ARCHIVES of FOUNDRY ENGINEERING

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

ISSN (1897-3310)
Volume 7
Issue 3/2007

79 – 82

16/3

Evaluation and Verification of Time and Costs of Production Activities in Foundry Industry

S. Kukla *

* Department of Industrial Engineering, Bielsko-Biała University, Willowa 2 Str., 43-309 Bielsko-Biała, Poland
* e-mail: skukla@ath.bielsko.pl

Received on: 24.04.2007; Approved for printing on: 27.04. 2007

Abstract

This work presents the possibility of using technology of modelling and simulation of productive systems in the management of cast iron production by means of automated foundry lines to maximize assembly line structure. The computer model of foundry has been planed and conducted in order to compile the schedule of cast production. The variants of solution have been estimated talking into account time limitations imposed by clients and the criterion for prime costs appointed on the basis of the ZAR by means of aided detailed calculation according to planes of their formation. In the research, problem connected with exploitation of automatic foundry lines have been taken into consideration. Moreover, the analysis of line work stoppage has been conducted and construction of schedule of the planned service of line device has been undertaken on the basis of the knowledge of timetables of correct work of these devices. Furthermore, the operational database has been prepared so as to assemble and process data about the damaged and other line work stoppage. It should be noted that the database will give the possibility of working out the schedule of planned service. The problems has been presented by using the pocket for modelling and the simulation of productive systems – ARENA

Keywords: Application of information technology to the foundry industry, Modelling and simulation of production systems, Automated foundry lines, Costs calculation, Production scheduling

1. Introduction

The basis of an effective management of an enterprise is getting data and conducting analyses of the borne production costs. In the literature of the subject much space is devoted to technologies and computer systems which aid contemporary enterprises [1, 2, 3]. This subject is also dealt with by software designers who make programs aiding action in this domain with the use of state-of-the-art achievements of information technology. Also, an appropriate management of technical devices' exploitation is of great importance for proper enterprise functioning [4, 5, 6].

So far, however, no enterprise management system has been designed for the conditions of repeatable, series and large-series production of casts which would enable to evaluate and verify time and costs on the stage of production scheduling and which would take into account the issues of technical devices' exploitation. By designing and function analysis of cast production systems we meet many variants of possible solutions and their complexity usually makes it impossible to choose the best option. Using optimization techniques for a large scale is impossible because of complexity of foundry processes, lack of stability of production plan, occurring disturbances in the course of the process and high costs and time of conducting optimization projects. Cost calculation which does not take into consideration the changing conditions of production system functioning and its surrounding is also a far stretched simplification.

Hence, a method of modelling and simulation becomes useful [7, 8, 9, 10, 11, 12, 13, 14]. Literature gives us many examples of using this method in the foundry industry for analyzing the process of filling a form with liquid metal, metal coagulation and forming of material structure or cooling connected with tensions and cracks in both casts and forms [15].

Modelling of devices' operation, such as systems of furnaces or foundry lines as well as modelling of functioning of the whole foundry departments are not commonly used due to lack of the prepared computer software ready to deliver practical application for foundry industry. In this case the gist of modelling does not consist in mathematical description of physical phenomena occurring in the given object, but in describing functional connections between elements of the analyzed object (e.g. foundry department), and the external conditions [16, 17, 18, 19].

2. Description of the research object

The object of the research in the paper is a system of iron castings manufacturing on automated foundry lines to maximize assembly line structure (fig. 1).

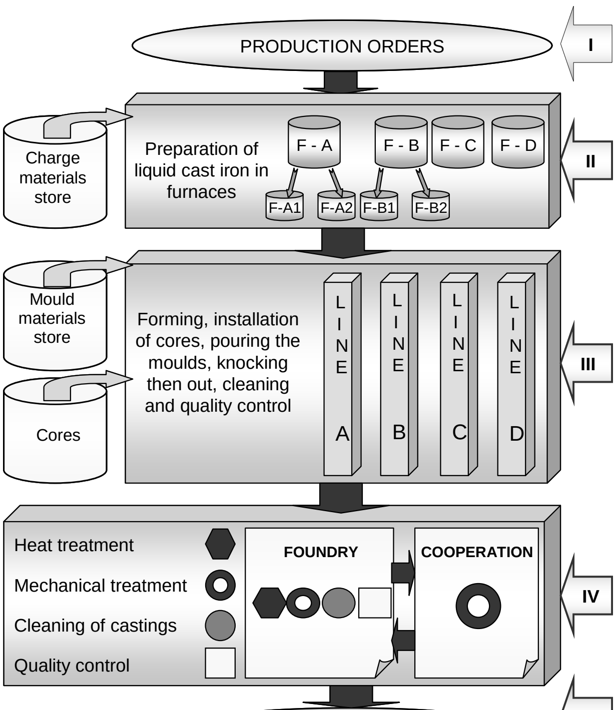

Fig. 1. Manufacturing system of iron castings on automated foundry lines

The lines are supplied with liquid cast iron (grey or ductile cast iron) prepared in electric arc or induction furnaces. Liquid cast iron is transported in ladles to the pouring stand of the foundry lines. Lines are driven by liquid grey cast iron or with cast iron with ductile graphite prepared in electric arched or induction furnaces. Liquid cast iron is transported in ladles for deluging stands of foundry lines. The lines may be powered either by electric furnace batteries, where metal is melted in an electric furnace of high efficiency and poured into induction furnaces where it is kept or by melted metal which is kept in induction furnaces. The processes of forming, putting cores, deluging, cooling, putting off forms and initial cleaning are realized by automatic foundry lines with horizontal and vertical (Disamatic lines) division of forms. Further, the casts undergo the processes of additional cleaning, mechanical treatment, heat treatment and quality control.

A proposed idea of realization of simulation research for foundry work was presented on fig. 2.

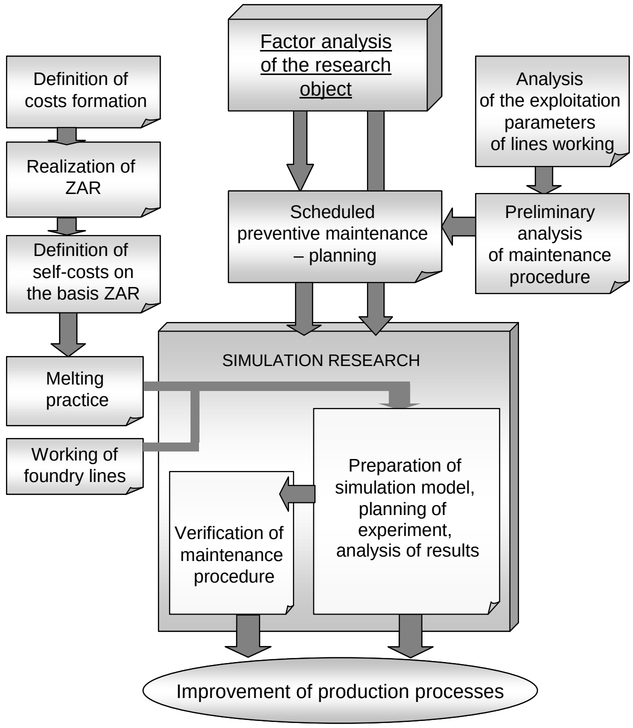

Fig. 2. Idea of research

A factor analysis of the research object was carried out, with division for input and output factors, as ell as fixed and disturbing ones. Self costs of producing casts were estimated by means of the method of detailed calculation according to places of cost generation. The function of aim was created by the below formulation determining minimal self costs of manufacture on the basis of factory spreadsheet (ZAR).

$$f(K_{mb}, K_{st}^{st} + K_{st}^{zt}) \rightarrow \min \qquad (1)$$

where:
K_{mb} - direct material costs,
K_{st}^{st} - fixed stand costs,,
K_{st}^{zt} - variable stand costs.

Taking into consideration a low level of usage of automatic foundry lines, which constitute the weakest link of cast production, it would be reasonable to consider the problem of their rational utilization. Positive effects in this respect could be reached by means of proper preventive activity and better organization of the production process.

Within the scope of this work the database of exploitation data was enlarged. After the time schedule of proper work for particular devices on the line has been settled, building of schedules for foundry line operation was started. There exists a possibility of preparation of many variants of this operation schedule, which arise of organizational possibilities of the factory. The technique of modelling and simulation was proposed as a reasonable method which could ensure proper design of such schedules. The effects of implementation of the chosen way of line operation procedure were analyzed on a computer model. In case when different partial elements of the line are matched with the same values of determined operation periods, those elements were gathered in groups with common operation period (fig. 3).

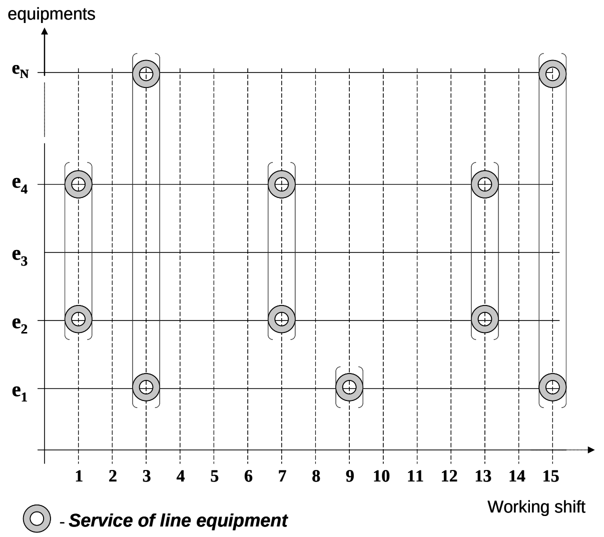

Fig. 3. Schedule of automated foundry lines services

3. Description of achieved results of own researches

Figure 4 presents a simulation model of production system including the processes of liquid cast iron preparation, forming, form deluging, cast removal, initial clearing and eye control.

On the basis of factor analysis of the research object different variants of schedules of the course of melting and work of foundry lines were generated. Further, the variants were checked on a computer simulation model.

On the basis of the conducted simulation experiments, a rational choice was made of the variant of melting process course in the sense of sequence of order realization, the size of production parts, the choice of the line and input and order of castings. The variants of manufacture scheduling were prepared on the basis of deformed data. The criteria for variants' evaluation were: time of order realization and self costs of cast production.

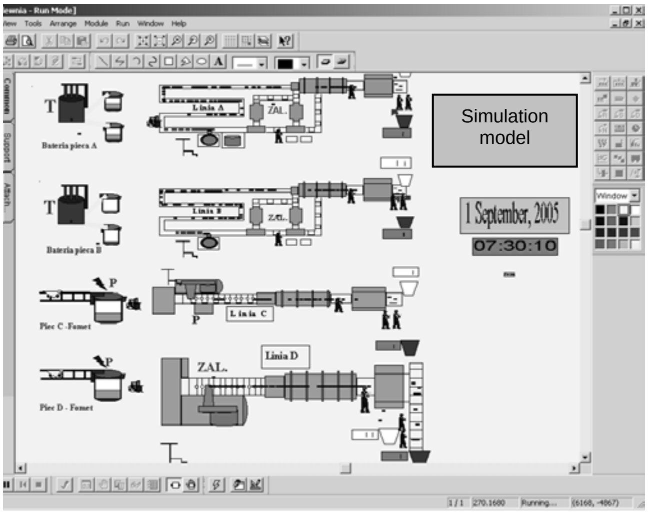

Fig. 4. Simulation model of production system made in ARENA

After excluding the schedule variants which did not fulfill time limitations (W1, W2, W3, W6), estimation of costs of the remaining variants was started basing on the factory spreadsheet. Figure 5 presents a graph of collective self cost borne in the report period, which show that the preferred (the best) variant of production scheduling is the one signed as W7.

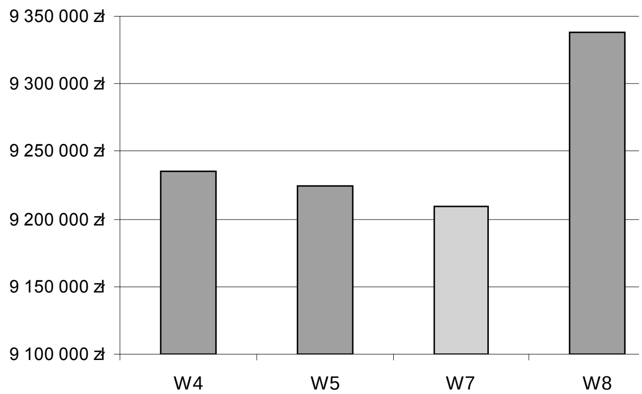

Fig. 5. Self cost on the basis ZAR

4. Conclusions

The present paper presents a trial to synthesize many devices, which are interconnected with mutual relations, and many phases of manufacture into one production system by means of using modelling and simulation of production systems. A universal simulation set which is useful for modelling the work of banks, shops, hospitals or service firms was used for analyzing series and large-series production of iron casts on automated foundry lines with chain reliability structure. In the simulation process issues connected with exploitation of foundry lines were taken into consideration.

Thanks to simulation, it will be possible to analyze problems related to changing assortment of production and to changing size of orders in the automotive market. Manufacture of larger casts with larger cross-sections and bigger demand for liquid metal on one form is connected with the need of diminishing line speed or with investments related to line rebuilding in order to prolong the way of cast cooling. Speed decrease of lines will reduce the system efficiency, without any influence on fixed costs in the report period. Consequently, fixed stand costs in calculation on the product will increase due to smaller quantity of the produced casts in relation to the available fund of work line time. After implementing the investment which consists in line modernization, fixed stand costs will increase in the report period. Consequently, higher costs will be calculated on a larger number of produced casts in the available fund of work time. By means of computer model it will be possible to evaluate the efficiency of furnaces preparing liquid cast iron and lines in their present state and after modernization, without the need to experiment on the real system, and by means of ZAR it will be possible to estimate unitary stand costs depending on the load of foundry lines.

References

[1] D. Cleland, L. Ireland, Project management – strategies and implementation, McGraw – Hill, New York 2002.

[2] J. Gibson, J. Donnelly, J. Ivancevich, Organizations, behavior, structure and processes, McGraw – Hill, New York 2003.

[3] J. Matuszek, J. Košturiak, M. Gregor, J. Chal, J. Krištàk, Lean Company, Wydawnictwo Akademii Techniczno – Humanistycznej w Bielsku – Białej, Bielsko – Biała 2003.

[4] P. Willmott, Total Productive Maintenance, The Western Way, Butterworth – Heinemann, Oxford 1994.

[5] F.T. Chan, H.C. Lau, R.W. Ip, H.K. Chan., S. Kong, Implementation of total productive maintenance - A case study, International Journal of Production Economics, Vol. 95, 2005, 71-94.

[6] B. Pisarek, Cause and effect analysis of failure of machines and characteristic of TPM-fv02 database for analysis in precision foundry and control of realization of program TPM, Archives of Foundry vol. 5, No. 17 (2005) 405-416 (in Polish).

[7] M. Gregor, M. Haluškova, J. Hromada, J. Košturiak, J. Matuszek, Simulation of manufacturing system, Wydawnictwo Politechniki Łódzkiej Filii w Bielsku – Białej, Bielsko – Biała 1998.

[8] R. N. Callahan, K. M. Hubbard, N. M. Bacoski, The use of simulation modelling and factorial analysis as a method for process flow improvement, International Journal of Advanced Manufacturing Technology Vol. 29, No. 1-2 (2006) 202– 208.

[9] W. Kelton, R. Sadowski, D. Sadowski, Simulation with Arena, WCB/McGraw-Hill, Sewickley 1998.

[10] A. Law, D. Kelton, Simulation modelling and analysis, McGraw – Hill, New York 2000.

[11] D. Montgomery, Design and analysis of experiments. Wiley, New York 1997.

[12] C. Chung, Simulation modelling handbook: a practical Approach, CRC Press, London 2004.

[13] V. Hlupic, Z. Irani, R. J. Paul, Evaluation framework for simulation software, International Journal of Advanced Manufacturing Technology, Vol. 15, 1999, 366-382.

[14] M. Wrona, Methodics of computer simulation construction in production process management, Archives of Foundry vol. 5, No. 17 (2005) 385-392 (in Polish).

[15] M. Perzyk, S. Waszkiewicz, M. Kaczorowski, A. Jopkiewicz, Foundry, WNT, Warszawa 2000, (in Polish).

[16] J. C. Hernandez-Matias, A. Vizan, A. Hidalgo, J. Rios, Evaluation of techniques for manufacturing process analysis, International Journal of Advanced Manufacturing Technology Vol. 17, No. 5 (2006) 571 – 583.

[17] D. Plinta, S. Kukla, Optimisation methods in the modelling and simulation of production systems, 7th IFAC Symposium on Cost Oriented Automation, June 7-9, 2004, Gatineau (Quebec), Canada, International Federation of Automatic Control, 291-294.

[18] J. Matuszek, S. Kukla, Management of the casting production aided by modelling and simulation technique of the foundry lines working, Archives of Foundry vol. 5, No. 17 (2005) 169-174 (in Polish).

[19] S. Kukla, Modelling and simulation of the foundry production systems, Doctor’s thesis, 2006 (in Polish).