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Case on In-House Logistics Modeling and Simulation

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Abstract: Modelling and simulation can make time of research and achieving necessary solutions shorter and more effective. In this study, researchers at the beginning present relevant related researches from the fields of logistics systems modelling and some features of advantages and disadvantages of computer simulation. Subsequently, decisive characteristics of simulation tool Dosimis-3 are described. Finally, the study offers a short case on some experiences from using simulation software in order to optimise the production process in real conditions.

Key words: In-house logistics, simulation, modelling, Dosimis-3, conditions, Romania

INTRODUCTION

To model a logistics system, it is expected to understand the purpose of a logistics concept and to identify the system constraints. Logistics systems are often affected by changes occurring outside the system environment. Therefore, in order to model logistics systems it is necessary to decide on the boundary between the system and its relevant environment. This decision usually depends on the purpose of the study. Since, it is rarely feasible to experiment with a real system it is necessary to build a model as a representation of the real system and to study it as a surrogate for the real system. Pidd (1999) defines a model as follows: a model is an external and explicit representation of part of reality as seen by the people who wish to use that model to understand to change to manage and to control that part of reality in some way or another. Mathematical models are ones of the models used in processes modelling and simulation. They are especially helpful because they make directly basis for usage of the computer tools in problem solving approaches (Dima *et al*., 2010). Another advantage of it is providing the possibility to evaluate numerous logistics processes alternatives. One of the main disadvantages of mathematical models is that they cannot precisely predict the feasibility of the modelled logistics processes in real-life. Moreover, it has to be also said that such a model is only reliable if the right assumptions underlying the model are made.

RELATED WORK

Different types of models in generally can be used to optimize logistic performance of production systems in research and practice. According to Nyhuis *et al*. (2010) the most widely analytical models in in-house logistics are Queuing theory models and on the other hand, simulation is a widespread technique for the exploration, design and optimization of complex production systems. In analytical models the relationships between the elements of the system are expressed through mathematical equations. However, most real-world systems are too complex to allow for analytical modelling and these models are therefore preferably studied by means of simulation.

Hoover and Perry (1998) identified some advantages of analytical models: conciseness in problem description, closed form solutions, ease of evaluating the impact of changes in inputs on output measures and in some cases the ability to produce an optimum outcome. On the other hand, they recognised some disadvantages such as assumptions regarding the system description which may be unrealistic and complex mathematical formulations which defy solutions. For example, many systems can be modelled as queuing networks but either the assumptions required for analytic solution are somewhat unrealistic (e.g., exponential inter-arrival and service times) or the mathematical formulation necessary to reflect the desired degree of realism is intractable (Fahlbusch, 2000). Silver *et al*. (1998) states that if mathematical models are to be more useful as aids for managerial decision making, they must be more realistic representations of the problem in particular, they must permit some of the usual givens to be treated as decision variables. Moreover, such models must ultimately be in an operational form such that the user can understand the inherent assumptions, the associated required input data can be realistically obtained and the recommended course of action can be provided within a relatively short period of time. In order

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Table 1: Advantages and disadvantages of simulation

Advantages	Disadvantages
Most systems with stochastic elements are too complex for analytical evaluation. Thus, simulation is the only possibility	Each run of a stochastic model produces only estimates of a model's true characteristics for a particular set of input parameters. Thus, several independent runs of the model are required. An analytical model if appropriate, can produce the exact true characteristics
Simulation allows one to estimate the performance of an existing system under some projected set of operating conditions	Expensive and time consuming to develop
Alternative proposed system designs can be compared to see which best meets a specified requirement	The large volume of numbers produced or the persuasive impact of a realistic animation often creates a tendency to place too much confidence in a study's results
Better control over the experimental conditions than when experimenting with the system itself	If a model is not a valid representation of a system under study, the results are of little use
Allows one to study a system with a long time-frame in compressed time or even in expanded time	

to ensure that input data will be available in pertinent time period, researchers can effectively used for this purpose modern identification technology especially Radio Frequency Identification (RFID). According to Modrak *et al.* (2010) the impact that RFID will have on business operations and support infrastructure definitely calls attention to IT specialist to start aggressively planning for RFID.

Simulation models can compensate for the disadvantages of analytical models but not without sacrificing some of the advantages of the analytical models. Several methodologies have been developed to improve logistics performance and introduce integrated logistics management. Law and Kelton (1991) also mention a number of advantages and disadvantages of simulation (Table 1).

Most analytical models only take a few variables into account. For example, they may look at inventory and the cost of running out of stock but ignore other costs such as order processing, handling and transportation. Another optimisation approaches cope with a scheduling problem to find a feasible sequence of jobs on given machines with the objective of minimising some function of the job completion times (Modrak and Pandian, 2010). The complexity of analysing logistics chain processes is much too large for analytical models also due to the dependent demand in the logistics chains. Furthermore, probabilistic demand in logistics chains modelling creates extreme modelling complexities in a multi-echelon inventory situation (Wilson, 1993). In now-a-days, decisive logistics activities in modern factories are supported by Manufacturing Execution System (MES) that include logistics performance analysis (Modrak and Mandulak, 2009). Simulation techniques used in material flow planning and operations are more or less an effect of the IT systems. Today simulation techniques are used in logistics area for planning changes in every activity of the whole supply chain. Among the most reliable simulation techniques in this area, genetic algorithms are recognised to be well suited for such purpose (Semanco *et al.*, 2011).

DESCRIPTION AND PURPOSE OF DOSIMIS-3 SOFTWARE USING

One of the well-known simulation packages that are used in a high range of application and industries including for material flow modelling and simulation is Dosimis-3. It is a modular-oriented simulation package developed by SDZ® GmbH based on interactive graphical simulator working with Windows 95/98/NT or UNIX. The simulator works event-discrete and allows for the simulation of possible time-discrete material flow systems. A simulated production process can be developed graphically so as to be interactive on the screen. Standard elements such as sources, sinks, work stations, buffers and vehicles etc. which in their structure represent essential modules from the material flow field, allow a rational layout by means of a menu-controlled user interface. Modules with several entrances and possess intelligence over which local strategies such as FIFO, minimal occupation of the succeeding module etc. can be realised when controlling the object flow. Thanks to the modular concept there are theoretically no limitations to the scope and size of the simulation. Super-ordinated levels enable the planner to define failures and breaks or to simulate the deployment of workers in any number of freely-definable work sections (Bukowski *et al.*, 1999).

Dosimis-3 can be useful for modelling and simulation of the material flows and work places. Today high production systems flexibility is required because of shorter and shorter periods of order realisation or wide order diversity. Adequate work station planning and efficient internal transport can ensure the flexibility. The role of internal transport in logistics and production process management is extremely significant. The internal transport connects work stations and storerooms. The aims of internal transport is delivering of particular sorts and quantities of raw materials, semi-manufactured parts and products in right time and right place of production system. The impacts of badly working internal transport are (Kot and Slusarczyk, 2009):

- High transportation costs
- Wastes of time and transportation means
- High level of inventories
- Ineffective work stations' operation
- Long time of order realisation
- Incomplete utilisation of production capacity

Because of aforementioned factors it is better to plan, analyse and develop the internal transport system, production process and management without building the real structures. It is possible using Dosimis-3 because the user builds and tests virtual structures (Builds model of the real structures and simulates it). For example user can analyse internal transportation systems. Analysis carried out using the simulator shows components of transport system where the improvements are necessary. In this way user can:

- Organise the effective internal transport system
- Find or avoid of disturbances in transport process
- Improve of internal transportation effectiveness
- Manage of raw materials or semi-manufactured articles supplies for the particular work stations
- Establish the best parameters of production system operating
- Eliminate or make shorter the interruption during the operations on the work stations
- Minimise of internal transportation costs and production as a consequence

Applying Dosimis-3 it is possible to make tests of many transportation alternatives in short time and their influences on effectiveness of production system and basis on this; user can choose the most suitable alternative for the production schedule. User can also optimise number and sort of transportation means, plan transportation routes or speed of transportation. Dosimis-3 allows for evaluation the simulation results; it offers a variety of tables and graphics. A dynamic presentation of the transport system behaviour presented within the animation let user understand the production process mechanisms better.

DOSIMIS-3 SOFTWARE APPLICATION CASE

A case study was conducted in order to optimize the industrial production process of butter, a process which damages the membranes of butterfat found in cream resulting in the production of small butter grains. Butter production process is a periodical activity that contains few separate stages. The most important are: raw milk pasteurising, putting raw milk through a cream separator, cream pasteurising once again, cooling, biological maturing, milk buttering, shaping and packing, storing, a milk selection and quality control. During the study, researchers have identified all stages of butter production process described above paying special attention to the number and type of operations, the operation parameters and sequence, type and parameters of machines. Subsequently, the necessary parameters of the researched production process adapting them to the software requirements were systematized. In this operation a special problem appeared.

Because Dosimis's parameter specification requires the length of flowing objects, there were alternatives: quantify the flow of raw milk in another unit than litres or give up Dosimis application for this simulation. Because the user's imagination can be a barrier to the simulation of new applications and because researchers had used Dosimis in previous researches (Purchasing new simulation package would be probably expensive) so it was decided to quantify flow in the raw milk stream in cubic meters.

Transformation of other parameters to Dosimis requirements was comparably easier. Then, the simulation model using the module palette was built. It was easy because the Dosimis-3 screen looks very similar to standard MS Windows and it can be modify using the same procedures. The simulation building process consists of following stages:

- Introduction of modules to the Dosimis-3 window
- Modules parameters (data) specification
- Modules connection according to the production process sequence
- Determination of simulation parameters (time, pre-run time and statistic interval)

After these stages we obtained the simulation model and simulated material flow through the production process. Based on statistical analysis of the particular process element efficiency it was estimated what elements worked with full efficiency and what elements made the production process slower or blocked the production process (Fig. 1).

We found for example that because of the low efficiency of the packing machine compared to other workstations, all the machines existing before the packing machine in the production process were blocked for a considerable amount of time. Based on a statistical elaboration we changed the model structure to optimise the production process. It was impossible to increase the packing machine efficiency in reality so, researchers decided to add one more packing machine for the process. The effects of the changes are shown in Fig. 2. The new model structure is shown in Fig. 3.

In order to verify the change accuracy it was also carried out a process animation to find the points in the system, blocking the production before change and after it. It was also necessary to perform several simulations changing parameters each time, considering workstation occupation, utilisation, throughput or raw milk supply

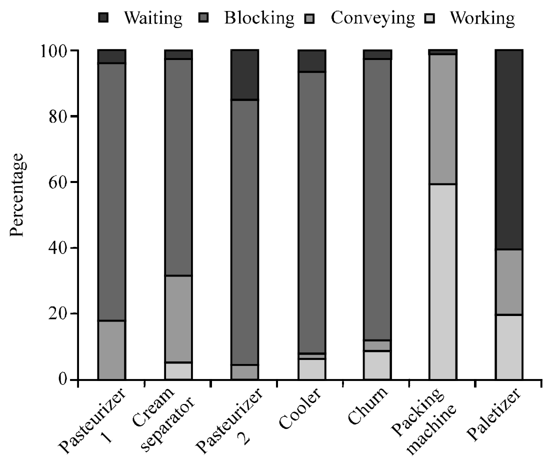

Fig. 1: Workstation utilisation-model before changes

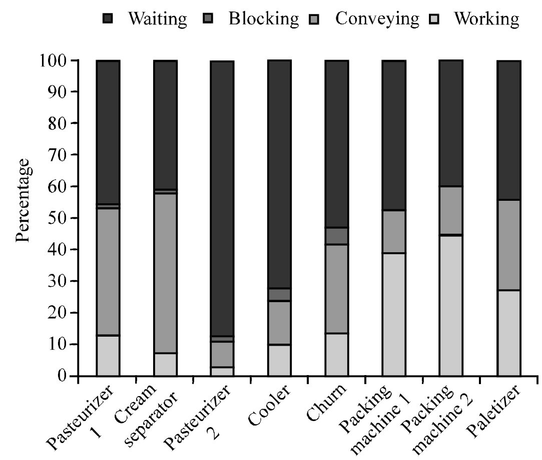

Fig. 2: Workstation utilisation-model after changes

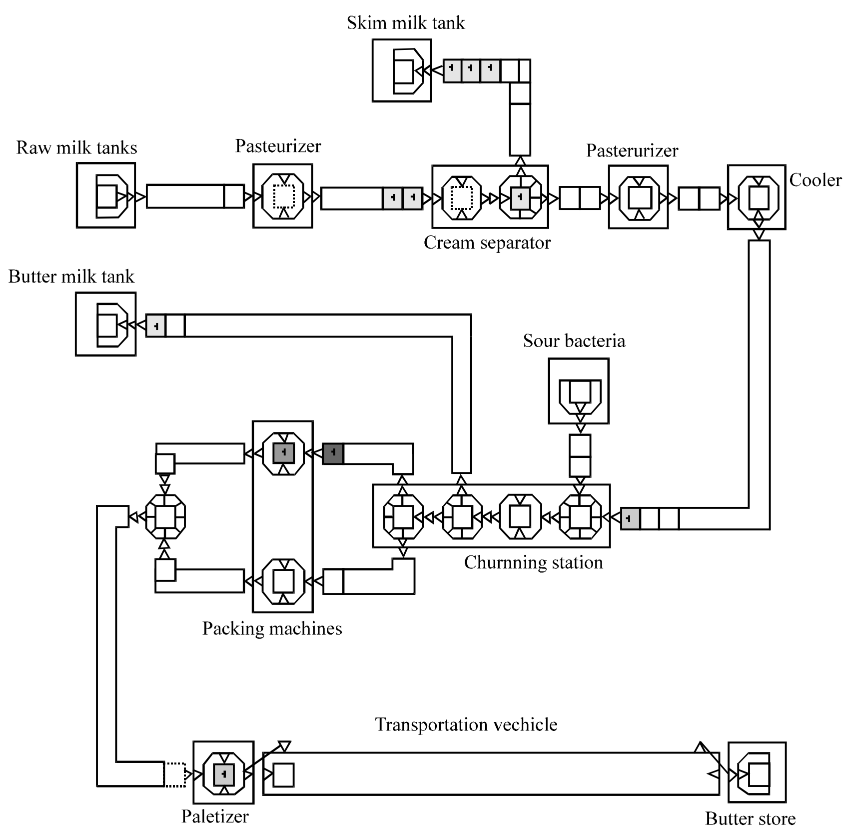

Fig. 3: Simulation model during animation after changes

variation. The last considered element was very important because the seasonal variation indicator of raw milk supply in Poland (it is a quotient of the biggest daily supply and the least daily supply) on average amounted to 1.47. During successive simulations many others possibilities for material flow improvement and increase in production effectiveness have been found. The last step was the most crucial: the presentation of simulation effects to decision makers in order to demonstrate effective application of proposed changes in reality. Finally, the results of simulation allowed adopting the reorganization of processes of supply chain aiming at:

- Increasing the amount of daily supply and decreasing the number of suppliers in current areas of distributio
- Making it possible to increase the efficiency of milk pretreatment processes
- Searching for new opportunities for extending distribution, specifically those ensuring faster flow of products (Canvassers, wholesale-retail trade networks)

DISCUSSION

For the decision makers was important to be confident about consistency of theoretical findings and possible practical aspects. It depends on validity of the model used that is based on the degree to which the performance measures produced by the model and those observed in the system are similar.

It is generally impossible to perform a statistical validation between model output data and the corresponding system output data due to the nature of these data. The output processes of almost all real-world systems and simulations are non-stationary (the distributions of the successive observations change over time) and auto correlated (the observations in the process are correlated with each other). Law and Kelton (1991) believe that it is most useful to ask whether or not the differences between the system and the model are considerable enough to affect any conclusions derived from the model. Researchers also recommend that the system and model be compared by driving the model with historical system input data (actual observed consumer demand data and service times) without the use of a formal statistical procedure. Thus, the system and the model experience exactly the same observations from the input (random) variables.

CONCLUSION

It can be also stated that modelling and simulation are useful and effective using computer support for processes improvement but it should be remembered that there are some important preconditions. They are as follows: user large experience, elimination of error during simulation e.g., simulation has wrong definition, inadequate level of model complexity or insufficient user's work in model elaboration (wrong documentation, incomprehensible results, model separation from the reality and uncompleted information).

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