JOURNAL OF ENGINEERING MANAGEMENT AND COMPETITIVENESS (JEMC)
Vol. 1, No. 1/2, 2011, 6-9

DEVELOPMENT OF A STOHASTIC MODEL FOR DETERMINING THE ELEMENTS OF PRODUCTION CYCLE TIME AND THEIR OPTIMIZATION FOR SERIAL PRODUCTION IN METAL PROCESSING INDUSTY AND RECYCLING PROCESSES

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Accepted 2 September, 2011

This project is a continuation (previous ours) project, where it was found that production cycle (PC) time is extremely long in domestic companies. Then, in the National Strategy of Technological Development of Serbia it was pointed out that metal products account for less than 30% of the overall amount of waste, even though the process output contains approx. 70% of recyclable materials. On the other hand, in the lead journals, over the past years there have emerged novel PC management methodologies, coming from Italy, Croatia, Slovenia, Taiwan and Tanzania, indicating the importance of the area which, when involves the need for cleaner production, reaches the very top of attractiveness. That is why the goal of this project is to develop a stochastic model for determining the elements of PC time and their optimization. They will enable quality monitoring and analysis of the PC time, which results in lesser stocks levels and larger turnover of means in the production and recycling processes, raising Serbian metal processing industry competitiveness, with adequate waste management and industrial pollution reduction, and all this to comply with the Decision No 768/2008 of the European Parliament and of the Council of Europe.

Keywords: production cycle, serial production, processing industy, recycling processes

INTRODUCTION

The goal of the project is to develop a stochastic model for determining the elements of production cycle (PC) time and their optimization for serial production in metal processing industry, including the recycling processes. The newly set model will enable quality monitoring and analysis of PC time, which results in reduced freezing of funds, smaller stocks levels and larger turnover of means in the production and recycling processes. Its final outcome is a raised competitiveness of Serbian metal processing industry, with adequate waste management and diminished industrial pollution, and all this to comply with the Decision No 768/2008 of the European Parliament and of the Council of Europe. The project sub-goals involve:

a) Setting a modified model of current observations which eliminates the drawbacks of the Tipett model and introduces a more detailed analysis of the PC time elements.
b) Setting a PC model where stochastic functions do not follow binomial but normal distribution law.
c) Development of a PC monitoring method based on methods of quality control with the error of ± 2 SD.
d) Determination of the impact of series size, organizational level and product characteristics on the PC duration, i.e. the coefficient of flow by applying structural equation modeling (SEM). Setting and development of a model of influential factors on PC duration.
e) All above mentioned will be designed in accordance with the idea of a supply chain model that includes regional recycling centers.

The project will contain:

ISSN 2217-8147

Available online at http://www.tfzr.uns.ac.rs/jemc

- Research of advanced methodologies for PC time reduction, increasingly emerging in SCI-list papers in the past years (Int. Jour. of Prod. Research, Jour. of Cleaner Prod., Technovation, and Int. J. Adv. Manuf. Tech.), coming often from less competitive regions such as Serbia.
- Formulating and interpreting the hypothesis that the stochastic method of current observations of the PC time elements is applicable in practice.
- Experimental evidence of the hypothesis obtained from screening a larger number of sections with serial production in metal processing industry and in recycling processes.
- Setting and development of models of impact factors on PC duration, on the basis of experimental research.
- Analysis and practical application of methodologies in Serbian companies, and
- Publication of results in lead international journals.

In our former research the emphasis was placed on PC time elements related to the machine, and results were published in lead international journals (Klarin et al., 2000; Klarin et al., 2010). These results were cited in Serbia and lead international journals. A new research is a continuation of mentioned investigations.

It is notorious that the product persists on the market if it is of adequate quality, price, volume of production, and time of delivery. These factors can be further divided into their variables, but being functionally interconnected, they can lead to position loss on the market, and finally to product and company vanish. The factor having the greatest number of interconnections and dependencies is the time of delivery, the factor depending most on PC time, i. e. the overall purchase-sales cycle. Under conditions of increasingly easier monitoring and regulating of business activities, the core of purchase-sales cycle has not become optimized yet – PC in metal processing industry, especially in serial production, while the possibilities of recycling have been considered very rarely (except in the case with FIAT). According to the 2010-2012 Strategy of economic development of the Republic of Serbia, the deterioration of processing industry competitiveness in 2005 was also affected by inadequate recycling, so in the period 2010-2012 the emphasis will be placed on waste management and industrial pollution reduction. Hence, PC research within this project will be related to serial production in metal processing medium-sized plants as well as to plant recycling sections as a supply chain, because they are of utmost importance for production restarting in Serbia and establishment of sustainable development from the standpoint of the promotion of ecology through the process of product recycling in metal processing industry.

The modified method of current observations will enable the determination of percent of each element of PC time against the overall PC duration of both production and recycling. As it is statistic and is based on a certain number of current observations of a certain activity, it is simpler and more efficient than continuous screening method. Monitoring within the PC will include technological time with preparation-finish time and manufacturing time, non-technological time: time for transport, control, packing, and within the non-production time: stoppage due to poor organization, deficit of raw materials, breakdown and deficit of tools, machine breakdown and groups of other diverse stoppages, their interdependences, as well as other factors – series size, organizational level and product characteristics – influencing those above mentioned. Also, analysis will be carried out on effect of PC reduction on the company's market and financial performances.

Investigation will be in lerge number of enterprises, according to time the elements of PC on the Figure 1 and the sheet Work Sampling in the Figure 2, and on that basis we can determine percent of certain elements in the whole production cycle (PC).

On the other hand according to Vila et al. (1982) and Kralev (1991) we investigatate flow coefficient, whose function is presented on the Figure 3.

The basic production indicator of the flow coefficient, whose forms the relationship between the total production time T_{pc} and the process machine time t_{tm}

$$K = T_{pc} / t_{tm}$$

In mass production again the increase of the pieces number the coefficient is reducting.

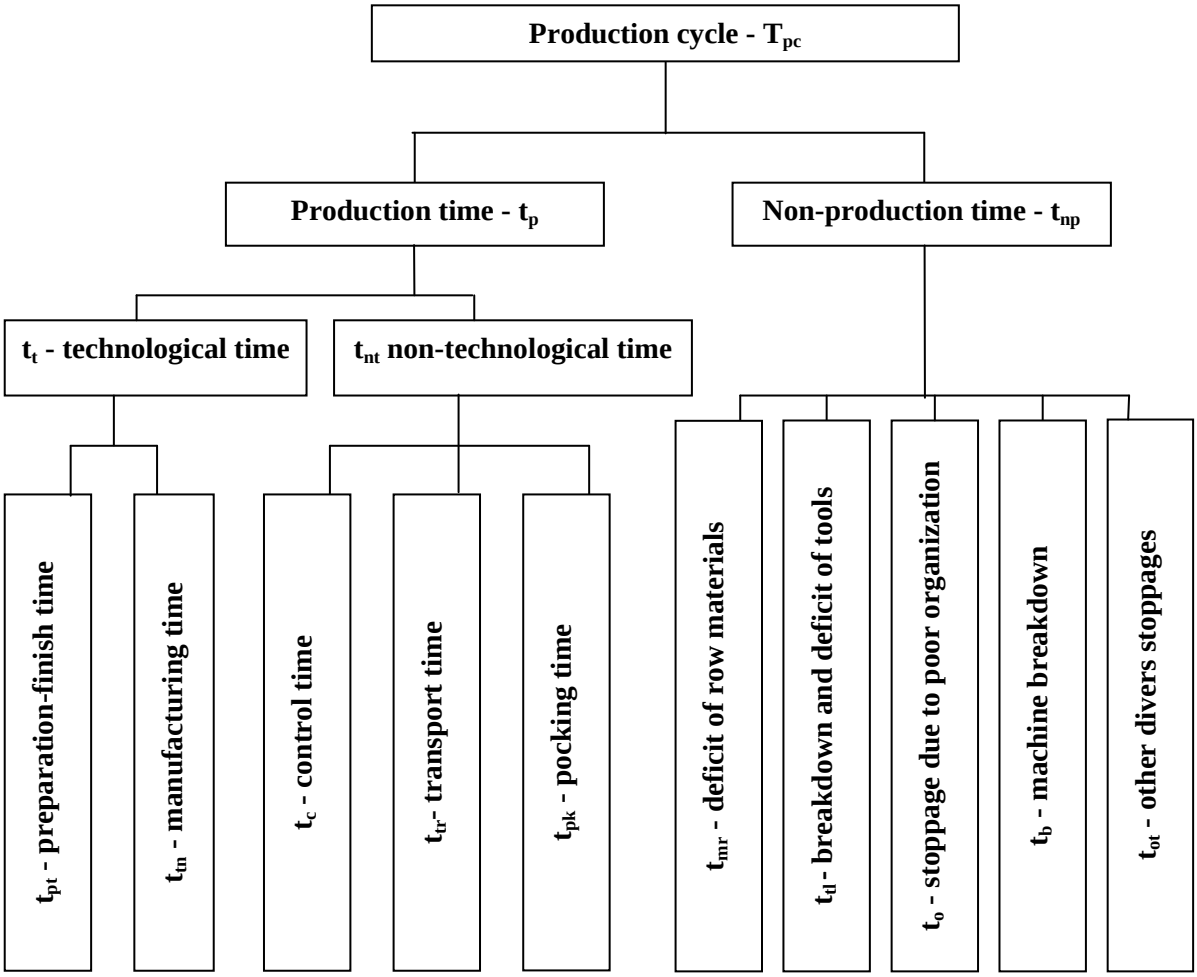

Figure 1: Production cycle

No	Time		Production time					Non- production time				
	h	min	t_{pt}	t_m	t_c	t_{tr}	t_{pk}	t_{mr}	t_{tl}	t_o	t_b	t_{to}
1	8	31		+								
2	10	12										+
3	10	26								+		
4	11	55	+									
...												
n	14	41										
∑												

Figure 2: Observation paper per Work Sampling Method

In the ILR factory according to Koprivica (1980) for a series of 3 to 11 pieces, i.e. for individual production it is:

$$K_p = 2.76 + 17.64/t_{tm}$$

The project is of crucial importance both for general theory and practice. According to the information available, there have not been attempts in the world to solve the issue that this project is dealing with by applying the stochastic methods, hence the issue is of importance in this respect. After the interest and research in this area have declined for a few years, there occurs a renewal of interest in the world of science. This is what the Editor-in-Chief of Int. Journal of Production Research said about the rebirth of interest in this area of research.

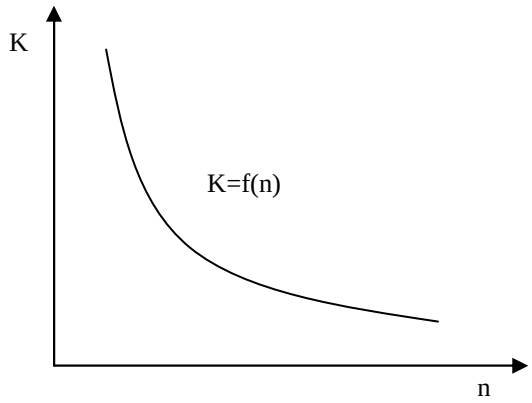

Figure 3: K factor coefficient relationship of pieces number n.

The results expected mirror themselves in:

- Setting a modified model of current observations which elements the drawbacks of the Tipett model and introduces a more detailed analysis of the elements of production cycle (PC) time.Setting the PC model where stochastic functions do not follow binomial but normal distribution law. Development of a model for PC monitoring, based on methods of quality control in time with the error of ± 2 SD.
- The work was supported by a grant from the Serbian Ministy of science under contract No 35017.

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