from the next coil. The unfolded sheet metal is stored in the accumulator, which acts as a buffer for the entire line, and the material from the accumulator is continuously fed to the profiling part. At subsequent forming stations, the tape is gradually bent, which allows to obtain the desired shape of the profile. Depending on the type of profile, it may be necessary to make from 5 to 15 bends. After bending, the two sections of the profile are welded with high-frequency current where they meet. Excess material is removed with cutting knives. The next step is to protect the weld area with a zinc coating. Then the profile goes to the cooling chute, where a special emulsion removes the excess heat generated during the process. This step is necessary before profile calibration, during which the profiles are straightened and reach their final dimensions. After calibration, the operator visually checks the quality of the weld and verifies the dimensions of the profile. The next step is to cut the profiles to the desired lengths using a flying saw. After this stage, the profiles are dried, and the table ensures the gravitational outflow of the remaining emulsion, which is in the profiles after subsequent stages of the process. After the profiling process is completed, two operators place the profiles on the storage table, where the packages are formed. To protect against the formation of white corrosion, the profiles are packed using plastic separators that prevent them from touching each other. After the packing is completed, the ready packages go to the other part of the hall and are placed on the floor. Due to problems with picking orders, packages are not placed on storage racks. The use of the FlexSim simulation model will contribute to the improvement of the warehousing process and will facilitate the completion of customer orders. Thanks to the simulation, it will be possible to optimally plan the warehouse layout, reduce picking time and minimize storage costs, which will bring benefits in terms of efficiency and customer satisfaction.

3.2. Analysis of the simulation - discussion

The model was constructed taking into account the loading and unloading operations. The production process focuses on the production of closed galvanized profiles with a circular cross-section. These profiles, made of galvanized sheets, provide long-term protection against corrosion and are commonly used in structures that require increased strength (Jurczyk, 2023). To obtain profiles with a circular cross-section, the cold rolling method was used. In the warehouse, three products (diameter ø27x1, ø30x1, ø40x1) were processed by cutting, then placed on a storage table and formed into packages. The first stage of the work was to build a model based on the current layout (Figure 2) (Guerrero et al., 2022).

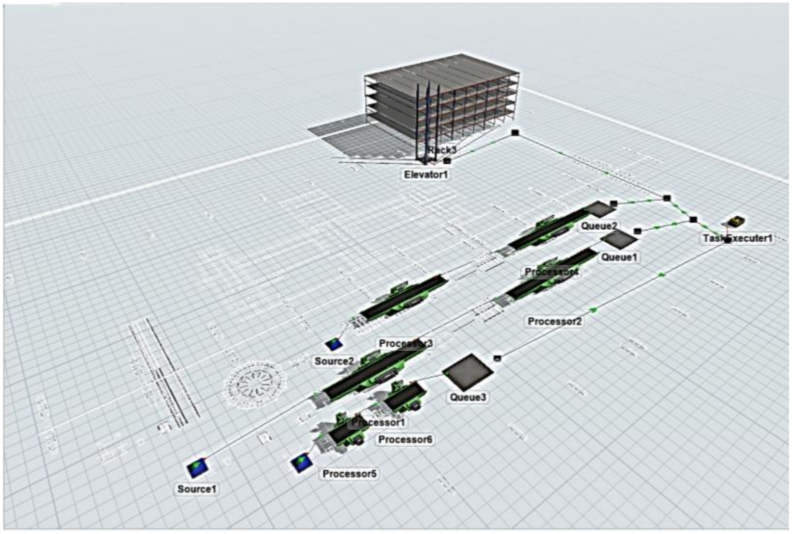

Figure 2. Magazine layout.

Source: Own elaboration.

The model includes a source, i.e. an order generator, three production lines, and storage racks, built of storage places (slots). The model proposes its addressing scheme for manufactured products. In the analyzed model, each of the three given storage racks will consist of 3 rows with a width of 2 each and 6 levels with a height of 1.40 m each. In each storage cell designated in this way, there are 2 slots with a width of 1 m. The stored parcels will be moved away from the front and rear edges of the rack by 15 cm and by 10 cm from the right and left edges of the designated slot (Figure 3) (Jurczyk, 2020).

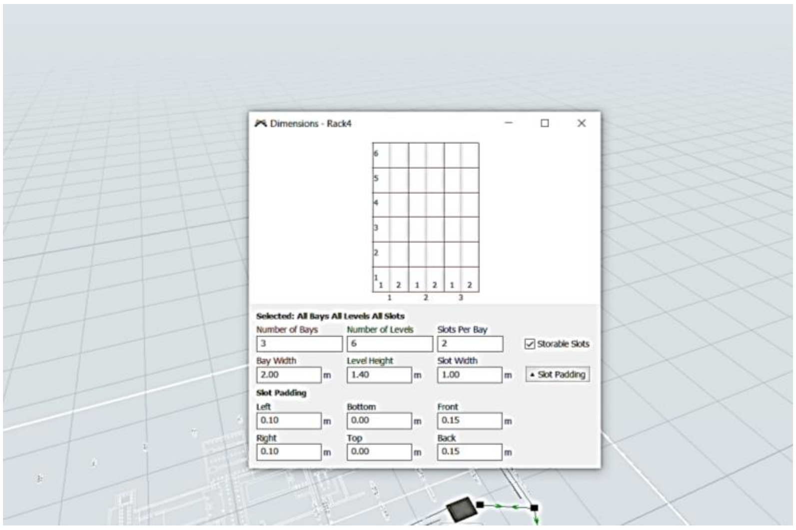

Figure 3. Layout and parameterization of the rack.

Source: Own elaboration.

On each production line, through the source, a product is generated that is labeled "type". The model defines the type of product that can be stored in each available place (profile ø27x1 - green, profile ø30x1 - yellow, profile ø40x1 - red) (Figure 4), and slots on the racks are marked with appropriate colors. Each storage location was labeled - each slot was assigned a label called "kind" (Figure 5) (Jurczyk, 2021).

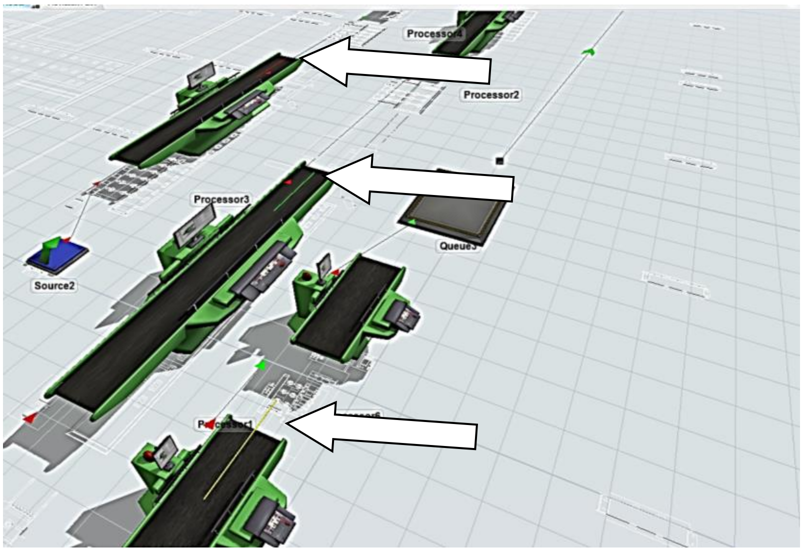

Figure 4. Product parameters.

Source: Own elaboration.

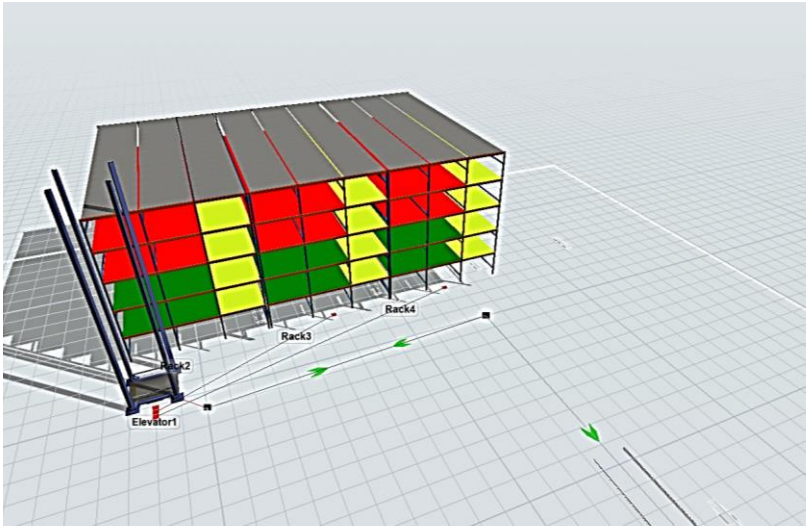

Figure 5. Defining labels.

Source: Own elaboration.

The addressing scheme is A.R.L.S, where:

- A –rack identifier,
- R – row identifier,
- L – level identifier,
- S – slot identifier.

The initial data regarding the marking of individual storage locations and the initial stock can be generated conveniently: by creating a script or importing data from MS Excel. The database should be filled in such a way as to adjust the values entered into successive cells. The created code responsible for generating the relevant data is shown in Figure 6 (Mourtzis, 2020).

```
1 treenode link = node ("..>objectfocus+",c);
2
3 Table baza = Table("DaneMagazyn");
4 int regal = 3;
5 int rzedy = 3;
6 int poziomy = 6;
7 int sloty = 2;
8
9 double q1 = rzedy * poziomy * sloty;
10 double q2 = poziomy * sloty;
11 double pojemnosc = q1 * regaly;
12
13 double wypelnieniePocz = Table("Dane")[1][1];
14 int p;
15
16 baza.setSize(pojemnosc,6);
17 for (int i = 1; i <=baza.numRows; i++) {
18     baza[i][1] = Math.ceil(i/q1);
19     if (baza[i][1] == 1) {
20         baza[i][2] = Math.ceil(i/q2);
21     } else {
22         baza[i][2] = baza[i-q1][2];
23     }
24     if (baza[i][1] == 1 && baza [i][2] == 1) {
25         baza[i][3] = Math.ceil(i/sloty);
26     } else {
27         baza[i][3] = baza[i-q2][3];
28     }
29     p++;
30     if (p > sloty) {
31         p = 1;
32     }
33     baza[i][4] = p;
34     baza[i][5] = baza [i][1] + "." + baza [i][2] + "." + baza [i][3] + "." + baza [i][4];
35     baza[i][6] = "Klient_" + baza [i][1];
36     if (baza [i][3] <= 2) {
37         baza [i][6] = "Grupa_1";
38     } else {
39         if (baza [i][3] <= 3) {
40             baza [i][6] = "Grupa_2";
41         } else {
42             baza [i][6] = "Grupa_3";
43         }
44     }
45     double liczba = uniform (0,1);
46     if (liczba <= wypelnieniePocz){
47         baza [i][6] = 3 * duniform(1,3);
48     } else {
49         baza [i][6] = 0;
```

Figure 6. Variable declaration.

Source: Own elaboration.

The code is responsible for declaring variables after which particular operations are performed. In line 3, the tabular variable database was declared, the value of which is a reference to the Database table. In lines 4-7, the dimensions of the warehouse are declared. In lines 9-10, the variable q1 was declared, which corresponds to the value of a single rack, and the variable q2, which is responsible for the capacity of a single row. In code line 11, the capacity of the entire warehouse is declared. Line 13 is responsible for the initial filling of the warehouse, and line 14 declares the numerical variable p, which is used for slot numbering. In line 16, the setSize function gives dimensions to the table that will serve as the database. The number of rows in the table is equal to the number of all pallet places, and the number of columns is equal to 6. In lines 17-51 a for loop was used, thanks to which all cells of the analyzed base table were filled. Line 18 contains a mechanism for marking successive storage racks. Lines 19-23 contain a mechanism for marking successive rows in racks. Lines 24-28 contain a mechanism for marking successive levels in individual rows. In line 29, the variable p is incremented. Then, in lines 30-32, it was checked whether, as a result of this action, the value of the variable p did not become greater than the number of slots available in each storage cell, if so, the value is reduced to one. In line 33, the current value of p is assigned as the slot identification number. In line 34, the addressing scheme was created. In line 35, the name of the customers has been assigned to the pallet locations. Assuming that there is a separate rack for each customer, it can be assumed that the customer name will be a combination of the phrase "Customer_" with the rack ID. In lines 36-44, using the if conditional statement, information about the assortment group from which products can be stored on subsequent pallet places has been introduced. Lines 45-50 contain the mechanism for generating the initial stock. On line 45, we declare a variable called a number whose value is a random number between 0 and 1 (Schuhmacher et al., 2019). The if conditional checks to see if the value of this variable is less than or equal to the initial fill value (Trott et al., 2019). If so, a random numerical value representing the initial stock level was entered into the appropriate cell of the base table. Otherwise, the value 0 was entered (Pawlewski, 2019). Finally, the parameter responsible for filling the warehouse was set. The minimum allowed value is 0.1, which corresponds to 10% fill of warehouses (Qiao et al., 2021). At the same time, you cannot enter a value greater than 1 into the data cell, because the warehouse can be filled to a maximum of 100%.

4. Summary

The article presents the use of design simulation in a production company specializing in the production of galvanized steel profiles. Using the FlexSim software, advanced analyzes were carried out to optimize the storage process and the arrangement of profiles. As a result of the research, a package addressing scheme was developed and a special code was introduced to optimize logistics processes.

The project aimed to increase storage efficiency and optimize the profile storage system to effectively serve the growing customer demand. For this purpose, an accurate simulation model of the company was built, which reflects the actual production and storage process.

The simulation allowed for the identification of low-performance areas, which allowed for the implementation of effective solutions. The use of FlexSim software made it possible to test various storage scenarios and strategies, which enabled the selection of optimal solutions for a given situation. The results of the simulation showed the benefits of the new warehouse layout, such as minimizing the waiting time for the profile and increasing the availability of goods. In addition, the use of the address code contributed to the effective management of parcel storage, which allowed for the quick and precise location of the profiles in the warehouse. Optimization of the warehousing process contributed to increasing the efficiency and competitiveness of the company. Quick access to galvanized profiles allowed us to minimize the time of order fulfillment for customers, which resulted in increasing their satisfaction and loyalty.

The study concluded that design simulation using FlexSim software is an invaluable tool for manufacturing companies. It allows you to identify areas for improvement, test different solutions and optimize processes. Thanks to simulation, it is possible to make more informed decisions, which contributes to achieving better business results. As a result, the use of simulation project management at the manufacturing company to optimize the warehouse preparation and placement of the galvanized steel profiles using FlexSim software resulted in numerous benefits. Effective use of this method allows the company to achieve a higher level of efficiency, improve logistics processes and increase competitiveness in the market.

Acknowledgments

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References

1. Abbasi, A., Jaafari A. (2018). Evolution of Project Management as a Scientific Discipline. *Data and Information Management, 2(2),* 91-102.
2. Beaverstock, M., Greenwood, A., Lavery, E., Nordgren, W. (2011). *Symulacja stosowana: modelowanie i analiza przy wykorzystaniu FlexSim*. Orem.
3. Beaverstock, M., Greenwod, A., Nordgren, W. (2017). *Applied Simulation Modeling and Analysis Using FlexSim.* 5th ed., FlexSim Software Products, Inc.
4. Dziekoński, K. (2010). Zarządzanie projektami w małych i średnich przedsiębiorstwach. *Ekonomia i Zarządzanie, no. 2/4.*
5. Garrido, J.M. (2009). Introduction to Flexsim. In: J.M. Garrido (Ed.), *Object Oriented Simulation. A Modeling and Programming Perspective* (pp. 31-42), Dordrecht: Springer US.
6. Griffin, R.W. (2017). *Podstawy zarządzania organizacjami.* Warszawa: PWN.
7. Guerrero, N., Escobar, L. (2022). Process Optimization with Discrete Event Simulation Software: An Experience in Ecuador Small Enterprise. In: M. Botto-Tobar, H. Cruz, A. Díaz Cadena (Eds.), *Recent Advances in Electrical Engineering, Electronics and Energy. CIT 2021. Lecture Notes in Electrical Engineering, vol. 931*.
8. Jurczyk-Bunkowska, M. (2020). Using Discrete Event Simulation for Planning Improvement in Small Batch Size Manufacturing System. In: G. Królczyk, M. Wzorek, A. Król, O. Kochan, J. Su, J. Kacprzyk (Eds.), *Sustainable Production: Novel Trends in Energy, Environment and Material Systems. Studies in Systems, Decision and Control, vol. 198* (pp. 19-43).
9. Jurczyk-Bunkowska, M. (2021). Tactical Manufacturing Capacity Planning Based on Discrete Event Simulation and Throughput Accounting: A Case Study of Medium Sized Production Enterprise. *Advances in Production Engineering & Management, 16(3),* 335-347.
10. Jurczyk-Bunkowska, M. (2023). Wykorzystanie dyskretnej symulacji komputerowej w zarządzaniu systemami wytwórczymi małych i średnich przedsiębiorstw. *Zeszyty Naukowe Politechniki Częstochowskiej. Zarządzanie Research Reviews of Czestochowa University of Technology. Management, No. 49,* pp. 61-74.

11. Kaczmar, I. (2015). Cost optimization of blend preparation with the use of the Flexsim environment. *Agricultural Engineering, Vol. 4, No. 156*, pp. 51-60.
12. Kopczewski, M. (2009). *Alfabet zarządzania projektami. Zarządzanie projektem od A do Z*. Gliwice: Helion.
13. Leks, D., Gwiazda, A. (2015). Application of FlexSim for modeling and simulation of the production process. *Selected Engineering Problems, Vol. 6*, pp. 51-56.
14. Matwiejczuk, R. (2018). About the Research Concerning the Relations Between Logistics and Business Management. A Wide Back to the Past and a Brief Look into the Future. *Gospodarka Materiałowa i Logistyka, 10,* 2-10.
15. Meredith, J.R. (2002). *Developing project management theory for managerial application. The view of a research journal's editor*. Proceedings of PMI Research Conference: Frontiers of Project Management Research and Application, Project Management Institute, Newtown Square, 47-53.
16. Morris, P. (2010). Research and the future of project management. *International Journal of Managing Projects in Business, 3(1),* 139-146.
17. Mourtzis, D. (2020). Simulation in the Design and Operation of Manufacturing Systems: State of the Art and New Trends. *International Journal of Production Research, 58(7),* 1927-1949.
18. Pawlewski, P. (2010). Technologie informatyczne używane w symulacji procesów logistycznych. *Logistyka, no. 1*.
19. Pawlewski, P. (2019). *Built-In Lean Management Tools in Simulation Modeling*. N. Mustafee, K.-H.G. Bae, S. Lazarova-Molnar, M. Rabe, C. Szabo, P. Haas, Y.-J. (eds.). Son Proceedings of the 2019 Winter Simulation Conference.
20. Qiao, D., Wang, Y. (2021). A Review of the Application of Discrete Event Simulation in Manufacturing. *Journal of Physics: Conference Series, 1802(2).*
21. Schuhmacher, J., Hummel, V. (2019). Self-Organization of Changeable Intralogistics Systems at the ESB Logistics Learning Factory. *Procedia Manufacturing, 31*, 194-199.
22. Sołtysik, M. (2016). *Współczesne trendy w zarządzaniu projektami*. Kraków: Mfiles.pl.
23. Trocki, M., Grucza, B., Ogonek, K. (2003). *Zarządzanie projektami.* Warszawa: PWE.
24. Trocki, M. (2019). Podejścia badawcze w zarządzaniu projektami — geneza i ewolucja. *Przegląd Organizacji, 3,* 3-8.
25. Trott, M., Auf der Landwehr, M., Viebahn, C. (2019). A New Simulation Approach for Scheduling Consolidation Activities in Intralogistics – Optimising Material Flow Processes in Industrial Practice. In: M. Putz, A. Schlegel (eds.), *Simulation in Produktion Und Logistik* (pp. 325-334). Wissenschaftliche Scripten, Auerbach.
26. Williams, T. (2005). Assessing and Moving on from the Dominant Project Management Discutirse in the Light of Project Overruns. *EEE Transactions on Engineering Management, vol. 52, No. 4*.

27. Wirkus, M. (ed.) (2013). Zarz*ądzanie projektami i procesami. Teoria i przypadki praktyczne*. Warszawa: Difin.
28. Witkowski, J., Rodawski, B. (2007). Pojęcie i typologia projektów logistycznych. *Gospodarka Materiałowa i Logistyka*, *3*, 2-6.
29. Wyrozębki, P. (2007). *Elastyczne podejście do zarządzania projektami*. In: S. Lachiewicz, M. Matejun (eds.), *Problemy współczesnej praktyki zarządzania*. Łódź: Wydawnictwo Politechniki Łódzkiej.
30. Wysocki, R.K. (2013). *Efektywne zarządzanie projektami.* Tradycyjne, zwinne, ekstremalne. Gliwice: Helion.