Achievements in Mechanical and Materials Engineering

COMMENT Worldwide Congress on Materials and Manufacturing Engineering and Technology
16th - 19th May 2005
Gliwice-Wisła, Poland

COMMITTEE OF MATERIALS SCIENCE OF THE POLISH ACADEMY OF SCIENCES, KATOWICE, POLAND
INSTITUTE OF ENGINEERING MATERIALS AND BIOMATERIALS OF THE SILESIAN UNIVERSITY OF TECHNOLOGY, GLIWICE, POLAND
ASSOCIATION OF THE ALUMNI OF THE SILESIAN UNIVERSITY OF TECHNOLOGY, MATERIALS ENGINEERING CIRCLE, GLIWICE, POLAND

13th INTERNATIONAL SCIENTIFIC CONFERENCE
ON ACHIEVEMENTS IN MECHANICAL AND MATERIALS ENGINEERING

Modeling of manufacturing systems and robot motions

G.G. Kost, R. Zdanowicz

Silesian Technical University in Gliwice, Faculty of Mechanical Engineering and Technology, Department of Technological Processes Automation and Integrated Manufacturing Systems, ul. Konarskiego 18a, 44-100 Gliwice; gabriel.kost@polsl.pl, ryszard.zdanowicz@polsl.pl

Abstract: The paper presents problems involving the identification, modeling and simulation of the operation of flexible robotized manufacturing systems. The modeling process of a cell flexible system was presented, with the application of Petri network theory, as well as exemplary parameters and obtained simulation results for most typical cases where the system is tended by an industrial robot.

Keywords: Manufacturing systems, Modeling, Petri network, Robot motion planning

1. INTRODUCTION

Increasing expectations of present-day customers involving the quality and variety of produced goods are becoming more and more critical on the market. With fast changing tendencies on the market, the life-cycle of a product is constantly getting shorter, and the attention of manufacturers is slowly turning to competition and exploration the new markets to sell the goods. The requirements, on the other hand, necessitate the introduction of changes in the organization of production process, through the launch of automation, computer aid in design works and management, and the development of modern multi-stand machining systems, such as flexible manufacturing systems (FMS).

2. FLEXIBLE MANUFACTURING SYSTEMS

High level of integration allows to obtain excellent results with respect to the following:

- reduction of total batch production time,
- minimized running production volume,
- reduction of the time necessary to change the assortment being produced,
- better communication with planning system and scheduling system,
- better utilization of machines.

To ensure optimal functioning of such a system it is necessary to apply special decision-making structures. Such a multi-level decision-making structure is made up by planning and control system of production. Three decision-making levels can be distinguished in that system:

- strategic planning (long-term planning),
- tactical planning (medium- and long-term planning),
- operating control (short-term and current control).

Each of the above planning methods requires the analysis of a number of parameters, therefore, to reduce and optimize decision-making, computer aid is often commonly applied - theoretical models of the systems are created as well as computer-made simulations illustrating their functioning. Examples of such approach include off-line systems of programming industrial robots (IGRIP), which enable CAD-3D modelling of robot scene, and, consequently, the generation of collision-free trajectories of robots tending industrial systems [1].

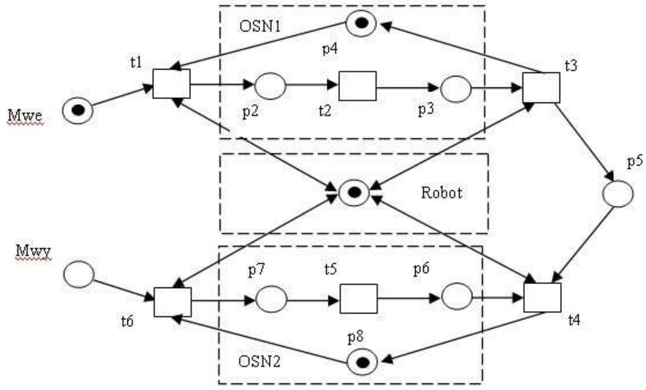

Figure 1. Serial mode network model for tending the flexible system

The principal function of the models is to make the decision-making process easier or to determine unknown characteristics or parameters of the system. The most common tools for the modeling of production systems are queuing networks, Markov chains [2] and simulation techniques. The most common method used for the assessment of parameters of flexible manufacturing system is discrete simulation, and the most suitable tools used for discrete simulation are Petri networks [3,4] which allow to analyze technological manufacturing structures understood as systems (fig.1). The comparison of processes, operation times, time relations, accessibility and storage of raw materials can be modeled more easily than with the application of other modeling methods.

The created model must correspond with functional assumptions of manufacturing system because they play a decisive role when introducing new kind of production in the technological system, which are based on the analysis of such parameters as:

- limitations (involving capacity and time of particular technological objects of the system being modeled: machine tools, storage places, etc.),
- liveness (possibility to realize the tasks in the continuous way within time limits defined by production plan),
- reduction of the influence of “bottle-necks” on the performance of the system,
- possibility to develop the system due to strategic management to effect better assessment of so called development flexibility of the system of optimal sequences of modeled operations,
- assessment of suggested changes involving the order of realized operations and technological routes (by-pass routes for break-down situations),

- assessment of the influence of production volume on the algorithm of system control (minimum size of production batch, operation algorithm e.g. serial, parallel etc.),

succession of destinations of transporting -manipulative systems (for example a robot) that designate the trajectories resulting from the sequence of operations and the assumed rules of their prioritization.

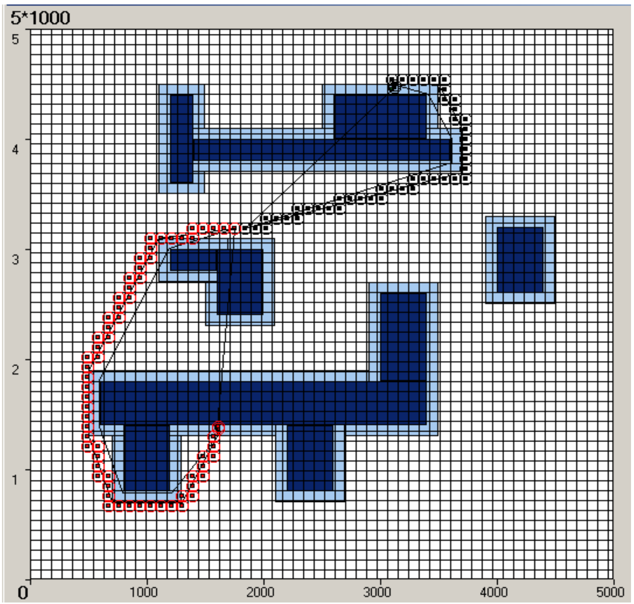

Figure 2. Generation of collision-free trajectory

On the grounds of the data obtained from the simulations and accepted by the operator, except for the control of the efficiency parameters of the modeled system, it is possible to apply the designated and accepted sequence of servicing system work stands performed by a manipulative robot. Consequently, the final stage of the modelling process, despite the determination of the optimal operating conditionds for the discussed system, is a possible planning of collision-free trajectories for the transporting-manipulative robot (fig. 2).

3. CONCLUSIONS

The present work was dedicated to analyzing the influence of functional configuration parameters on flexible manufacturing system basing on its model. The modeling provides the answer to the question involving optimal control of the system, which is reduced among others to the problem of batch size at the engineering planning phase for which it would be profitable to select an appropriate operating mode of the system (serial, parallel, etc.)

Modeling of the flexible system’s operation allows within short time to determine basic technical parameters of the system (throughput, liveness, loading of production stands), by which it is possible to enhance its configuration parameters and to determine optimal tending algorithm;

The results of the carried out simulations involving the operation of the investigated technological system provide only general orientation and can be interpreted solely as the symptom of certain tendencies involving the behavior of the system in particular operation conditions, as well as certain relations taking place between organizational and technological factors. The applicability of simulation results for decision-making processes involving the implementation of the system into production is subject to individual decision of experts and should be based on their experience;

To carry out full and comprehensive investigation of the behavior of complex manufacturing systems, different modeling and investigation methods must be applied, and only the results of such analyses may constitute grounds for making more reliable decisions involving the qualitative assessment of the investigated technological system.

REFERENCES

1. G.G. Kost: Method of avoiding collisions of a robot with its environment based on the system of weights. Proc. of the 7th International Conference ROBTEP 2004-Automation/Robotics in theory and practice, Vyšné Ružbachy 2004, pp. 301-304, Slovak Republic.
2. G.G. Kost: System of designing robot trajectory on the grounds of Markov's decision processes and Q-learning algorithm. Proc. of the 7th International Conference ROBTEP 2004-Automation/Robotics in theory and practice, Vyšné Ružbachy 2004, pp. 309-312, Slovak Republic.
3. R. Zdanowicz: „Investigation of the FMS using the Taylor II system". Method and Models in Automation and Robotics. Wydawnictwo Uczelniane Politechniki Szczecińskiej, t. I, str. 391-396, Szczecin 1995.
4. A.W. Colombo; R. Carelli; B. Kuchen: „A temporised Petri Net Approach for design, modelling and analysis flexible production systems", International Journal of Advenced Manufacturing Technology, Vol. 13, p. 214-226, 1997