Computer support as a tool to study logistic processes of the storage service

Introduction

Simulation and optimization of the logistic processes is a very difficult and complex issue, particularly when regards stock processes. Such systems behaviors result not only from decisions taken in their range, but also from external conditions. Modelling requires a determined set of subsystems components characteristics and their interrelations. It is involved with the fact that in market economy conditions the enterprises must solve more complex problems in a shorter time. Rapid development of computer technology and simulation programs enables to use this methodology almost in every design unit. Based on existing production process as well as based on characterizations flow knowledge in a given process the model is created, which subjected to simulation research provides experimental results in terms of defined problem. Computer techniques application simultaneously creates new possibilities of rational reserves use, which are in every technological process. Using modelling and simulation tools it is necessary to take into account so that achieved benefits from these techniques application were greater than incurred expenditure on their implementation. So that carried out simulation gave the best effect, it must be based on accurate models, precisely reflecting real conditions and process specificity. Computer simulation techniques were presented in the work, what enable to examine dynamic models behaviors of distribution systems of goods in different, changing conditions, thanks to which it is possible to avoid expensive and laborious observation of the real system. Taking into consideration the existing demand and contemporary technique state, the computer model can be an information sources for further analyses and decision-making processes, supporting business management.

Identification of the distribution center system

Distribution is a spatially-functional object along with the infrastructure and organization, in which logistic services are carried out. A main center task is receipt, storage, distribution and delivery of goods to the company customers. Storage needs results among others from the fact that production time of individual goods doesn’t coincide with their consumption time. These differences are deadened by appropriate stocks supplies in the warehouses, in which apart from goods storage also other tasks are performed, like e.g. inventory, completion, order picking of assortments, packaging, economical tasks, means as well as technical and organizational activities. Rational storage of goods should ensure most favorable results with specific conditions and restrictions in a given time. For that purpose the storage programs are drawn up, distribution of warehouses in the distribution network are designed as well as individual objects in the structure are laid out. Decisions about the warehouses structure depends largely on the customer’s requirements and total distribution cost. Currently many enterprises diverge from extended warehouses structure in aid for the central inventory management (centralized). It results above all from the fact that central warehouses provide better conditions of the supplies management and their availability. Besides on the market operate logistics companies, forwarding-shipping, and a use of their services gives possibilities to reduce distribution costs in the enterprises. In real production conditions the processes associated with storing and storage of goods constitute a limiting link as well as located are in final structures of the hierarchy logistic activities, what presents Figure 1. An impact on it has among others: a way of effective planning, which may eliminate storage need as well as technical purpose and warehouse function as the wholesale of goods.
Tasks and functions of goods storage with taking interrelations into account in the streams flow stock structures are presented in Figure 2.

Fig. 1. Warehousing in the logistics framework [1]

Fig. 2. Common warehouse activities [1]
Distribution centers have not only a basic impact on the effective achievement of commitments in the supply chain structure, but directly are responsible for 20% of entire logistic costs. For that purpose, so that distribution centers could be competitive, they should be reliable, flexible and open to a new innovative design and structural solutions, aimed to improve their performance. A response to those requests is implementation on every warehouse management level the automation processes, what in a significant way will streamline logistic carried out operations. An example of such an approach is e.g. system of the automatic storage and retrieves goods (ASRS) [2], which scheme is presented in Figure 3.

![Fig. 3. Loading unit of the automatic storage and retrieve goods (ASRS)](image)

Different computer-operated microprocessors are included in this system, which in the automatic way search and retrieve goods from determined storage places, what in addition reduces lead time, ensures inventory control in a real time and enables to make effective logistic decisions.

Modelling and simulation of complex production systems

Modelling and simulation methods are applicable when obtaining a solutions by analytical methods is too complicated or impossible, but direct experimentation on the practical (physical) model is too laborious, dangerous and expensive. The modelling is also applicable when other methods don’t provide a required reliability level that the real manufacturing system will be preserved according to accepted assumptions of the theoretical model (virtual). Modelling and simulation production processes enables their analysis as well as to study a selected object function (position, operation, procedures, activity, transport, warehouses state, disruptions, etc.), sometimes lasting many years, within only a few minutes. Allows to conduct verification of concluded assumptions before their practical implementation, as well as to determine irregularities, which may occur in the operating time, including particularly weak points of designed or realized production system. Modelling and simulation of production process consist on computer virtual model creation of the real manufacturing system, on which a series of experiments are carried out.

As a simulation result the report sets are obtained, thanks to which further actions are drawn up, e.g. a selection of the organizational forms of production positions is carried out or type and number of transport means, including changes program which it is possible to conduct in the existing system in order to obtain established effect, like e.g.: production productivity or reduction of production cycle. It is possible to improve the studied model of the production system and to carry out subsequent simulations for different variants and settings such as: different products number, warehouses capacity, expected interferences and breaks connected e.g. with the conservation and machines repairs as well as their failure frequency etc. Moreover into the analyses it is possible to include production costs or investment for selected system variants, what in turn allows for rapid economic effectiveness analysis. Information as well as input data characterized by an appropriate quality level, forms and amounts are necessary for production system model development. It is an initial stage, which enables to obtain certain view in order to solve problem, including information about new methods that can be used for their solution. Additionally, the input data allows to drawn up a process model about the appropriate accuracy, according to minimum objects number principle, required to achieve project objectives in the simplest way. To basic information about the created system model it is possible to rank [3]:

- Information about system objects, such as the type and machines number, transport means as well as their repairs plans and organization of production posts.
- System productivity, such as the production program, parts size.
- Number as well as capacity of input, output and inter-operational warehouses.
- Order of carried out productions.
- Material costs, direct labor, workplace, charges, etc.
In times of dominant market competition and constant enterprises aspiration to reduce its production costs, the application of computer modelling and simulation techniques is one of methods which contribute to significantly faster design a new system as well as verification of existing manufacturing systems. It allows not only to reduce projects development time, but simultaneously allows to perform experiments on many variants of a virtual production process and follow up the implemented changes effects before final decisions. This reduces a failure risk which may be very expensive, and moreover impacts on the increase qualitative indicators, both of already developed and applied in the future technology that enables to choose the most beneficial variant in real application conditions.

Model structure of the automated distribution center

An aim of research presented in hereby study was the simulation model creation and projection of main processes occurring in it. System subjected to research was an automated distribution center of products from the chemistry industry. Despite wide variety of individual products, taking into account the packages dimensions, there were distinguished only four types and classes: cans, barrels, big barrels and barrels with dangerous substances. In Figure 4 an area fragment of goods receipt and products sorting were described. Area consists of the goods receipt place, sorter which divides products according to dimensions, transport system: transporters team, distribution track and the last sorting stage, in which products identification and palletization are carried out. After sorting process a next step is labeling operation for their unique identification and dispatch of marked load unit to the appropriate place in high storages warehouse area.

Administration center accepts orders from customers and through a computerized warehouse management system sends information to warehouse automation equipment. The next step in the process is carried out by properly synchronized system rack stackers, which retrieves the appropriate pallet loading unit with high storage and transport through the subsystem sends it to one with several picking zones. When you reach the designated area the unit load is identified, then if there is free space gets to the point of dismantling, where the robot gets out of the appropriate number of products resulting from the order. Articles obtained motorless get on the conveyor, which in the final part of another robot sets the respective article to be shipping pallet. After completing the appropriate marking and ready unit load goes to the zone order [4]. Adopted the principle that the palette order were possible up to a lot of articles about the same dimensions, that is, if the pallet can hold four pack of articles, a customer ordered two packaging of various goods, they should be on the pallet. This will minimized the number of units pallet is sent to the customer and will be reduced transport costs external to the client. Part of the dismantling of loading units still contain loads - in this case, it is checked whether located on the articles are listed next orders directed to implementation. If this condition is met, the entity remains picking in the buffer zone, otherwise it will be diverted into the transport to the storage area, which generates a transport order suspended transport subsystem. In the case where after the completion of dismantling the pallet is empty is led towards the place where the units of this type are stored in the form of a stack. After the ten pallets in the stack is transported to the warehouse pallets via forklift. Forklifts move the designed circuit along a rail attached to the support center. Additional elements of the system are crossovers and intersections that allow easy change of track driving cars, shortening their routes and expansion of the system of without collision area maintenance. Transfer of cargo units between the transport system and other areas of the center was possible through assemblies loading and unloading stations, which followed edition or downloading of loading units [5]. Figure 5 shows a simplified diagram of the flow of materials in the test system.
Technical and transport parameters, used for creation of the simulation model, reflect industrial real conditions which prevail in the analyzed distribution center:

- Structure of identified object was reflected in the simulation model.
- Transport equipment parameters correspond to devices in a real subsystem.
- Length of transport roads corresponds to real routes dimensions.
- Inputs and outputs relations of the object as well as computer model are identical.
- Amount and goods processing times on the object are in accordance with data entered into a model.
- Characteristic technical parameters of stacker cranes are in accordance with real data.
- Friction parameters of devices entered into a model are identical as for the value with equipment parameters in a real object.

Algorithm of determining completion zone for order from its report in the system up to unbatching moment of load unit in the order picking zone is presented in Figure 6.
Structure elements of the technical modeled center system were copied in a simulation environment using elementary components of the material flow systems. With their help recreated a behavior of technical devices, such as: roller transporters, pendular trucks, service stations, etc. Information flow model and algorithm of applied control strategies of circulation materials was implemented using decision-making tables, to which it is possible to assign such attributes, which values can later be modified in simulation research [6].

Created model consisted of about 500 elements (sources, flows, transporters, buffers, loading-unloading stations, stock zone elements, etc.) and 120 decision tables, which are used to implement algorithms of the load units flow control or information. In order to recreate a behavior of dynamic objects (different load unit’s types, empty palettes, objects associated with the information flow), 43 different types of these objects were assigned and encoded.

Analysis of conducted research results

One of main aims to create a studied center model as well as to conduct simulation research on it was a need to review assumptions about system productivity [7, 8]. An objective indicator for such evaluation is the orders number, which distribution center is able to perform in a given unit time (e.g. per day) and load units number on the output completion system. Based on forecasts and stakeholders expectations it was assumed that the system should carry out about 300–350 customers orders per day, what involves with preparation of about 1200–1400 completed pallet shipping units.

Next experiments aim was to determine number of transport means, which are used in the load units flow processes between individual center areas, a potential bottlenecks identification of the completion and transport subsystem.
Preliminary research assumed to carry out simulation with a set simulation time for one working day. In next analyses the simulation experiment duration included (7 days) and constituted an actual work time in the center, i.e. in a two-shift mode (from 6:00 am to 10:00 pm). A model presented in Figure 7 was used for model verification as well as simulation experiments taking real conditions into account in the distribution center. Based on this model it is possible to determine bottlenecks which appear in the system and to implement preventive tasks along with reported needs.

Analyzed distribution center has a limitation in respect to bad transport strategy applied within the plant. A large number of carried out orders and inappropriate transport means management causes a blockage of these means in the system as well as an inefficient utilization of their full production capacity. This affects an increase of goods storage costs and delays in orders realization.

One of conducted simulation experiments was used to study an impact of applied trucks number in conveyance transport on the completion orders productivity zones. Also a rate of vehicles utilization was determined, including variables that describe their behavior. Carried out simulations were aimed to improve the in-plant transport cycle, which is a bottleneck of analyzed logistic subsystem. Examples of simulation results were presented in graphs shown in Figure 8–9: an average needed time for order completion to the customer as well as diagram of percentage vehicles utilization, which transport goods between receipt zones, completion and high storage warehouse.

Considering established criteria of data used for creation of the simulation model it was determined that average needed time to prepare a single pallet for dispatch is equal 8.23 min. Compared with real conditions, this parameter was significantly reduced by average of 1 min. Specified by the user parameter contributed to it – individual code of the customer order, which was assigned as a part of single implemented order. Detailed transport system characterization was presented in Table 1.
Analyzing results from Table 1 it is possible to state that certain priorities in the system have impact on the effective and efficient in-plant transport. The highest priority have palette units with the largest orders number.

Presented characterizations in Figure 9 refer to three strategies of transport trucks orders control:

- Priorities strategy of shipment places – with such a control at the very beginning while transport means allocation are taken into consideration places of transfer objects (shipment stations) with the highest assigned priorities.
- FCFS strategy (First Come First Served) – allocation of transport orders according with they report in the system.
- The shortest way strategy – transport orders, for which a transport road between shipment point and its final destination is the shortest, are handled as first.

From the analysis of Figure 9 results that majority of available transport trucks in the analyzed distribution center expects for order processing. Their production capacities aren’t fully exploited and are on the level of 73.2%. It indicates a disturbance in the rhythmic distribution center function, ineffective use of transport means as well as increase in the production costs. Table 2 shows an example result of the percentage transport trucks utilization of one of subsystems in the complementation zone as a time function.

Tab. 1. Transport system statistics

<table>
<thead>
<tr>
<th>Transport system</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage - Assembly [min]</td>
<td>6,1</td>
</tr>
<tr>
<td>Assembly - Storage [min]</td>
<td>2,5</td>
</tr>
<tr>
<td>Replenishment of stock [min]</td>
<td>3</td>
</tr>
</tbody>
</table>

Tab. 2. Percentage utilization of one subsystems transport trucks

<table>
<thead>
<tr>
<th>Assembly section utilization</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrels Section Utilization [%]</td>
<td>6,05</td>
</tr>
<tr>
<td>Cans Section Utilization [%]</td>
<td>23,27</td>
</tr>
<tr>
<td>EX Section Utilization [%]</td>
<td>0,04</td>
</tr>
</tbody>
</table>
Based on received results it is possible to state that the highest system productivity can be achieved with a use of about eight trucks in the selected vehicles control strategy, agreed at priorities of shipment places (in example the high priority was assigned to shipment stations at the high storage warehouse). From conducted analyses results that the majority of transport cycles times doesn’t differ substantially from individual trucks, what may provide about the accepted accuracy in experiment of parameters as well as assumptions and control algorithms.

Summary and conclusions

Model created for these researches purposes can be directly applied in the enterprise. If necessary there is a possibility to make alterations of the model and corrections of cargoes flow control implement strategy without major changes in the model structure.

Conducted simulations showed that applied means of materials flow control and information enabled a realization of established objectives. System elements which can constitute a potential bottleneck in the system were also indicated.

Application of the systems theory allows for accurate relation recognition between individual transport devices. Thanks to that a correct identification of the existing production system is much simpler. Existing transport system in the analyzed distribution center is designed with a large capacity excess, resulting in an incomplete, since on the level of 73%, transport means utilization.

Created model can be a basis for the logistics system development including: goods streams flow, information flow as well as costs and decision flow.

Abstract

Study regards modelling problem and simulations of complex logistics processes which occur in the enterprises. In research the modelling methodology was applied, based on mechanisms systems of discreet event-driven. One of automated distribution centers systems of products from the manufacture industry was subjected to research. One of applied approach is to support decision determining labor intensity of stock processes as well as to carry out experiments including system load variables. Presented research results prove a usefulness of proposed models as tools supporting decision-making processes on the business management level.

REFERENCES