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Practical Application of Simulation of Business Processes

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***Abstract*—**Company managers are always looking for more and more opportunities to succeed in today's fiercely competitive market. To maintain your place among the successful companies on the market today or to come up with a revolutionary business idea is much more difficult than before. Each new or improved method, tool, or approach that can improve the functioning of business processes or even of the entire system is worth checking and verification. The use of simulation in the design of manufacturing systems and their management in practice is one of the ways without increased risk, which makes it possible to find the optimal parameters of manufacturing processes and systems. The paper presents an example of use of simulation for solution of the bottleneck problem in the concrete company.

***Keywords*—**Practical applications, business processes, systems, simulation.

I. Introduction

THE companies, which want to succeed in the current strong competition, must systematically deal with methodology oriented on designing, planning, implementation and enhancement of industrial processes, as well as on implementation in the area of innovations in order to ensure their high efficiency.

Top management of any organization has a right to choose such strategy and tactics, which it will apply at its functioning. If an organization wants to be permanently successful in its field of business, it must not only keep up with its competitors, but rather try to be one step ahead of them. It is therefore important to know its own weak points and possible external threats, and to know well its competitors, but also its partners.

According to the survey performed by the company ERNST&YOUNG, in which participated in 2012 altogether 63 organizations from Czech Republic and Slovakia, it appeared that the most frequently realized projects are projects aimed at modernization of IT (74%), followed by the projects of process re-structuring and re-organization (55%), development / introduction of new product (52%) and projects aimed at reduction of costs (21%). These projects realized in the private sector often fail. The failed projects represent in the case of modernization of IT 36%, in process re-structuring and re-organization 39%, development / introduction of new product 28% and in reduction of costs 17% [4], [2]. The question is, how big is financial loss caused by those unsuccessful projects and what is the cause of those failures.

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Currently several principles exist, such as Six Sigma, TOC (Theory of Constraints), Lean production, etc. Their integration within the organization (see Fig. 1) enables achievement of synergic effect, which in the final phase will lead to the maximal satisfaction of the customer, employees and other involved parties. These principles can be successfully applied in all fields of production and services.

		Synergic effect
Principle	**Purpose**	**Result**
Lean	Minimisation of wastage	More efficient processes
Six Sigma	Minimisation of variability of processes	Competent processes
TOC	Maximisation of flow	High performance processes

Fig. 1 Synergic effect of integration of various principles into the company system

For completeness let us present the basic ideas of the above terms. The Lean production is based on the assumption that all company activities that do not add value for the customer, are a waste and that they must be eliminated as such. The Six Sigma is a structured and highly quantitatively based approach to improving the quality of products and processes with use namely of teamwork, when trying to achieve a level of such quality, that more than 3.4 failures may occur per one million of opportunities. Use of Six Sigma makes it possible to reduce variability of processes. The TOC focuses on the search for bottlenecks, on maximization of flow and minimization of production costs. The competitive ability of any company is given by its ability to minimize production costs in combination with creation of new or innovative products or entirely new innovation opportunities.

Solution of the projects aimed at restructuring of processes, reduction of costs, introduction of new production into the established, and running systems is not easy and the expected results are verified only after some time. It is possible to use for an optimization of the projects, as well as for designing of production systems or for their control in practice, a simulation in the simulation software, thanks to which it is possible to find without an increased risk the optimal parameters of manufacturing processes or systems.

Simulation can be understood as realization of experiments with use of a computer model, which simulates the functioning of real processes and systems in order to analyze their behavior under different conditions, in order to find the optimal process parameters with regard to the required criteria. It is a set of complex numerical and logical relationships, which can be evaluated without the necessity of their actual implementation in practice.

II. Simulation Tools

We can encounter in practice various simulation software, examples of some of them are presented in Table I.

TABLE I
EXAMPLES OF SIMULATION SOFTWARE

MATLAB	For mathematical purposes, technical fields and disciplines of economics – company MathWorks [9].
ARENA	General simulation software for industrial applications and business process re-engineering, graphical animation system, principles of hierarchical modeling, designated for any industries – company Rockwell Automation [1].
PROMODEL	Simulation product for prediction in various fields and industries – industry, army, aviation, health service,... – company Promodel Corporation [8].
SIMPROCESS	Simulation of company processes, it integrates process mapping, discrete simulation and activity–based costing – company CACI International Inc. [7].
SIMSCRIPT	Programming language for simulation projects; simulation and modeling of applications with interactive graphical user interface, presentations and 2-D animation of graphics – company CACI International Inc.
WITNESS 13	Set of tools for modeling and simulation of any company processes in various fields and industries - company Lanner Group Ltd. [5].
SIMUL8	Simulation software, which can be used by anyone for visualization, evaluation, and enhancement of processes; commercial simulation software – company SIMUL8 Corporation [6].

Computer simulations can be used in numerous practical situations, for example at optimization of complex production systems, including logistic ones, scheduling of production, forecasting of prices on financial markets, as process tools for engineering simulation, municipal simulation models and traffic engineering, simulation of behavior of structures under various conditions, meteorological forecasts, projects management, risk management, etc.

Use of simulation software in company practice has numerous advantages:

- it is possible to simulated without an intervention into real operation;
- it is possible to experiment also with situations, which could not be tested in real conditions;
- simulation offers more comprehensive view of the resolved problem and leads to better understanding of the real system;
- simon offers broader overview of company processes;
- it is possible to resolve even very complex systems that cannot be resolved by analytical methods;
- it is possible to verify comparatively rapidly several different variants of solution;
- it is possible to investigate behavior of the system in real, accelerated or decelerated time;
- it is possible to find or to verify real functioning of the system in contrast to suppositions and guesses of individuals.

Disadvantage of simulation is difficult interpretation of results of some simulation tasks, as well as the fact that they are often highly time consuming or expensive and that they require knowledge and experience of the workers with creation of models and knowledge of work with the simulation software.

We will show below an example of successful simulation in practice realized with use of the simulation software WITNESS.

Use of the WITNESS software in the company sphere will depend mainly on finances, which the organization will be willing to use for purchase of the WITNESS system. The cost of the basic model is already of the order of several hundred thousands of Czech crowns (approx. CZK 650 thou. [4]). But even so this software can be worth it for large organizations. Smaller organizations can use services of advisory companies, which specialize on simulation of various tasks. Another possibility is collaboration of these companies with universities within the frame of scientific and research activities, when teachers together with students work scientifically on resolution of concrete tasks or problems, which the companies are unable to resolve by their own efforts. It appears that companies are interested in solution of problems by simulations. Since 2009 at the VŠB - Technical University of Ostrava, Faculty of Mechanical Engineering, altogether 14 final works were solved with use of the WITNESS software, particularly from the field of traffic engineering, optimization of manufacturing processes, and bulk service.

III. Example of Practical application [3]

The company needed to increase capacity of the bottleneck, i.e. forwarding department. Solution of this task was based on the Theory of Constraints (TOC). The main requirement was to increase the productivity of delivery of orders from the warehouse in the forwarding department, which at that time had low performance, time necessary for shipment was too long and therefore customer requirements for short delivery times was fulfilled insufficiently. Management of the company required an increase of the forwarding department performance at least by 20%.

Analysis of the existing state found the following facts:

- number of workers in the forwarding department– 7;
- number of working sites (scales) – 7;
- number of containers with the assortment– 7;
- each working site was equipped with display showing individual orders;
- each of the workers had at his/her disposal different kind of assortment;

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- each customer's order was packed into its own case. Empty cases were situated above the heads of the workers;
- the cases were transported by belt conveyor.

The whole process was divided into several stages (see Fig. 2):

1. Preparation of individual orders by six employees.
2. Weighing of the prepared cases by the seventh employee on the checking scales.
3. The cases were then loaded into the truck, which distributed the orders to customers.

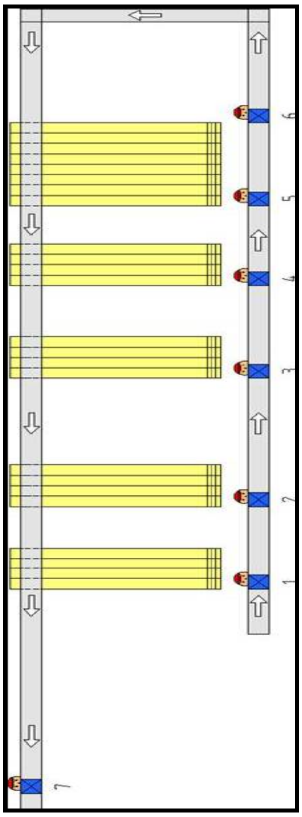

Fig. 2 Principle of preparation of the orders [3]

The worker at the scales No. 1 prepared the assortment in accordance with order to the case, which he afterwards weighed. After having weighed the last item of the order he sent the case to the scales No. 2, where the next worker prepared his case and after having weighed the last item of the order he sent to the next worker together with the previous case. In this manner the remaining sent their and possibly also previous received cases (into which it was not required to add their assortment) towards the checking scales. Each completed case was weighed on the checking scales and then loaded on the truck and prepared for transport to the customer. [3]

As it was already mentioned above, the company required to increase the productivity of labor of the forwarding department and ensure thus delivery of the orders to the customers in the required quality in agreed terms. The task was therefore namely to accelerate the speed of preparation of the orders and to shorten the time of stay of the customer's order in the forwarding department. Passage through the bottleneck had to be accelerated at least by 20%, so that the change of the system might be of significant importance.

Search of an optimum variant of layout of the working site was realized with use of chronometric study and computer simulation.

The following was established on the basis of the performed and evaluated chronometric study:

- average time of preparation of one order was 128.06 s;
- the forwarding department shipped on average 142 orders per one hour;
- stabilization of the scales lasted on average 4 s;
- duration of transport of an order between the last scales and the checking scales was on average 56.5 s.

Procedure of preparation of the simulation model in the program WITNESS (see Fig. 4) was realized in the following steps:

- creation of diagram with use of individual elements;
- assignment of operators;
- defining of the length of intervals of processing by the given elements;
- determination of material flow;
- running of simulation.

Diagram of the model was plotted with use of elements from the library (see Fig. 3).

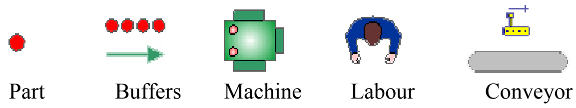

Fig. 3 Elements used for creation of simulation model

The element "part" represents a product of food industry and it shows then also the prepared case containing individual products. The element expressed as "machine" holds the position of containers of assortment and of scales of forwarding department. These machines are operated by workers "labor". The scales are connected by "conveyor", which transports prepared cases. All the cases weighed by the checking scales are then captured in the "buffers". We defined to the elements "machine" the length of intervals, during which the "part" is processed in the given "machine" (for example duration of handling at the scales). We then determined the product flow from its withdrawal from the container of assortment till its dispatch (placing into the "buffer" at the end of process). At the moment when the model is set in this way, it is ready for running of the simulation process itself.

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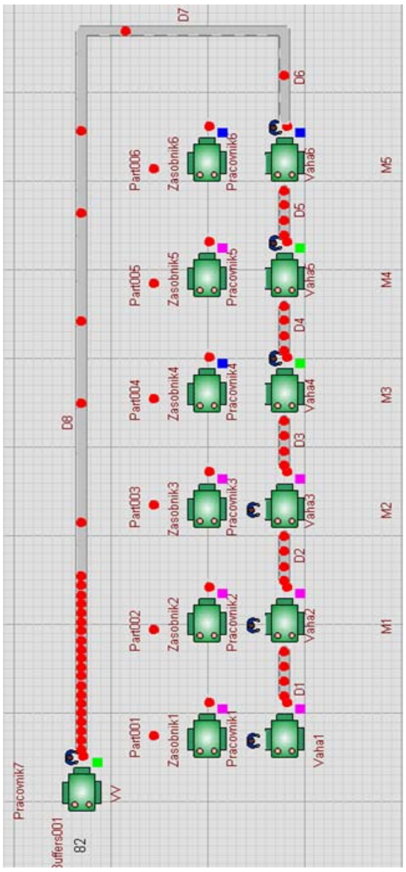

Fig. 4 Simulation of the current state of WITNESS [3]

The main task is to minimize or the eliminate the activities, which do not add a value for the customer, and to accelerate thus the whole process. [3]

IV. Evaluation of the Proposed Solutions

Solution of this task required identification of the problems, which caused limitations of the system. On the basis of analysis of the existing state with use of chronometric study we found the main problems, which represented the limitations hindering acceleration of preparation of the order and thus also increase of flow-rate of the orders passing through the system.

<u>These problems comprised the following:</u>

- occurrence of large number of operations, which did not add any value;
- long time of stabilization of scales;
- accumulation of cases in front of scales and necessity of their subsequent shifting;
- excessively long conveyor.

Operations, which do not add any value, are the processes, which are characterized as unnecessary, but it is not always possible to eliminate them completely. On the basis of chronometric study we established that almost 2/3 of system operations were those, which did not add any value.

Long time of stabilization of scales, is the time when it is necessary to wait for stabilization of the mass value of the weighed item. At present scales are already available with much shorter time of stabilization than the scales used so far in the forwarding department.

Accumulation of the cases in front of scales and their subsequent shifting has adverse impact particularly on the worker at the scales No. 6. Accumulation of the cases at the scales extends the total time for preparation of the orders.

Excessively long conveyor. Transport on the roller conveyor is one of the operations that do not add any value for the customer, but it is in certain degree inevitable in the whole system of forwarding. It serves for transport of the prepared cases (orders) between individual working sites (scales) and the checking scales. Duration of transport represents the longest time at preparation of an order. Transport of one order lasts on average 84.63 s. The distance between the last working site and the working site of the checking scales is unnecessarily long. At the rate of the roller conveyor of 1 m/s, each excessive meter of the conveyor extends the process of preparation by 1 s.

On the basis of these identified problems altogether 3 solutions were proposed. [3]

V. Division of Layout of the Sector for Preparation of the Orders

The purpose of this variant was to divide part of the system, where the preparation of the orders as such took place. We created two branches, each with four scales, which meant an increase of the total number of workers in the forwarding department from 7 to 9. The proposed layout ensured the required increase of flow-rate of the prepared orders. Its contribution was reduction of number of cases passing through individual scales. In comparison with the previous state, when through the last scales always 5 cases were transported, in this variant only 3 cases will pass through the last scales. Principle of division of the sector for preparation of the orders is shown in Fig. 5. Table II below shows individual performed operations divided to those that do add a value and those that do not add any value. The resulting time for preparation of the order was reduced down to 38.09 s. This increased flow-rate through the system required, however, increase of labor costs for additional 2 workers.

TABLE II
SYSTEM OPERATIONS – VARIANT 1 [3]

Operation	Characteristic	Time[s]
Grasping of case	Adding no value	1.11
Placing of case on the scales	Adding no value	1.77
Grasping of product	**Adding a value**	0.95
Putting of product into case	**Adding a value**	0.91
Weighing	**Adding a value**	2.50
Pushing of case to the next scales	Adding no value	1.12
Pushing of 3 cases from the preceding scales	Adding no value	6.10
Transport of case on the conveyor	Adding no value	18.83
Weighing of 8 cases on the checking scales	Adding no value	4.80
		38.09

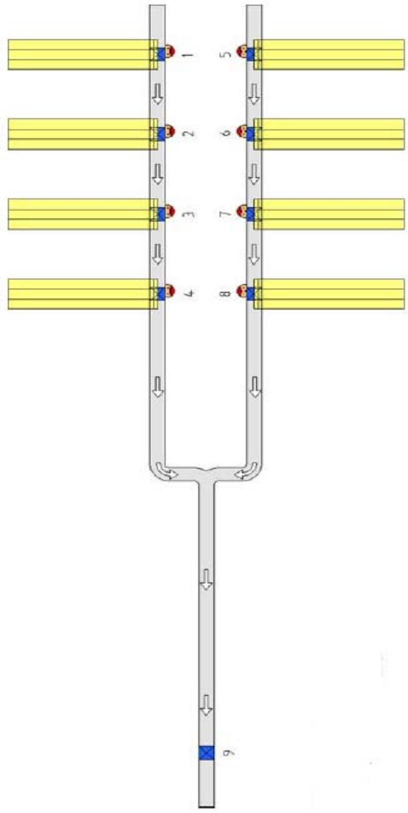

Fig. 5 Layout of the sector of preparation of the orders [3]

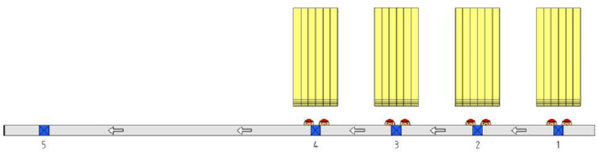

Fig. 6 Diagram of cooperation of workers [4]

VI. Cooperation of Workers

This variant deals with turning of the workers towards the containers with the assortment. This operation does not add any value to the customer and it extends the process of preparation of the orders. One worker was added to each scale, who will aid with preparation of the orders. One worker will perform weighing, while the second worker will take out the relevant assortment from the container. This should reduce the time of preparation of the orders. We suggested 4 scales with 8 workers. Total time of preparation of an order will be in this case 38.15s [3]. Similarly, as in the previous variant the increased flow-rate through the system is achieved at the cost of increased labor costs for additional 2 workers in comparison with the existing state. Disadvantage of this variant is small space for movements of 2 workers at the scales and their insufficient synchronisation.

TABLE III
System Operations – Variant 2 [4]

Operation	Characteristic	Time[s]
Grasping of case	Adding no value	1.11
Placing of case on the scales	Adding no value	1.77
Putting of product into case (2x)	**Adding a value**	0.91x2
Weighing (2x)	**Adding a value**	2.50x2
Pushing of case to the next scales	Adding no value	1.12
Pushing of 3 cases from the preceding scales	Adding no value	6.10
Transport of case on the conveyor	Adding no value	18.83
Weighing of 4 cases on the checking scales	Adding no value	2.40
		38.15

VII. Itemized Weighing of an Order

TABLE IV
System Operations – Variant 3 [4]

Operation	Characteristic	Time[s]
Turning of the worker by 90°	Adding no value	0.88
Grasping of product	**Adding a value**	0.95
Turning back of the worker with product by 90°	Adding no value	1.10
Putting of product on the scales	Adding no value	0.91
Weighing	**Adding a value**	2.50
Shifting of product away from the scales	Adding no value	0.98
Transport of the item by belt conveyor	Adding no value	4.50
Relocation of product from conveyor into case (4x)	**Adding a value**	1.70x4
Grasping of case	Adding no value	1.11
Weighing of full case (2x)	Adding no value	2.50x2
Shifting of product away from the scales (2x)	Adding no value	1.45x2
		25.93

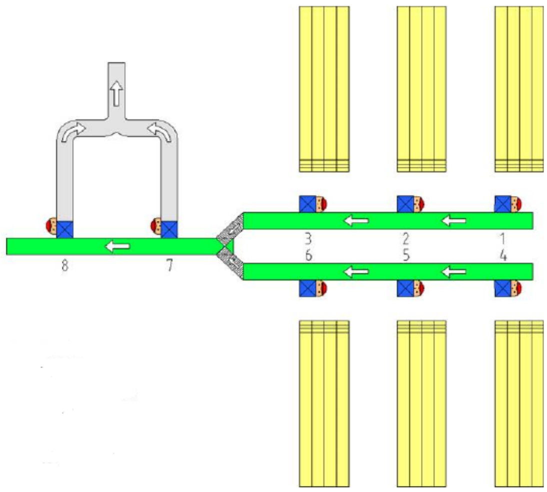

Fig. 7 Diagram of itemized weighing of an order [3]

This variant will cancel filling of individual cases (orders) by the workers in the sector for preparation of the orders. The orders will be prepared sequentially and not simultaneously as it was done until now. Number of workers and scales will remain the same. The scales will be located into two branches, path of the belt conveyor, on which the items will be transported, will be shortened. The workers will prepare from their containers individual items of the order, which they will weigh and send by conveyor to the checking scales, where they will be loaded to the cases, weighed, and as soon as they achieve the maximum carrying limit of the case (15 kg) the whole case is weighed and sent by the roller conveyor to the loading platform and prepared for transport to the customer. Time for preparation of one order will be in this case 25.93 s.; however, in the final result this will bring lower number of prepared orders per day due to waiting for completion of an order. This variant has also a risk of confusion and mixing of orders [3].

VIII. Simulation of the Chosen Variant

On the basis of evaluation of feasibility of individual variants the company management chose as the most suitable the variant based on division of layout of the sector for preparation of the orders.

We defined in the model of the existing state, as well as in the model of the proposed variant, that each worker at the scales will take and weigh only one item, which he puts into the case and sends it by conveyor towards the checking scales. A container is placed at the end of the conveyor, which registers the quantity of the dispatched cases. This quantity is an indicator of performance of each variant.

For observation of cases dispatched by the system we entered a time limit of simulation equal to one shift of 8 hours. Throughput of cases through the system was increased from initial 142 orders per hour to final 397 orders per hour, which represents a 2.8 fold increase. In spite of increase of number of workers by 2 additional workers and additional equipment of the working sites by new scales and shelves the return of investments will be of the order of several hours.

IX. Conclusions

The paper dealt with the issues of use of simulation of company processes in practice. Simulations are one of the possibilities how to verify without any bigger risk the envisaged changes in the manufacturing process, or how to set optimal conditions of the system. We simulated on an practical example from practice from food industry with use of the software WITNESS the procedure of preparation of orders in the forwarding department, and it was proven that realization of the proposed solution can bring an increase of performance by 180%, which surpasses several times the original requirement of the company management. We know now that the proposed variant has already been successfully implemented in the company.

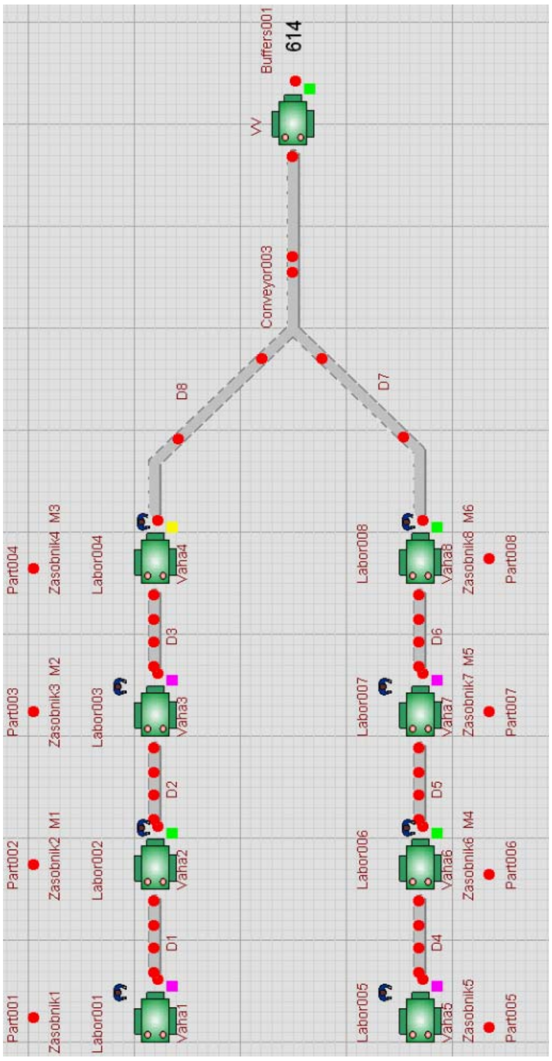

Fig. 8 Simulation of the variant chosen in WITNESS [3]

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