HMLV Manufacturing Systems Simulation Analysis Using the Database Interface

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Abstract: - The paper describes a simulation approach for the High Mix Low Volume (HMLV) manufacturing systems analysis. Simulation model for the manufacturing system analysis is expected to reliably represent the real system attributes. To be the case in the simulation of the HMLV systems, the simulation model must contain a large number of real system parameters. This paper provides an approach of using the direct link between simulation software and database interface. Experiment shows that the proposed approach allows flexible adaptation of the simulation model to the real system behavior.

Key-Words: - HMLV manufacturing system, Simulation, Analysis, Database system, Production scheduling

1 Introduction

Fast-changing market conditions and products customization are the main reasons of the increasing need in the manufacturing systems flexibility. Manufacturing company competitive advantage resides in the ability to fit the specific customer demands. This is known as agile competition. Rather than offering the customer a plethora of different options and models from which to choose, the customer works with the producer to arrive at solutions to the customer`s specific problem. The logical result of this type of cooperation is a wide range of the product types in the production system [1].

High-Mix Low-Volume manufacturing systems are nowadays the worldwide trend in various areas of the industrial production, e.g. in electronic manufacturing. A typical HMLV system is able to produce more than 600 different types of products in volumes 0–1000 pieces per single production order [1]. Products are segmented into the product families - groups of products derived from a common product platform. The flexible character of the HMLV manufacturing systems brings some new specifications of the production behavior, e.g. [2]:

- repeated machines setup requirements
- high WIP (work in process) inventory
- long production lead times
- low capacity utilization
- low productivity etc.

Since all of the production system specifications above are undesirable there is an increasing need in the HMLV systems analyzing and optimization. This paper provides a simulation approach in the HMLV system analysis using the direct link between the simulation software and the database system.

The rest of the article is organised as follows. A problem formulation is given in Section 2. Section 3 provides software architecture. Application example is given in Section 4. Finally, conclusions are summarised in Section 5.

2 Problem Formulation

Traditionally, analytical models are used in solving optimization and analytical problems in manufacturing systems. However, for the complexity and randomness inherent nowadays in most real-world problems, it is difficult to establish accurate analytical model for them. Simulation technology can be an effective alternative in studying the characteristics in behavior of a system, as it is capable of combining the relevant elements of the system according to the actual logic of the operations, which can help reflect the real behavior of the system [3]. Perhaps the biggest benefit of the simulation is the possibility to evaluate the impact of the local changes on the whole system performance [4].

Simulation analysis has been proved a necessity by several studies, as due to the highly uncertain

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environments of the discrete manufacturing systems, it is hard to build mathematical models for the analysis and optimization of the systems. Simulation approach is perhaps the only choice.
Gert Zulch presented a model combination and hierarchical simulation method for complex systems [5]. H. Bley reported a toolkit for the modeling of large systems. It uses multi-stage processes to model a system, making classification for the hierarchical models and using artificial neural network to conduct the model simplification or abstraction [6]. Lengyel et al. used a simulation model to evaluate the performance of make-to-order manufacturing systems where a high variety of products of different volumes are requested to be produced by a tight due date [7]. Haskose et al. discussed the make-to-order manufacturing sector particularities like wide variety of products, quantities, WIP, average lead times, capacity etc. The work shows differences among simulation, usual approach in research on the behavior of MTO production systems, and different types of queuing network modeling methods [8]. Chan and Chan presented simulation modeling and analysis of a serial production line in a printed circuit board (PCB) factory, which is a typical example of a HMLV manufacturing system. The analysis aimed to maximize the average throughput rate and to minimize the average lead time. The simulation model in Simfactory software examined the utilization of the work resources and the average queue lengths [4].
One of the major challenges facing the simulation is an effort the simulation model is an appropriate representation of the real system - verification and validation of simulation model. Therefore, it is necessary to import all the data that represent the real manufacturing system behavior to the simulation model, e.g. number of machines, number of production steps, material flow, machines breakdowns, labors behavior, material queuing and sequencing rules, production times, setup times, batch sizes, transport sizes, buffers capacity etc. Some of these parameters such as production times, setup times, batch sizes or transport sizes are strictly dependent on the actual product type. For that reason in HMLV manufacturing systems simulation it is especially important to consider the appropriate way of the data importing. There have not been done a lot of researches on this problem.
A lot of manufacturing companies use the ERP systems in their environment. Products from suppliers such as SAP, Oracle and more recently, Microsoft, dominate the market [9]. All of these products have the integrated database systems which significantly reduce data storing and data arrangement questions. Work on the presumption that most of the HMLV system environments have the product type dependent attributes stored in the ERP database system it is assumed that the direct link between simulation software and database system is a convenient way to solve the problem of importing data.
This article provides an example of the direct connection between the simulation software WITNESS and the MS Access database system.

3 SW Architecture

3.1 Witness Simulation Software

Witness is a discrete event and continuous process simulator providing a graphical environment to build simulation models. It enables to represent a real world process in a dynamic animated computer model and allows automating simulation experiments, optimizing material flow across the facility, and generating animated models.
Complex routing and control logic is achieved with input and output rules as well as special actions using functions.
Results of simulation can be viewed on the screen either in tabular or graphic formats. Reports allow user to examine the performance of elements in the model and provide him with relevant information about their interaction, details and status.
The main simulation program is supported by the extended modules such as Virtual reality module, Scenario manager module or Optimizer module [12].
In this paper the Witness Power with Ease 2.0 is used.

3.2 MS Access Database System

Microsoft Office Access is a relational database management system from Microsoft that combines the relational Microsoft Jet Database Engine with a graphical user interface and software-development tools. It is a member of the Microsoft Office suite of applications, included in the Professional and higher editions or sold separately. Access stores data in its own format based on the Access Jet Database Engine. It can also import or link directly to data stored in other applications and databases [10].
In this paper the Microsoft Office Access 2007 is used.

3.3 Connection of the SW Components

Connection between Witness simulation software and MS Access database system is provided by the Visual Basic for Application (VBA) language.
First of all it is necessary to define a Witness object in VBA language, which link a Visual Basic program to a running copy of Witness. Example of the link command is as follows:

Set WitObj = GetObject ("Witness.WCL")

Once the Witness object is created in VBA language data transmission is provided with the OLE commands. Examples of the main OLE commands for Witness could be as follows:

WitObj.Begin - set simulation time to 0
WitObj.Run - run simulation with animation
WitObj.Batch - run simulation without animation
WitObj.Stop - stop simulation
WitObj.Variable - set or read a variable value

Scheme of the Witness simulation software and MS Access connection is depicted in Fig. 1.

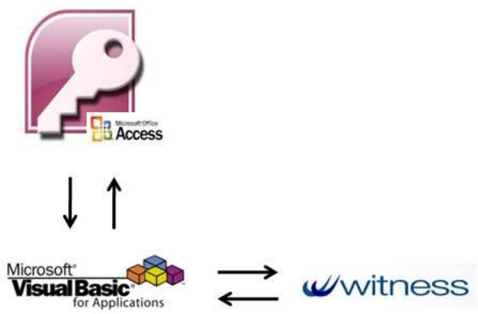

Fig. 1 Witness and MS Access connection scheme

Direct link between simulation software and database system allows easily import all the necessary data stored in the database system to the simulation model. Since Witness simulation software is able to be controlled by external OLE commands, database system can serve as the user interface as well. In this case it is possible to use the simulation model for the real manufacturing system analysis even without special Witness simulation software knowledge.
Another advantage of using a direct connection between simulation software and database system is the simulation experiments evaluation. Results of experiments can be easily stored in the database system where they can be subsequently processed, graphically evaluated and compared with the previous analysis.

4 Application Example

The described concept has been used for production system analysis in EP (embedded product) division of a manufacturing company producing a variety of industrial power supply units (AC/DC and DC/DC). The division provides a flow-shop manufacturing with different number of machines at each production stage which differ in production times, setup times, batch sizes, transport sizes, breakdown occurrences etc. according to the current product type. Block diagram of the EP division production line is depicted in Fig. 2 [11].

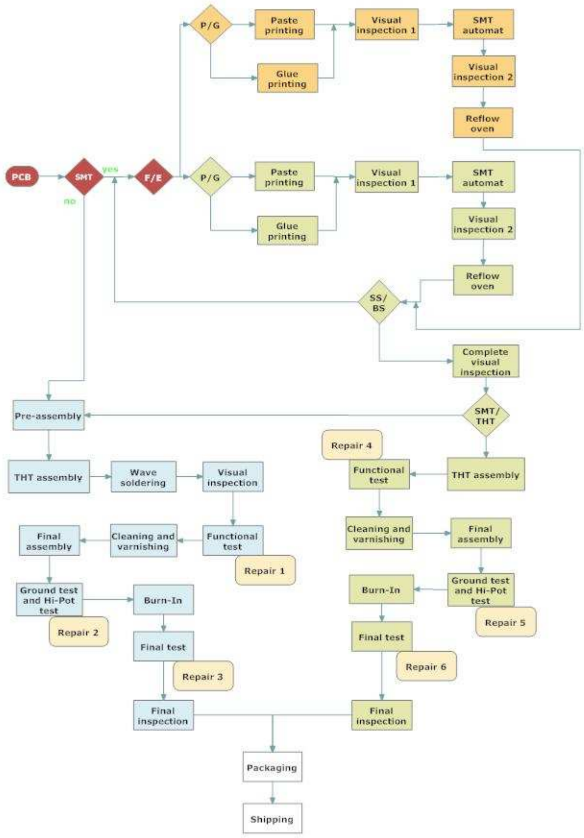

Fig. 2 Block diagram of the production line

4.1 Simulation Model

Simulation model of the EP production line (Fig. 2) has been constructed in Witness PwE 2.0 simulation software. All the real system elements that are requisite for production line performance analysis such as machines, labors, conveyors, buffers, control rules etc. are represented in the simulation model. Parameters that are unchanging and independent of the product type (number of machines, speed rate of conveyors, labors allocation etc.) are set directly in simulation software. Parameters that vary according to the actual product type (production times, setup times, batch sizes,

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transport sizes, failure rate etc.) are imported directly from the database system during the simulation experiment. Products enter to the system according to the production schedule set also in database system interface. Graphical representation of the simulation model in Witness environment is depicted in Fig. 3.

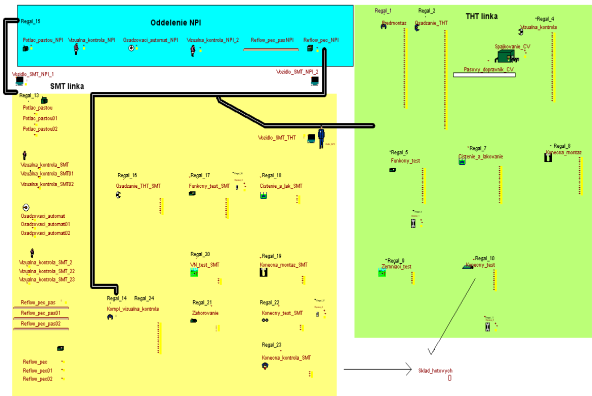

Fig. 3 Graphical representation of the simulation model in Witness environment

Model validation has been established by statistical procedures for comparing real-life observations and simulation output data. In this study, standard techniques of statistical inference are used to validate the simulated model, and observe whether it reflects the actual case or not, by conducting hypothesis tests. Table 1 presents the results of these hypothesis tests of various products in terms of makespan. On the basis of the experiment results (Table 1) we can carry out our evaluation by applying the simulation model in order to analyze the system performance.

Product family	Product family percentage		Actual makespan (min)	Simulated makespan (min)	Standard deviation
A	12	17	Experiment 1		
B	27	24	4800	4764	36
C	7	11			
D	14	11	Experiment 2		
E	22	16	4800	4773	27
F	10	8			
G	8	13			

Table 1 Results of simulation model validation

4.2 Database System

Manufacturing company whose production system is the object of the application example in this paper uses Oracle database system in its environment. Since detail knowledge of the Oracle database system would be required to make a direct connection between Witness simulation software and the Oracle database, for the purpose of *simulation system - database system* link example MS Access 2007 database is used instead.

Database has been created to all intents as user interface. Whole application is controlled using the user interface forms. Once the application is run *Main menu* form (Fig. 4) is opened. This form serves for opening all other forms in the database system.

Fig. 4 Database system - Main menu

Database stores all the data representing selected product types of the real manufacturing system such as batch sizes, transport sizes, failure rate, order sizes, operation times and setup times. All 7 product families (A - G) are included, each represented by more than 40 specific product types. Product type attributes are set using the *Product families* form. (Fig. 5)

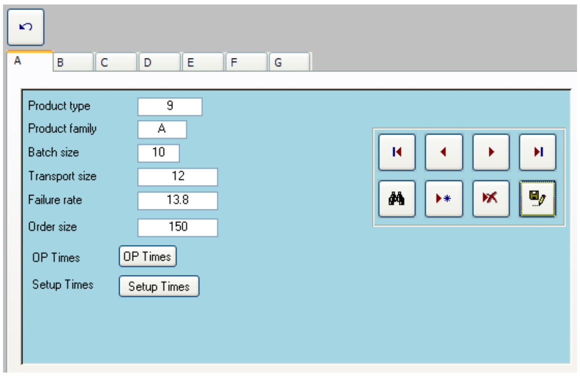

Fig. 5 Database system - Product families

The biggest advantage of using the direct connection between database system and simulation software is the flexibility of the simulation model parameters setting. In HMLV systems the production schedule is changed daily and so the simulation model parameters are. In manufacturing company whose production system is used in this example the average rate of new production orders

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is 45 orders per day. For that reason the production schedule is updated daily. Using the *Production schedule* form (Fig. 6) it is possible to set actual production order. All the parameters necessary for the simulation experiments are than imported to the simulation model automatically according to the production schedule.

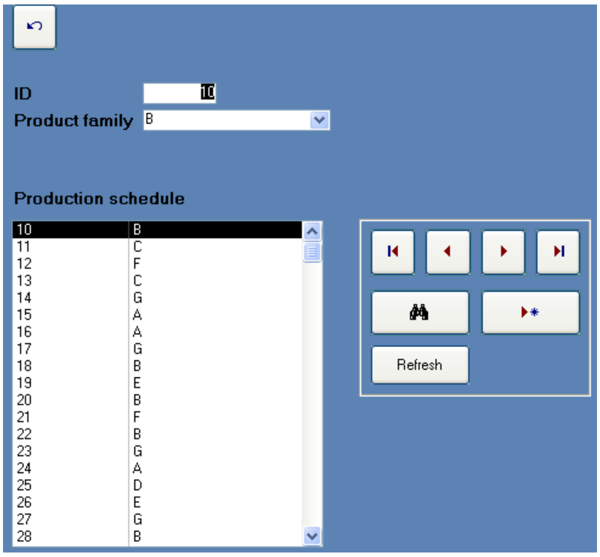

Fig. 6 Database system - Production schedule

Several experiments have been run for proving the assumption about the flexibility of simulation analysis using the direct link between simulation software and database system. It would take a lot of time to set the hundreds of simulation model parameters every time when the production schedule is changed. With using the database system interface it is a matter of minutes.

5 Conclusion

The article presented an approach of the HMLV manufacturing systems simulation analysis using the direct connection between the simulation software and the database system. It shows that considering the high production schedule fluctuation in HMLV systems this approach can significantly reduce the time required for the simulation model parameters setting. Simulation model of the real manufacturing system in Witness simulation software and database interface in MS Access have been constructed for the purpose of the example case study.

Acknowledgements

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