ANNALS of the ORADEA UNIVERSITY.
Fascicle of Management and Technological Engineering, Volume VI (XVI), 2007

CONSIDERATIONS ON THE NEW APPROACHES IN THE SIMULATION OF FLEXIBLE MANUFACTURING SYSTEMS WITH THE HELP OF MATHEMATICAL GAMES THEORY

Senior Lecturer, PhD., Eng. *Florin Lungu*
Professor, PhD., Eng., Ec. *Ioan Abrudan*
PhD. Student, Eng. *Calin Otel*
Management Department
Technical University of Cluj-Napoca
B-dul Muncii 103-105, Cluj-Napoca, Romania
Tel/Fax: 0040264415484
Email: flungu@yahoo.com

Abstract: In this paper we have considered the flexibility of the production system as being its capacity to achieve more types of products. The passing of production system from the achievement of one type of product to the achievement of another type of product is named transition and supposes a flexibility effort (time, cost etc) named transition cost. If it's reported the global transition cost to the number of transitions, it's obtained "average transition cost" (CMT) which can be a measure unit of the system flexibility.

In this paper the mathematical games theory is used to offer a solution in these circumstances indicating through probabilities what type of product should be made in the system, so that the system to remain flexible and the changing costs of manufacturing tasks to be as low as possible.

The paper made a comparison between the average transitions costs (CMT) obtained in different ways of simulation of Flexible Manufacturing System.

Key words: flexibility, math game, system, transition, cost, production task

From all the types of changes that a production system has to deal with within the limits of the flexibility concept, the changes due to the different typology of the production charge are essentials.

The Flexible Manufacturing System (FMS) is provided with a set of aptitudes that makes possible the processing of a given products typology; so it is dedicated to a gamma or family of products typology. The activation of the FMS's aptitude to process a type of product generates a system state and brings in the adequate technology. The system's passing from processing a type of product to another type of product, respectively from a state to another is called transition and in fact represents the system's passing from one manufacturing technology to another. The system's "movement" in its multitude of states in accordance with the typological variation of the production charge gives the content of the system's flexibility concept.

It may be estimated that an objective for optimization in FMS could be the effort minimization of the system's adaptation to the variable production charge, effort perceived in its economical dimension. So a category of costs arisen from the flexibility concept are the costs generated by the system's passing from a manufacturing technology to another accordingly with the modification of the products' type that enters in the system. These types of costs are called transition costs [1].

The transition costs are specific for FMS, measuring the system's flexibility and are linked by the automation degree of the system. With all the progresses from the automation domain these costs can't be eliminated, only reduced. So the transition costs must be linked with the activities that are running in FMS towards its adaptation and preparation when the production load is changing.

Literature [1,2,6] shows that in industrial cybernetic systems in all the cases there are induced expenses for system's adaptation to the variation of the production charge, that means that other manufacturing costs are continually accepted, but the equilibrium conditions require that these expenses to be restricted so the system to run profitable. I consider that the transition costs are the most characteristic for FMS and are inherent to the flexibility concept.

The transition costs' dimensions are linked by the FMS's automation level, but in all the cases the transition costs are determined for the flexible system's exploitation. The transition costs could be assimilated with the preparation-concluding costs from classical manufacturing being obtained from the beginning simultaneously with the FMS's input of a lot from a new type of products.

The transition costs may be unifier considered and registered or may be expressed in time units symbolizing in this case the elapsed time necessary for system's transition from one state to another.

The preoccupation for reducing the time between phases and groups of phases and fixing on this basis an optimum sequence of processing, a concernment comparable in some measure with the demarche concerning the sequence optimization for processing the products types within FMS, it's a desideratum of the FMS's optimum running.

The achievement of the typological gamut of components supposes an accumulation of transition costs. Depending on the system's input sequence of the components type one volume or another for the transition costs can be obtained. The system's input sequence of the products that minimizes the global transition cost afferent to a FMS's running period is considered optimum. The reference period for which is calculated the transition costs is the common plan period (decade, month, quarter and year). So we will optimize the FMS's running accordingly with the cancellation law of the transition costs' volume.

In the modeling of the FMS's running with the help of the mathematical game theory the conflict is between the production charge and the processing system [1,2]. The production charge that wants to be processed as many as possible products in the system represents the maximizing player. The processing system that wants to reduce this number represents the minimizing player.

In these conditions the conflict's stake is the transition cost. The transition effort is supported by the system in the benefit of the production charge's diversification. The game's matrix will be the transition costs matrix [1,2,6].

In this paper are presented the results obtained by using ten simulation versions upon a transition cost matrix. The goal is to study the manufacturing system's behavior to diverse input typologies and to choose the one or those that are the best in terms of costs (where CMT is the lowest). The FMS's running is simulated in the following cases:

- minimizing player's solution - optimal solution;
- maximizing player's solution
- in case in which in system enter all 25 types of pieces with equals probabilities;
- into the system enter 10 types of pieces (first 5 and last 5) with random probabilities;
- into the system enter 10 types of pieces (first 5 and last 5) with equals probabilities;
- in the minimizing player's solution it's introduced supplementary a piece with 0.1 probability;
- in the system enter the pieces from the minimizing player's solution with others probabilities;
- in the system enter the pieces from the minimizing player's solution with equals probabilities;
- in the system enter others pieces (random) with the same probabilities like in the minimizing player's solution;
- in the minimizing player's solution it's introduced supplementary a piece with 0.01 probability.

Those ten variants of input typologies chosen, far from exhausting their diversity, none the less we consider to be comprehensive and the conclusions may be generalized upon other variants.

In fact the chosen matrix of the transition costs represents the affinity coefficients matrix [1,2] from 25 products of shaft type. The affinity coefficients represent a typological distance between products. The transition costs are directly proportional with the affinity coefficients.

A particularity of this matrix is that the sum on the line is equal. This thing is because of the way of matrix calculation. Exceptions are three lines where we have identical affinity coefficients and therefore the numbers don't go to 24, the sum being different. This exception isn't essential and doesn't affect the conclusions taken.

With the help of a PC program the system's running for a number of 50, 100, 200 … and 1000 of transitions was simulated for each of those ten variants of the input typologies. CMT was calculated for each variant.

In figure 1 are shown the obtained results. It can be observed that the CMT variations according to the number of transitions have a low ampleness. The reduced variations show us that the system can also work with a lesser number of transitions.

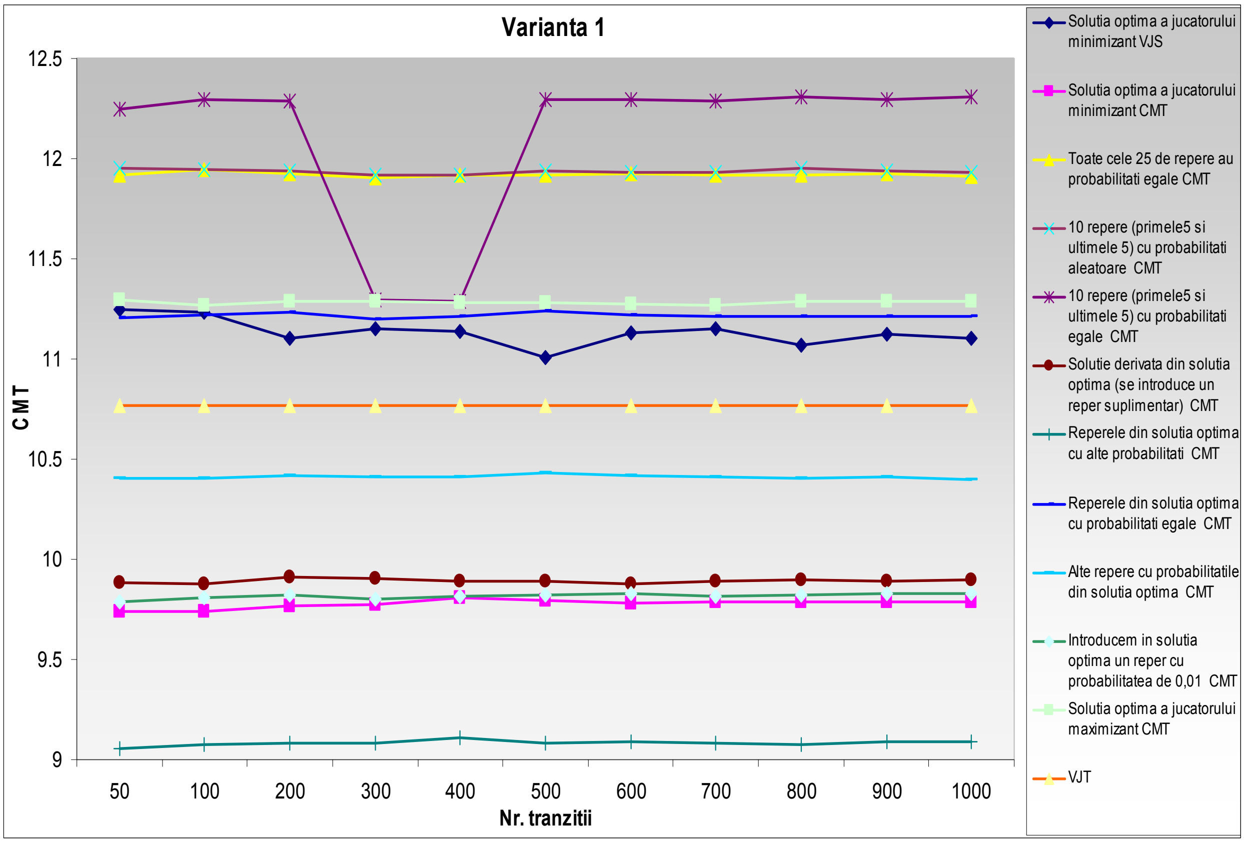

Fig.1. The simulation results

A very interesting conclusion that can be taken after analyzing the obtained results is that not always the solution of the minimizing player is the most profitable from the point of economical view so that to offer the lowest average costs of transition as not always the solution of the maximizing player is the most unfavorable being cases when other solutions of FMS's programming led to higher average costs of transition.

Anyway whatever the chosen variant is, the minimizing player's strategy is applicable because leads to average costs of transition below certain limit (game value). This thing leads to an economical running of the manufacturing system even if it isn't the most economical.

There is a probability of FMS to be running aleatory in the past and to wish to bring this running for a longer period of time, within the limits of some economical parameters generated by the minimizing player's solution. This thing is possible by controlling the future "inputs" accordingly with the optimum solution. In FMS's running concordantly with the aleatory demands, its simulation using the mathematical game offers a normalized level for comparison and evaluation.

REFERENCES

1. Abrudan, I., - *The economy of FMS design*, Editura UTC-N, Cluj – Napoca, 1993.
2. Abrudan, I., *Flexible Manufacturing Systems. Management and design,* Editura Dacia, Cluj-Napoca, 1996.
3. Abrudan, I., Niemann, J., Galis, M., Lungu, F., *Considerations concerning programming the production in FMS using the math games theory*, The 5th International Conference on Engineering Design and Automation EDA 2001, Las Vegas, SUA.
4. Abrudan, I., Lungu, F., *Considerations on the simulation of Flexible Manufacturing Systems with math games theory*, Proceedings of 29-th Annual Congres of ARA, University of Applied Sciences Bochum, Germany, September 7-12, 2004.
5. Lungu, F., Abrudan, I., *Some aspects on the simulation of Flexible manufacturing systems (FMS), with the help of math games theory*, 4-th International Conference on the Management of Technological Changes, Chania, Greece, 2005.
6. Lungu, F., *Research and contributions on the management of flexible manufacturing systems*, PhD Thesys, Technical University of Cluj-Napoca, 2005.