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THE ANALYSIS OF THE ELASTICITY OF THE FREQUENCIES ENTRANCE OF PRODUCTS INTO A FLEXIBLE MANUFACTURING SYSTEMS SIMULATED WITH THE HELP OF MATHEMATICAL GAMES THEORY

Reader, PhD., Eng. Florin LUNGU
Management Department
Technical University of Cluj-Napoca
B-dul Muncii 103-105, Cluj-Napoca, Romania
Tel/Fax: 0040264415484
Email: flungu@yahoo.com

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Abstract: The aim of this paper is to find a correlation between the apparition frequencies of the parts inside a manufacturing system and the value of average transition cost (CMT), cost which express the flexibility of the system. Based on the value of the game we can imagine the entrances optimal successions of the parts into the system, so that the average transition cost not exceed theoretical value of the game.

1. INTRODUCTION

The Flexible Manufacturing System (FMS) is provided with a set of aptitudes that makes the processing of a given products typology possible; therefore it is dedicated to a typological gamma or family of products. The activation of the FMS's aptitude to process a type of product generates a system state and brings in the appropriate technology. The system's passing from processing a product type to another product type, respectively from a state to another is called transition and in fact represents the system's switching from a manufacturing technology to another technology. This system's transition from a state to another (each state corresponding to a product type) supposes a system effort which in minimal way it refers to the adjustment time of the machines, but usually includes and other components. This effort we can call it generically speaking, transition cost.

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 task is changing.

Inside a certain period of the system functioning more transitions are achieved and implicitly, a global transition cost is accumulated. If we report this global transition cost to the number of transitions which was achieved, we obtain the average transition cost (CMT).

We consider that for a Flexible Manufacturing System, the size of the average transition cost represents an economic criterion which must have been in view both in the designing of the system and in its functioning.

As in any production system, in the Flexible Manufacturing Systems the problem that interests us is the economical running of the system which is costs as low as possible. The question is if the inputs of the products type in the system are random, can it be found the optimum modality of FMS's running that is a minimum value of the average cost of transition.

In this paper we used the mathematical mechanism from the zero-sum game's theory, who gives the solutions in the confliction problems. The principles from that part of the games' theory that we will use it are given below:

1) The games theory is a theory of conflicts where are shown at least two conflicting interests promoted by two players (partners, rivals). What a player loses the other one gains it.
2) The player that loses is called minimizing because he wants to minimize the lost and the player that gains is called maximizing because he wants to maximize the benefit.
3) The optimum situation accordingly with the games theory between the two players shows a level of the bargain respectively of the loss, acceptable for the both players. This level of bargain/loss is called the game value. From the confronting of the two opposite tendencies, it appears an equilibrium situation (game value) which represents the solution of minimizer player and which for the production system determines an "optimal" flexibility (in the respect of mathematical games theory) corresponding to a system which is neither rigid (null flexibility, when it's achieved only one type of product) nor excessive flexible (this situation does not correspond to the economic desideratum).

Before the building of a FMS, it must simulated it's functioning for to discover in the design phase, the problems who can appear and to compute the running costs. The mathematical games theory gives this possibility of FMS simulation.

2. INTERPRETATION OF RESULTS

Based on a FMS who process 25 types of parts (the matrix of the game is given in [6,7]), it was made 170 simulations, in which was increased and decreased with 1% the entering frequencies of the parts and it was studied the variation of average transition cost. It was achieved and used a simulation computer program for each variant of FMS functioning. In the table 1 are shown the optimal frequencies of the products obtained as in [2,6].

Table 1. Optimal frequencies according to math games theory

Product	Frequency
R1	0.1765
R2	0.0509
R3	0.0506
R4	0.1137
R7	0.0826
R10	0.075
R11	0.0748
R12	0.0558
R13	0.0221
R16	0.118
R20	0.0344
R21	0.0132
R25	0.1326
Value of the game	10.828

a) It was modified a single frequency

In this case the variation of CTM is directly proportional with increasing or decreasing of the values of modified frequencies. So, in the same time with 1% increasing of the entering frequencies in FMS, we have an increasing of CMT, but under 1%. In every simulation variant we had not an increasing of FMS over the value of the game.

b) They was modified two frequencies

In this case, if the both frequencies increase, CMT decreases and if the frequencies decrease, CMT increases. The negative or positive variation appears to be done by the part who have frequency greater than 0.1. In this case also, CMT is under the value of the game.

c) They was modified three frequencies

If first 3 frequencies increase with 1%, CMT also decreases . If first 3 frequencies decrease, CMT increase, but not too much. So, the conclusion is that the CMT variation is inverse proportionally with the modification of the frequencies. This conclusion is true till the modification of the frequency of the four product, when the variation of CMT become direct proportionally with the modification of frequencies. If 2 frequencies increase/decrease with 1% and other one increases/decreases with 1%, the variation is inverse proportionally. From the simulations made till this point, we obtained an interesting conclusion: into a 3 products combination, the increasing of two frequencies determines the CMT decreasing.

d) They was modified four frequencies

If we modified first 4 frequencies, the CMT variation is inverse proportionally with the modification, true in the case of the combination of the frequencies (two increase, two decrease, three increase, one decrease or inverse).

In this case, the variation of CMT will be done by the products with higher sum of frequencies and will be proportionally with this modify.

e) They was modified five frequencies

If we modified first 5 frequencies, the CMT variation is inverse proportionally with the modification. If we modified 3 into a sense and another 2 in the opposite sense, the variation will be done by the products with higher sum of frequencies and will be proportionally with this modify. The modification of the last 5 frequencies has the same influence like the modification of the first 5.

f) They was modified six frequencies

If first 6 frequencies increase, CMT decreases. If first 6 frequencies decrease, CMT increases.

g) Through the modification of first seven, eight, nine and ten frequencies we observed that the modification of CMT is inverse proportionally with the modification.

h) Modification of all frequencies

The increasing with 1% of all frequencies lead to the increasing of CMT and the decreasing with 1% of all frequencies lead to the decreasing of CMT. If first value increases and the rest decrease, CMT will decreases. If the first value decreases and others increase, CMT will increase. So, we can say that the CMT variation is inverse proportionally with the modification of firsts value of the considered frequencies.

i) Modification in pair

Increasing first and last frequencies with 1%, then first two and last two frequencies and continuing until first six and last six frequencies, we obtained the increasing of CMT. The greatest variation of CMT was for the modification of the pair of six frequencies. The same variation it was achieved if the frequencies was decreased, the maximum variation being already in the case of modify of six frequencies pair.

If first frequency increases and last decreases or first two increase and last two decrease and continuing to first six with last six frequencies, we can observe that the variation of CMT is inverse proportionally with the sense of the frequencies modification of the pair who has the greatest sum of considered frequencies.

Anyway, in all the cases, CMT is under the value of the game.

3. CONCLUSIONS

The most important conclusion of this paper is that a modification with 1% of the entrance frequencies of products into a system do not increases the average transition cost over the value of the game. That means the FMS can be design with the help of math game theory and can running in the optimal conditions.

Another conclusion obtained as result of the 170 simulations of FMS is that the product with higher frequency determines the CMT variation. As the same, in the case of many frequencies variation, the CMT variation is determined by the products who have the higher sum of frequencies. The differences consist in fact that in the case of single frequency modification, the variation of CMT is direct proportionally with the sense of frequency modification and in the case of many frequencies modification, this variation is inverse proportionally.

I suppose that this paper can open the way to others researches of the variation of the entrance frequencies, so that to can be established a maximum level of variation of the entrance frequencies of products in FMS so that CMT to be under the value of the game. In the same time, using the simulation program of FMS, it can find a correlation between the modification of frequencies and the sensibility of the system. In this way it could be established a maximum level of the frequencies variation for which the sensibility of the system to be close by 100%.

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