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Modelling of Selected Logistic Process in Logistic Centre Using Dynamic Simulation

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Abstract

Today's turbulent and highly competitive market environment forces companies to continually improve and streamline their processes. One of the management and planning tools is modelling and dynamic simulation of business processes. It allows to model selected processes and simulate various proposed changes in processes in order to determine if these changes will improve the current situation. Logistic centres are one of the most important points of the logistic infrastructure, as they are usually supplied with different modes of transport. There are many logistic processes in logistic centres that need to be constantly monitored, analysed and improved. The logistic process of sorting consignments for further distribution is modelled and dynamically simulated using Witness Horizon Manufacturing Performance Edition software within this article. The aim of this paper is to improve the logistic process of consignments sorting using modelling and dynamic simulation.

KEY WORDS: dynamic simulation, logistic process, consignment, logistic centre

1. Introduction

In today's globalization, logistics has become one of the value added generators for the customers. Deconcentrating of demand and supply, increasing customer's demands lead to increased logistic costs. It leads to a decrease in the sales margin or an increase in prices. It is therefore necessary to improve logistic processes. Simulation is an effective tool for improving logistic processes [1]. The use of analytical techniques alone cannot completely analyse and optimize the logistic system. However, the simulation technique can show a specific state and identify the obstacle and idle source of the system, which provides a detailed description of the actual process information and production of the logistic system. Nowadays, simulation tools can replace experiments, design and improve systems, train and learn operators. All measures are designed to operate in an environmentally friendly and cost-effective way [2]. Simulation tools are becoming increasingly knowledge warehouses that flexibly and extensively guide the entire life cycle of a device from planning to dismantling. The isolated solution of partial tasks reaches its limits: complex manufacturing processes require a comprehensive view of the system and interdisciplinary work. This is especially true for process engineering (unit operations) and logistics (material and information flow). In addition, it is known that an economically successful process alone is not the sum of optimally functioning components. Understanding the interdependencies of all process subsystems enables trouble-free and convenient production. In this context, it is essential that holistic evaluation and improvement develop an integrative linkage of the corresponding simulation tools already used successfully in sub-disciplines. The assessment of overarching strategies and boundary conditions is another necessity.

With the rapid development of the economy, the development of logistic companies around the world is facing a major challenge, in particular, logistic companies generally lack basic competitiveness, efficient logistic processes and awareness of service innovation is not strong [3].

Logistic processes exist, directly or indirectly, in any business operation. More than ever, the complexity of logistic operations is increasing as they are influenced by changes in technology, business globalization, the nature of the workforce, and political and environmental factors. As these logistic processes become more complex, they are more difficult to analyse and modify to achieve optimal business logistic operations [4]. Today, many business-modelling tools are available to assist in analysing and identifying logistic processes. Although considerable progress has been made in supporting supply chain modelling and logistic network optimization, there is still a need for integrated modelling of logistic processes.

The aim of this paper is to improve the logistic process of consignments sorting using modelling and dynamic simulation using Witness Horizon Manufacturing Performance Edition software.

2. Theoretical Background

Process modelling plays an important role in any organization. One of the potential area of modelling is logistic process. Understanding these processes and presenting them as models allows to identify possible problems and provide solutions. Modelling requires the acquisition of skills to describe the studied reality in a way that reflects its most important characteristics but is not very complex. Simulation offers many potential solutions and allows iteration of a previously developed model. This can help optimize all logistic processes [5]. Simulation models are important for the planning, implementation and operation of logistic systems because they can display their dynamic system behaviour [6]. Computer simulation is a well-accepted tool for modelling the behaviour of large or complex operational logistic systems [7]. Logistic systems and processes are exposed to a number of risks that may arise from various negative scenarios. A characteristic feature of these risks is that they often simultaneously have an impact on both goods and the environment. A key parameter in the reliability assessment is the selection of appropriate methods, techniques and models in relation to the specific characteristics and characteristics of the logistic system under consideration and the available information and resources. Risk modelling is a dynamic process that involves a wide range of activities and skills, including system or process analysis, development, testing, simulation and application of methods and models, and periodic enhancements and fixes. Logistic processes often have considerable uncertainty associated with their complexity, the reliability of available information on current risks, and the availability of various statistical parameters from the previous period [8]. Distribution logistics is the last link in online shopping, whose importance grows with increasing demand from the company. Whether the goods can be delivered to consumers on time affects consumer satisfaction with this purchase directly [9].

Simulation modelling techniques are one of the basic tools used to identify, analyse and optimize logistic processes and systems [10]. Many modern logistic process simulation tools use discrete event simulation. References to discrete event simulation applications in logistics can be found in [11-14]. This kind of simulation is very useful and often the only tool supporting analysis of complex logistic systems, including their dynamics.

The logistic industry has also transformed itself into a rapid development phase. Distribution costs are estimated to account for more than 50% of total operating costs. This problem needs to be urgently addressed. In addition, distribution logistics as one of the three main logistic content (distribution, warehousing and management) includes planning management, distribution tools, distribution routes, delivery time, natural environment, human resources, etc. More important is the distribution logistics. Therefore, today it pays great attention to optimizing and analysing distribution logistics, shortening delivery times, improving distribution efficiency and reducing distribution costs [15]. Distribution tools are essential throughout the process, which takes up considerable resources under uncertainty of requirements. To dramatically reduce logistic costs, this reduction is significant through optimization [9, 15].

Foreign scientists have often discussed and studied factors affecting the core competencies of logistic companies from different angles and methods for improving the core competencies of logistic companies in the field of logistic processes [16-19]. Distribution logistics costs represent the highest proportion of total logistic costs and its rationalization can bring great business and competitive advantages [20]. Resource planning as well as proper distribution logistics are critical steps in managing complex logistic networks [21].

3. Methods

Authors used method of dynamic simulation using simulation software which is called Witness Horizon Manufacturing Performance Edition software (hereinafter referred to as Witness Horizon). Dynamic simulation enables to virtually streamline processes before their implementation. It is important that processes can be simulate without unnecessary risks and needless waste of money.

Authors created layout of logistic centre which is focused on the logistic process of sorting consignments. Figure 1 shows layout of the logistic process of sorting consignments. The aim of this paper is to improve the logistic process of consignments sorting using modelling and dynamic simulation. Logistic centre uses a high level of automation (primarily automatic identification technology – bar codes and QR codes and system of belt conveyors).

The simulation model consists of following basic elements:

- consignments,
- input gates,
- system of belt conveyors,
- machines (bar code scanners),
- output gates.

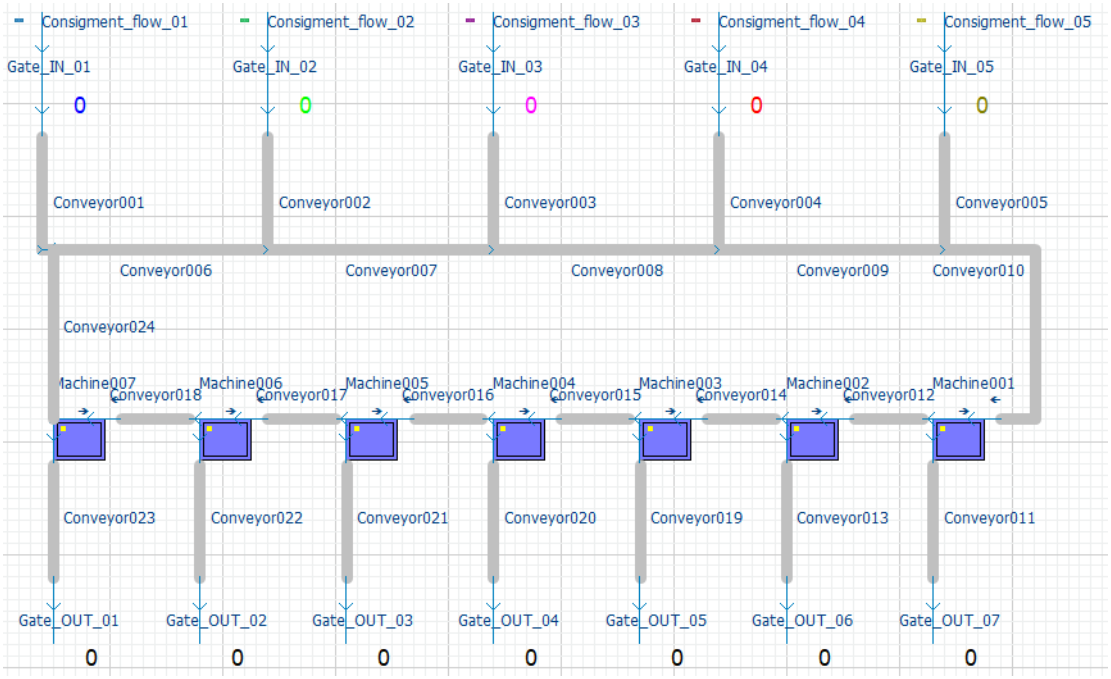

Fig. 1 Layout of logistic centre (simulation model) [authors using Witness Horizon]

The second [s] is the base time unit of the model and the conveyor speed [m/s] is the basic variable parameter of the model. There are listed parameters of the simulation model in Table 1.

Table 1

Parameters of the simulation model

Simulation parameters	
number of input gates	5
number of consignments per gate	5 000
number of output gates	7
time of picking one consignment at the input gates [s]	Triangle distribution (8, 12, 17)
number of consignments picked at one time per gate	1
the first consignment picked up in time [s]	0
001 – 005 conveyor speed [m/s]	s_1
006 – 009 conveyor speed [m/s]	s_2
010 conveyor speed [m/s]	s_3
012; 014; 015; 016; 017; 018 conveyor speed [m/s]	s_4
011; 013; 019; 020; 021; 022; 023 conveyor speed [m/s]	s_5
024 conveyor speed	s_6
scan speed of 1 consignment by reader (machine) [s]	2
reader failure rate (frequency)	Uniform distribution (175, 360)
fault repair time of reader (machine) [s]	10
total simulation time [s]	28 800

Source: authors using Witness Horizon

The total simulation time was 28 800 s which is 8 hours (one shift). The aim of the dynamic simulation was to find the optimal speed of the conveyors in the individual groups (variable $s_1 – s_6$) in order to sort the maximum number of consignments during the total simulation time. The authors performed several simulations and based on the evaluation of statistics of individual elements of the model, the variables $s_1 – s_6$ were adjusted.

There are listed parameters of individual simulations in Table 2.

Table 2

Parameters of individual simulations

Simulation parameters	**Simulation 1**	**Simulation 2**	**Simulation 3**
number of input gates	5		
number of consignments per gate	5 000		
number of output gates	7		
time of picking one consignment at the input gates [s]	Triangle distribution (8, 12, 17)		
number of consignments picked at one time per gate	1		
the first consignment picked up in time	0		
001 – 005 conveyor speed [m/s]…….. s_1	5.6	4.7	2.8
006 – 009 conveyor speed [m/s]…….. s_2	2.8	2.8	3.0
010 conveyor speed [m/s]…… s_3	2.2	2.8	2.1
012; 014; 015; 016; 017; 018 conveyor speed [m/s]…… s_4	3.0	2.6	2.8
011; 013; 019; 020; 021; 022; 023 conveyor speed [m/s].... s_5	6.9	4.2	3.0
024 conveyor speed …….. s_6	3.0	2.8	2.8
scan speed of 1 consignment by reader (machine) [s]	2		
reader failure rate (frequency)	Uniform distribution (175, 360)		
fault repair time of reader (machine) [s]	10		
total simulation time [s]	28 800		
sorted consignments in total [pieces]	10 859	**11 660**	9 432

Source: authors using Witness Horizon

Witness Horizon enables 2D visualization of the dynamic simulation of the model (see Figure 2) and thus it is possible to identify bottlenecks and subsequently to improve the logistic process of sorting consignments.

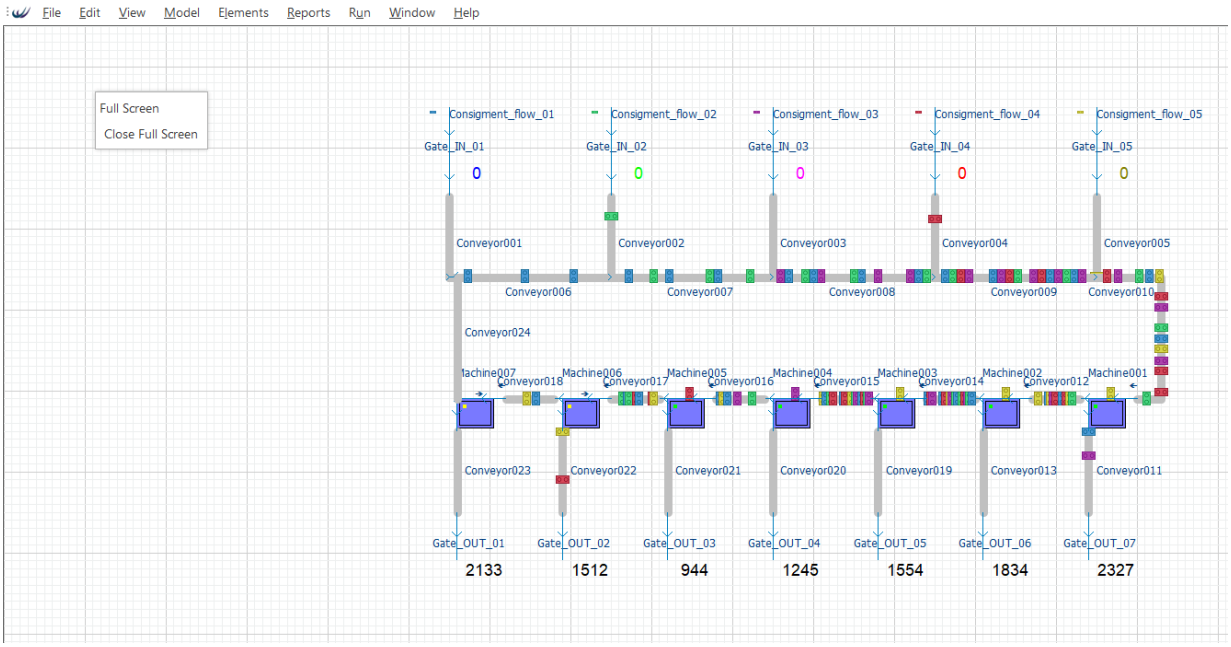

Fig. 2 Demonstration of simulation in software interface of Witness Horizon [authors using Witness Horizon]

4. Results and Discussion

Individual simulations were evaluated according to conveyor´s statistics (see Figure 3). The activity of conveyors during the total simulation time can be divided into three parts:

- % Empty – the conveyor moves without consignments
- % Move – the conveyor moves with consignments
- % Blocked – the conveyor is temporarily blocked

Furthermore, authors evaluated according to the maximum number of sorted consignments during the total simulation time.

Witness

Conveyor Statistics Report by On Shift Time

Name	% Empty	% Move	% Blocked
Conveyor024	85.58	13.99	0.43
Conveyor001	54.34	38.85	6.81
Conveyor002	52.07	38.94	8.99
Conveyor003	48.18	38.89	12.92
Conveyor004	43.03	38.65	18.32
Conveyor005	45.34	38.59	16.07
Conveyor006	0.02	93.01	6.97
Conveyor007	0.02	87.42	12.57
Conveyor008	0.02	81.13	18.85
Conveyor009	0.02	76.64	23.34
Conveyor010	0.02	79.58	20.40
Conveyor011	42.01	57.99	0.00
Conveyor012	0.13	96.67	3.19
Conveyor013	50.90	49.10	0.00
Conveyor014	0.28	97.70	2.02
Conveyor015	0.42	98.20	1.38
Conveyor016	0.63	98.60	0.76
Conveyor017	1.26	98.15	0.59
Conveyor018	5.08	94.68	0.24
Conveyor019	56.73	43.27	0.00
Conveyor020	63.82	36.18	0.00
Conveyor021	71.26	28.74	0.00
Conveyor022	58.02	41.98	0.00
Conveyor023	46.12	53.88	0.00

Fig. 3 Conveyor´s statistics - simulation 2 [authors using Witness Horizon]

The best results were obtained in simulation 2 (see Table 2). 11 660 consignments were sorted for the total simulation time (8 hours). This simulation also showed the best results in terms of conveyor´s statistics (no value % Blocked was extremely high).

5. Conclusion

The simulation of the production process is an excellent tool for the data analysis, which takes place in almost every production company. It is possible to monitor all areas in the company that produces any product through the dynamic simulation. The aim of this article was to improve the logistic process of consignments sorting using modelling and dynamic simulation. Authors performed several simulations which were evaluated and compared with each other. Using modelling and dynamic simulation were found the optimal speed of the conveyors in the individual groups (variable $s_1 – s_6$) as shown in Table 2.

Witness Horizon software is an important tool to support logistic planning and optimization of logistic processes because dynamic simulation enables to virtually streamline processes before their implementation in practice.

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