COMPUTER DATA ANALYSIS IN MODELING AND OPTIMIZATION OF MANUFACTURING PROCESS CONTROL SYSTEM

A.I. Yakimov, S.A. Alkhovik
Belarussian-Russian University
Mogilev, BELARUS
e-mail: ykm@tut.by, asa@tut.by

1 Software and Technological Package for Computer Simulation of Complex Systems BelSim

To comprehensively solve simulation modeling problems Software Technological Simulation Package BelSim has been developed. The primary objective of BelSim is to simulate, in accordance with ERP concept, the production and economic activity of industrial enterprises. BelSim includes (a) software for system's functional model developing using IDEF0 methodology [1]; (b) C++ integrated developing environment; (c) simulation system implemented as process simulation template library; (d) software for design of simulation experiments, making them and processing their results; (e) optimization software; (f) data analysis and presentation software [4, 5]. BelSim's structure taking into account its prospective development is shown in fig. 1.

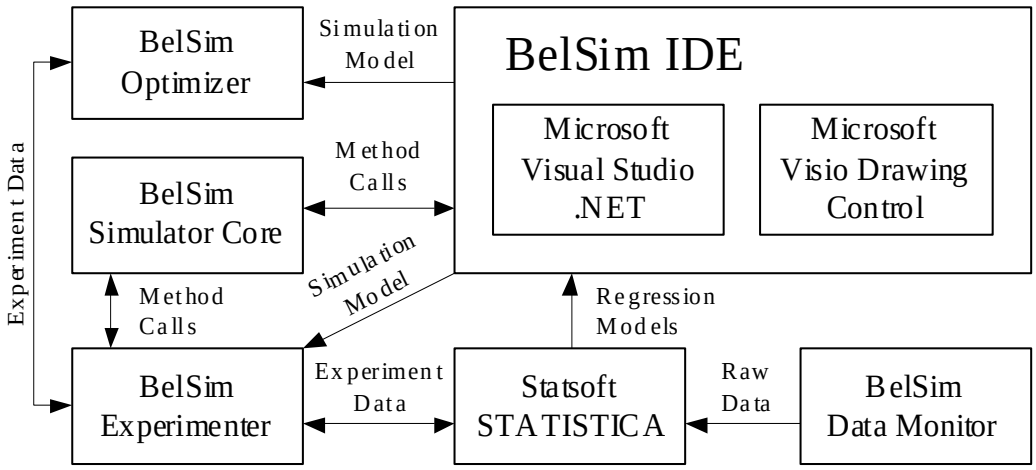

Figure 1: BelSim's structure taking into account its prospective development

One of the BelSim's design principles is the use of powerful software packages to solve a certain range of problems that one face with in the process of simulation modeling. For instance Microsoft Office Visio is used for informal description of a system and

to develop its functional model in terms of IDEF0-diagrams; Statsoft STATISTICA is used to process results of simulation experiments.

Besides basic functionality BelSim provides means for the structural analysis of a system and its internal processes and it is capable of modeling material, financial and information processes simultaneously. Simulation models can be integrated into enterprise's information system in order to get models' input data and to use them as an element of its automated control system. [3]

BelSim includes a basic simulation model of an industrial enterprise built according to MRPII/ERP standard. To solve specific problems respective components of the model are further elaborated. When there are enough statistical data available a real process can be approximated with functional dependencies that are then integrated into simulation model.

General technique of using BelSim for decision support in the field of manufacturing process control is shown in fig. 2.

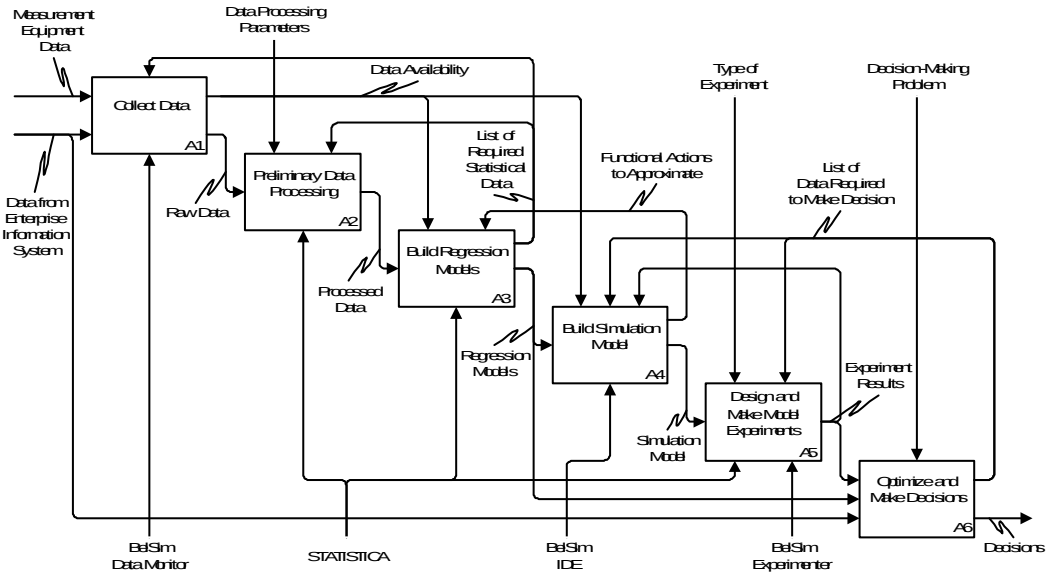

Figure 2: General technique of using BelSim for decision support

2 Example of Data Analysis in Modeling and Optimization of Manufacturing Process Control System

Many of optimization problems in the field of manufacturing control, e.g. producing capacity distribution problem in order to minimize production costs, can be solved by means of dynamic production and economic models. To lessen the effort required to build such models, which is difficult and time-consuming, when statistical data are available respective simulation model components can be approximated with functional dependencies instead of algorithms. The case study of computer data processing to find

the dependence of specific consumption of energy resources on producing capacity is shown below.

Energy resource consumption rates are stored in a specialized information system in the form of statistical data from metering devices. For processing the data are imported first into Microsoft Excel and then into STATISTICA. A scatter plot of specific consumption of some resource depending on day-work over a period of 5 years is shown in fig. 3 (The specific consumption of a resource 1 in department DMT-2 depending on a daily output).

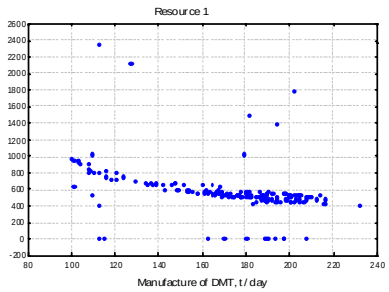

Figure 3: Resource 1 = FE(x)

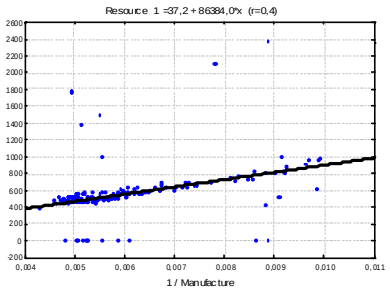

Figure 4: Resource 1 = FE(1/x)

A dependence of some sort can be clearly seen as well as outliers having metering and data input errors as their cause. To clean up the data one can specify a required coefficient of correlation. As it is determined only for linear dependencies [2]; it is necessary to linearize the initial dependence. In this case it can be done by making a plot of specific consumption depending on reciprocal value of day-work (fig. 4: Dependence of a specific consumption of a resource 1 from reverse value of daily output). Coefficient of correlation of 0.4 means weak mutual dependence. There are a few isolated data far from the main group and regression line. Based on expert judgments conclusion is drawn concerning the validity of the data. A plot of the resource specific consumption depending on reciprocal value of day-work with outliers removed is shown in fig. 5 (Dependence of a specific consumption of a resource 1 from reverse value of daily output without ejections).

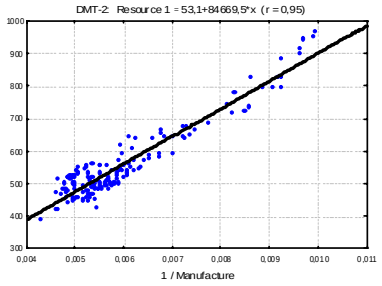

Figure 5: Resource 1 = F(x)

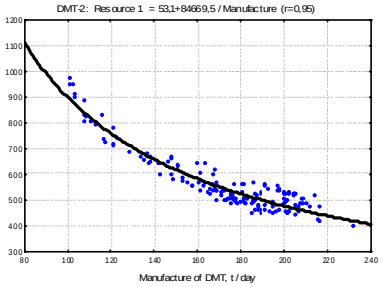

Figure 6: Resource 1 = F(1/x)

Now coefficient of correlation is 0.95 and it confirms the strong dependency between the parameters. A scatter plot of the resource specific consumption depending on

day-work without outliers is shown in fig. 6 (Dependence of a specific consumption of a resource 1 from daily output without registration of ejections). STATISTICA automatically finds regression equation of the dependence. A solid line in the plot is the regression line. Dependencies of the specific consumption of other resources on day-work for all the departments are found similarly.

The dependencies found are imported into the model. The automation of data import and statistical processing enables updating the model by correcting regression dependencies whenever new data are available, as well as make it possible for persons who are not specialists in the field of modeling and statistics to use the model. Microsoft Excel's Solver add-on is used to solve optimization problems.

3 Acknowledgements

The authors have won a tender for research work "The Development of a Dynamic Production and Economic Simulation Model of the Organic Synthesis Plant" (Mogilev, Belarus; St. Reg. No. 20066024). The authors are grateful to the Innovation Development Fund of Concern "Belneftekhim" for its support in the research work referred to in this paper.

References

[1] *IDEF0. FIPS Integration Definition for Function Modeling (IDEF0)*, Federal Information Processing Standards Publication 183. Computer Systems Laboratory, National Institute of Standards and Technology.

[2] Gerasimovich A. I. (1983). *Mathematical statistics.* – 2-nd ed., adv. and ad. – pp. 279, High. Sch., Mn.

[3] Alkhovik S. A. (2004). *Modelling of marketing activity of the industrial enterprises for forecasting efficiency of contracts:* abstract dis. ... Cand.Tech.Sci. - pp. 24, Gomel.

[4] Yakimov A. I., Alkhovik S. A. (2005). *Simulation modeling in ERP-management systems.* - pp. 197, Bel. Science, Mn.

[5] Deitel H. M., Deitel P. J., Nieto T. R. etc. (2001) *XML: How to Program.* - pp. 994, Binom, M.