SIMULATION ANALYSIS OF ORDER PICKERS WORKING SHIFTS: THE CASE STUDY OF MILŠPED

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Abstract: *The trend of increasing frequency and decreasing the quantity of goods in each delivery, as well as shorter deadlines for these deliveries, sets a difficult task in front of logistics providers, whose primary field of work is providing these services. Shifts scheduling and determining optimal number of the order pickers can significantly contribute to an adequate response to these requests. There are many different methods and tools that could be used in this purpose, and one of them is simulation. The advantage of simulation is reflected in the fact that the right model can represent a real system, with a possibility of changing different model parameters in order to obtain the best possible solution to the given problem. This paper covers the creation of order picking subsystem model in Milsped company. Before model creation, preparation of input data obtained by processing the received orders in the company, on an annual basis, is needed. By changing certain parameters, such as the number of workers in shifts, their efficiency and shift intervals themselves, and after processing the output data, decision can be made on which solution is the best from a set of simulated scenarios. By correcting model and taking into account all the factors while creating it, can contribute to a better projection of a real system functioning through simulation.*

Keywords*: Milšped, order picking, shifts scheduling, simulation model*

1. INTRODUCTION

The purpose of a simulation is to determine the information on real-world system using a model with the aim of their optimal planning and utilization. The computational modelling is the most economic mode of complex system simulation for this purpose. A simulation is a very powerful tool providing high-quality of logistics system analysis, quantification and dimensioning.

The elaboration of these models is significantly facilitated by the development of simulation software packages and one of them is FlexSim, which was used for simulation analysis of order pickers' working shifts in Milšped company. FlexSim belongs to software group being used for modelling systems whose states are changing in discrete time moments as a consequence of some events' realization. Some of the specific problems that could be solved by it are: improvement of efficient utilization of existing resources, reduction of queues and time spent in them, alternative investment project analysis etc. (Banks et al.., 2005).

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2. PROBLEM DESCRIPTION

Milšped company, whose order picking system is a subject of this case study, receives about 1000 orders daily, on which up to 124 order line (OL) could be found. The purchaser' requests underline orders to be processed, i.e. the goods have to be ready for loading in less than 24h. This impose a very complex task to the order picking system, especially in cases where the time passed from the order entry into system to the requested dispatch time is dramatically shorter, in some cases shorter than 10h. For the realization of these tasks the company engages 22 order pickers, scheduled in three shifts in following manner: three order pickers in first shift, seven in second shift and twelve in third shift (five most efficient ones are among them). Each shift lasts 8h, where first one starts at 6 a.m. This paper presents potential improvement of the system operational performances through the shift scheduling and number of workers determination, where the simulation analysis is used as a tool. One of the most important performances, which is monitoring through the simulation model and needs to be improved, is the percent of orders being processed on time.

3. INPUT DATA ANALYSIS

Milšped company has provided two data groups that were necessary for model elaboration: one related to the order picker work and other related to the orders. When it comes to the order pickers, these data refer to the number of workers per shift and their performances expressed in the number of OL that one order picker is able to process during one shift. Regarding the orders, the data are related to the number of orders arriving into the system, the number of OL being on each order and requested time for the termination of processing. These data are provided for each hour during a day, for the period of one year.

Given that the form of these data was not suitable for the entry into the model, it was necessary to perform their preparation. The order picker performance is expressed in time needed for processing one OL per order picker (h/OL/order picker). It was necessary to present the order data for each hour by following probability distribution: the number of orders distribution, the number of OL per order distribution and the distribution of requested time for each order processing termination. The test of empirical data fitting to theoretical distribution is performed by using χ^2 test, λ-Kolmogorov test and by applying Minitab software. Table 1 shows the parameters of above mentioned distribution that are used in model.

Table 1. The parameters of input data distribution for each hour

Period of order entry [h]	Number of orders			Number of OL			Ready for loading		
	Distribution	Parameter		Distribution	Parameter		Distribution	Parameter	
		μ / λ	σ		μ / λ / α	σ / β		μ / λ	σ
7 - 8	EXPON	0,440	/	NORMAL	15,980	11,980	NORMAL	3,15	1,15
8 - 9	EXPON	0,061	/	EXPON	0,081	/	EMPIRICAL DISTRIBUTION (2)		
9 - 10	NORMAL	28,620	19,040	LOGNORMAL	2,155	0,712			
10 - 11	NORMAL	87,660	39,424	LOGNORMAL	2,033	0,569	EMPIRICAL DISTRIBUTION (1)		
11 - 12	NORMAL	99,960	45,060	LOGNORMAL	2,027	0,538			
12 - 13	NORMAL	116,696	49,750	LOGNORMAL	2,025	0,515			
13 - 14	NORMAL	115,660	45,810	LOGNORMAL	2,038	0,521			
14 - 15	NORMAL	122,078	53,752	LOGNORMAL	2,028	0,526			
15 - 16	NORMAL	120,510	49,460	LOGNORMAL	2,023	0,531			
16 - 17	NORMAL	116,387	50,710	LOGNORMAL	1,948	0,527			
17 - 18	NORMAL	74,120	39,630	LOGNORMAL	1,987	0,523			
18 - 19	EXPON	0,86	/	GAMA	1,707	8,329	NORMAL	2,71	1,47

4. SIMULATION MODEL

Model used in order picker work shift simulation is elaborated in Flexsim simulation software and its layout is presented on Figure 1. This chapter explains the idea upon which the model function, without the description of code upon which each object performs its activities.

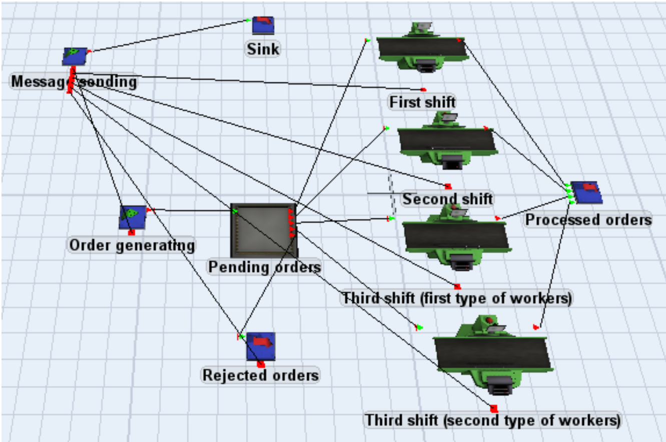

Figure 1. Simulation model

Source-type object, named "Message sending", mostly coordinates the operation of all other objects of this model. Each hour it generates one Flow item which immediately leaves the model through the Sink object. This procedure is necessary in order to Source "Message sending", when activating Trigger "On Exit", sends messages to the object that are connected with it by central connections. It sends messages to the Source-type object, named "Order generating", with information about the moment of order generating, as well as their number. The number of orders is generating upon the probability distribution which varies depending on period during a day. For example, the number of orders' distribution is not the same at 2 p.m., when the most of orders entry into the system, and in 7 a.m., when this number is relatively small. When order leaves the object "Order generating", it is assigned with information on number of OL being in that order and the information on hour when that order should be ready for dispatch. The information on number of OL and desired leaving hour is also generated upon the distribution which is not the same for each time of day. After assignment of all necessary information, the order enters the queue, which is simulated by Queue-type object, named "Pending orders". There are two possibilities for order to leave a queue: first one is that some free order picker from currently active shift takes the order and the other one is to leave a model through the Sink-type object, named "Rejected orders" if the order is not processed until the end of workday. At the end of the day the Source "Message sending" sends the command to the Sink "Rejected orders" to open its input port and remove from the model the all order not being processed until this moment. It should be noted that, in a real system, rejected orders in the model present orders being transferred into the next day in order to be processed.

Source "Message sending" forwards the information on first work beginning of the shifts to the Processor-type objects, by which the work shifts with certain number of workers are simulated. After receiving the messages on work beginning, the processors continue to operate automatically, i.e. they send messages to themselves to stop to work after eight hours and to start again after twenty four hours. The order retention in processors, i.e. their processing, depends of order picker operation efficiency and the number of OL being on the order. It is possible to adjust the number of workers and their efficiency in the processors.

5. OUTPUT RESULTS

Model described in previous chapter allow data monitoring such as: the number of orders processed on time, the number of unprocessed orders, the delay of these orders as well as the number of rejected orders at the end of the day. It is possible to monitor a large number of data, however, the previously mentioned ones were relevant for this case study. It is possible to simulate various system behaviours by changing the number of workers per shifts, their efficiency and by introducing the inter-shifts. Output data analysis leads to different system operation characteristics, which will be explained in the following text in more detail. At the beginning it is necessary to simulate current functioning of order picking system in Milšped company in order to be able to compare all other simulated variants with current state.

5.1 Variants with current resources

It is performed a simulation of great number of variants with current resources, from which only three will be presented and these are the variant that gave the best system operational performances based on the output data processing. These variants include: the introduction of an inter-shift from 4 p.m. to 12 p.m., an inter-shift from 12 a.m. to 20 p.m. and new worker distribution per current shifts. As it has already been mentioned in second chapter, 22 order pickers work in the company and they are scheduled per shifts in the following manner: three order pickers in the first shift (6 a.m. – 2 p.m.), seven in the second shift (2 p.m. – 10 p.m.) and twelve in the third shift (five most efficient ones are among them) with working time from 10 p.m. till 6 a.m. the following day. Figure 2 shows the graphs presenting the comparison of these variants' model operational performances with the current state.

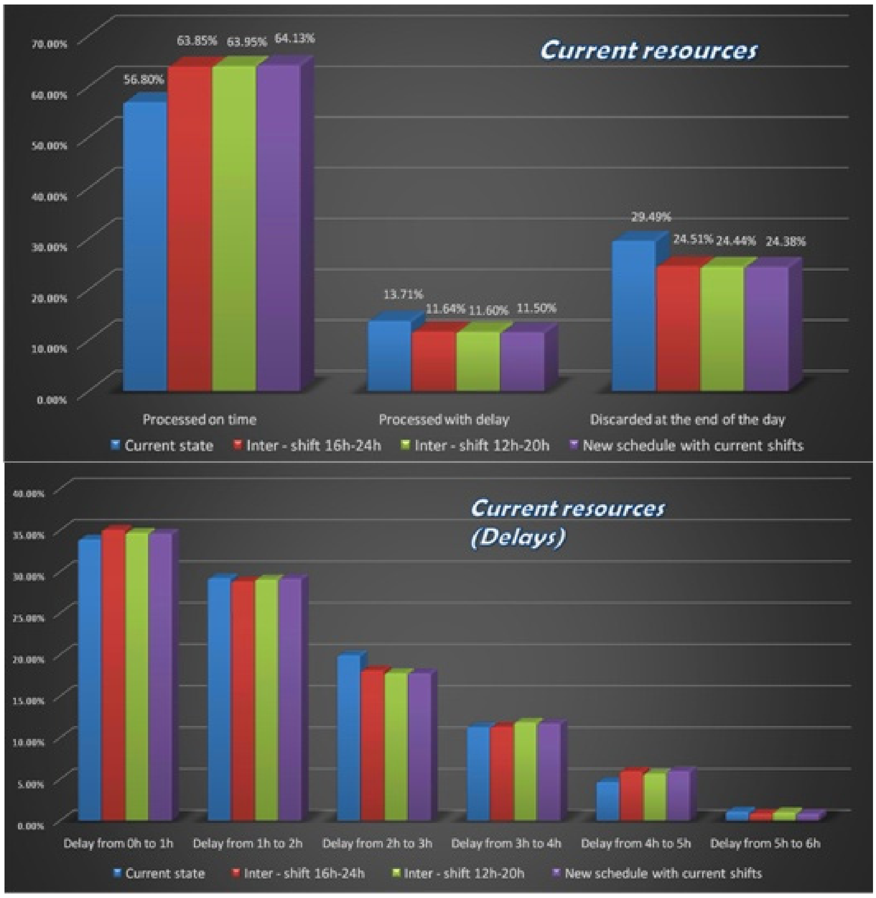

Figure 2. Model operational performances with current resources

The inter-shift from 4 p.m. to 12 p.m. is the variant where the current number of workers is changing in the following manner: one by one worker is transferred from the first and second shifts into the inter-shift, as well as two less-efficient workers from third shift. ***The inter-shift from 12 p.m. to 20 p.m.*** is the same combination of workers per shift as in the previous variant – the only one difference is in the start time of the inter-shift. ***New schedule of workers per current shifts*** implies the variant without inter-shift introduction, so the order pickers are scheduled per current shifts in the following manner: one order picker from the first shift and two less-efficient order pickers from third shift are transferred to the second shift. Therefore, by such a rotation, two order pickers will work in the first shift and ten in second and third shifts separately.

The previous graph shows the best performances are achieved by third variant, where the number of orders being processed on time is increased by nearly 8%, the number of processed, but on time processed orders is reduced by about 2% and the number of orders rejected at the end of the day is reduced by about 5%. Other variants have similar results, where performance values are different by 0.5% compared to previously described variant. The lower graph shows the performance values of delays related to the orders that are not processed on time. In the most cases the order processing delays is up to one hour, while the number of order being not processed on time linearly decreases as the time delays increases.

5.2 Variants with one additional order picker

As it was the case with current resources, here is also possible to simulate a large number of variants with one additional order picker. It will be presented only those variants from the set of simulated ones that had the best system operational performances. These variants include: ***the assignment of an order picker to the second shift***, implying simple increase in the number of order pickers in the second shift by one; ***the assignment of an order picker to the third shift***, ***the assignment of an order picker with a new schedule***, where an additional order picker is assigned to the second shift and the others are assigned to shifts as in the third variant of the previous section. Hence, it implies that two order pickers will work in the first shift, eleven in the second shift and ten in the third shift. Figure 3 shows the graphs presenting the comparison of model operational performances with the current state.

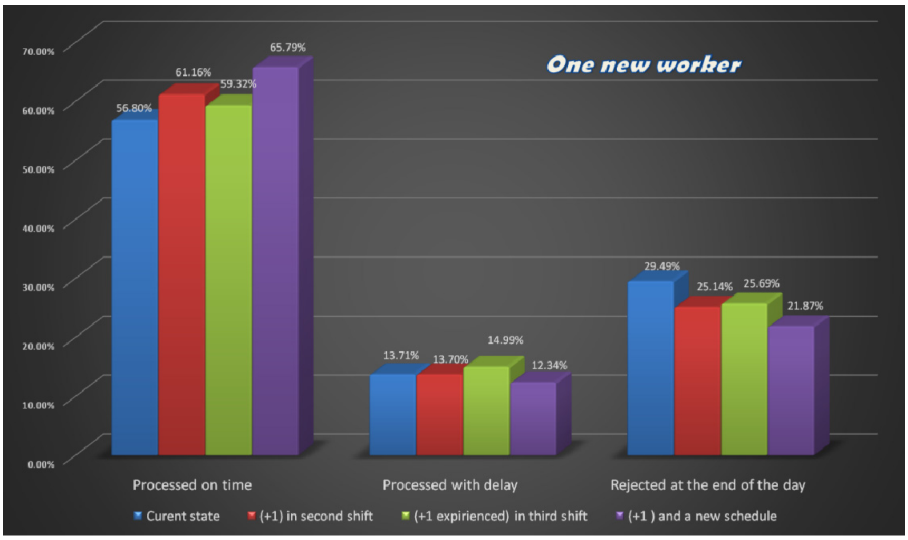

Figure 3. Model operational performances with one additional order picker

The third variant achieved again the best system operational performances, where the number of order being processed on time is increased by 9% compared to the current state, while the number of orders rejected at the end of the day is reduced by almost 8%. The performance values of delays related to the processing of the orders not terminated on time are very similar to those from previous section. Furthermore, to determine the number of order pickers needed for bringing down the percent of orders rejected on the end of the day to the value lower the 1% of total number of orders entering into system, it is necessary to increase them gradually until this performance value is achieved. Figure 4 shows the decreasing trend of the percent of rejected orders with the increasing number of order pickers.

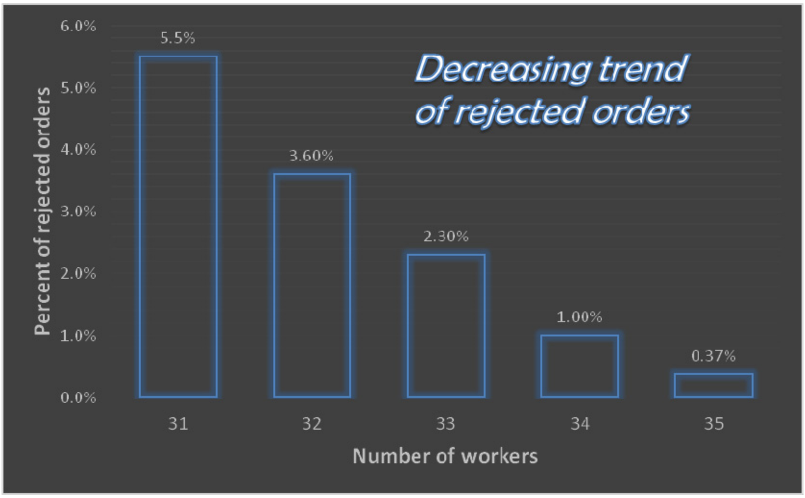

Figure 4. Decreasing trend of rejected orders

6. POSSIBLE MODEL UPGRADES

As it is already mentioned, this model does not completely describe the real order picking system in Milšped company for several reasons. One of the most important is the fact that the orders in the model being not processed until the end of the day are rejected from the model, instead to be transferred into the next day where they will be first ones processed by the order pickers. In order to model better describes the real-world system functioning, some recommendation for its improvement are given in the following text.

The order transferring is already noted as one of the possible improvement and, in addition, the model could function on the way that each order is assigned with priority information. Prioritized orders would have a priority when processing, where the priority is determined on the basis of the time when the order should be processed. Since there are some days during a year with extremely high number of orders, which are relatively known (e.g. days before holidays), it would be necessary to define the special distribution for them and to perform the special shift organization and to improve model in this manner. There is still a lot of factors that could be included in the model, such as operational performance monitoring for each order picker, the assignment of relevant information to each OL (mass, volume, packaging etc.), which could be the subject of future research.

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STUDY OF INVENTORY MANAGEMENT SIMULATION ANALYSIS: THE CASE STUDY OF MILŠPED

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Abstract: *The aim of inventory management is to provide sufficient quantities of goods in the warehouse so that user requirements can be filled at any moment. Considering the stochastic nature of demands, it is increasingly difficult to manage inventories. Depending on the time of delivery, ordering costs, cost of holding and lack of inventories this objective can be achieved by applying some of the inventory management strategies. By processing and analyzing the data of 57 items held in the warehouse of 3PL provider Milšped for a period of one year we determine requirements applying some of the strategies of inventory management.*

Keywords: *Inventory management, simulation, 3PL*

1. INTRODUCTION

Before the company make a decision whether or not to manage inventories, it is necessary to consider the advantages and disadvantages of keeping them in stock. The main reason that justifies keeping inventories is an increase of the level of customer service, despite the high costs that emerges when inventories are kept. Keeping inventories in the warehouse represents bound capital, especially when there is a surplus in the warehouse inventories.

Inventory management involves finding the optimal balance between product availability and total cost of inventories. The goal of optimal inventory management is to achieve a minimum total cost of holding inventories. Also, a time during the orders' replenishment, levels of demand, costs of keeping stocks and consequences of lack of stock must be respected. One of the most important factors in selecting inventory management model is the nature of demand. According to the factor based on the demand of a product, it is possible to affect the order of product, purchase of raw materials and production schedules (Ballou, 2004).

2. STRATEGY OF INVENTORY MANAGEMENT

The strategy of inventory management is one of the techno - economic characteristics of the stocks. In practice, there are different strategies of inventory management, and only few, basic ones, will be shown. A very important part of the strategy of inventory management is a choice of parameters that defines it.

The first strategy is the (Q, R) strategy. In this strategy, inventory is managed by two parameters: quantity Q and the level Rn. Q is a replenishment quantity which will be supplied

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