

## MATLAB APPLICATION DEDICATED TO THE COMPUTATION OF THE PRODUCTION CYCLE DURATION

Maria BROJBOIU, Virginia IVANOV

University of Craiova, Faculty for Electrical Engineering,  
e-mail: mbrojboiu@elth.ucv.ro, vivanov@elth.ucv.ro

**Keywords:** production cycle, computation program, software Matlab

**Abstract:** The sequence of the technological operations for the final product fabrication is named production cycle. The main feature of the production cycle is duration. The computation of the production cycle duration can be made using one of the three methods accordingly to the execution manner of the technological operation: successive method, simultaneous method and the mixed method.

The paper presents the results obtained by means an application Matlab dedicated the computation of the production cycle duration using one of the methods named above. The application is developed in an interactive and flexible manner in order to allow enter input data from keyboard or from the data files accordingly to the different production processes.

### 1. INTRODUCTION

The cycle production duration is the main parameter of the production management because based on the product time delivery, the beginning of the product fabrication is settled. The other times that allow the lagging in time and the work in control process are also settled. The computation of the production cycle duration can be made using one of the three methods accordingly to the execution manner of the technological operation: successive method, simultaneous method and the mixed method.

#### 1.1. The successive method

The successive method is applied when an operation from manufacturing flux of the final product part begins only after all parts from fabrication lot have been manufactured at the current operation. Analytically, corresponding to this method, the computation of the production cycle time is made using the following formula [1], [2]:

$$DCP_s = n \cdot \sum_{i=1}^m \frac{t_{ni}}{N_{im}} + D_n + D_a + D_i \quad (1)$$

where:  $n$  – is the number of the parts from the fabrication lot,  $m$  – is the number of the technological operation of the manufacturing flux,  $t_{ni}$  – is the unitary fabrication time of the  $i$  operation from flux,  $N_{im}$  – is the number of the fabrication points where the same operation is simultaneously running,  $D_n$  – is the natural process duration,  $D_a$  – is the auxiliary process duration,  $D_i$  – is the suspensions of work duration

#### 1.2. The simultaneous method

This method is a peculiarity of the extensive manufacturing or quantity production where the production system is organized on the production lines in technological flux. The part transport or the parts transport lot to the next operation from flux is made as the current manufacturing operation is finished. The rhythmicity production is accomplished through: the assignation of the certain manufacturing points, the launching in fabrication of the parts to the first operation from flux so that the manufacturing continuity to the main

operation (the operation having the bigger unitary time) to be obtained. Using this method one smaller duration is obtained.

Analytically, corresponding to this method, the computation of the production cycle time is made using the following formula [1], [2]:

$$DCP_p = (n - p) \cdot \left( \frac{t_{ni}}{N_{lm}} \right)_{\max} + p \cdot \sum_{i=1}^m \left( \frac{t_{ni}}{N_{lm}} \right) + D_n + D_a + D_i \quad (2)$$

where,  $p$  is the number of the parts which are transported together between two successive operations. The disadvantage of this method is the insertion of the suspensions of work to the one or more of the industrial equipment of the technological flux.

### 1.3. The mixed method

The mixed method has the feature that the transport of the parts from the one operation to next one is individually made only when the previous operation has a smaller duration or equal with the duration of the next operation. In case when the part is transported from the one operation having a bigger duration then the next one the transport of parts in lots is made.

Analytically, corresponding to this method, the computation of the production cycle time is made using the following formula [1], [2]:

$$DCP_m = n \cdot \sum_{i=1}^m \left( \frac{t_{ni}}{N_{lm}} \right) - (n - p) \cdot \sum_{i=1}^{m-1} \left( \frac{t_{ni}}{N_{lm}} \right)_{\min} + D_n + D_a + D_i \quad (3)$$

where,  $\sum_{i=1}^{m-1} \left( \frac{t_{ni}}{N_{lm}} \right)_{\min}$  is the sum of the minimum durations corresponding to the successive operations pairs.

## 2. PROGRAM ORGANIZATION

The simplified structure of the program is depicted in Figure 1.

The input data are:  $n$  – parts number from manufacturing lot,  $m$  – technological operation number from flux,  $t_n$  – the vector of the unitary fabrication times having the size equal to  $m$ ,  $p$  – parts number from transport lot.

This input data can be entered from the keyboard or from the data file.

The application user may select using the window menu, presented in figure 2, the desired computation method or comparative analyze between the results obtained using all three methods based on the efficiency indicators.

The Matlab application allows computing the economic efficiency indicators:  $v$  - execution speed,  $cp$  - simultaneously coefficients,  $1/v$  – average duration.

The methods comparison is made after running application corresponding to the three methods ones.

The graphical analysis allows determining the manufacturing cycle duration using the graphical methods [2].

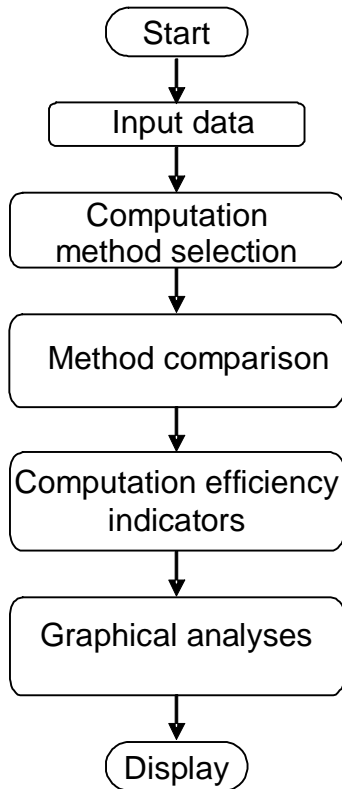


Fig. 1. Flow chart of the computation program

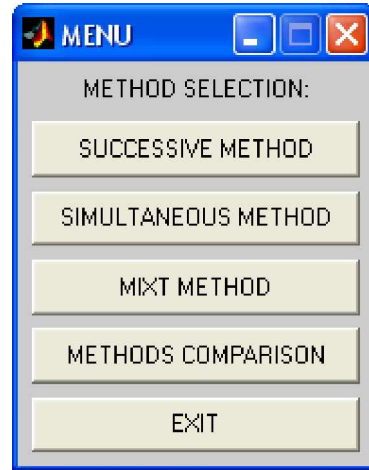


Fig. 2. The program menu

### 3. APPLICATION

The Matlab procedure developed and presented in this work has been applied for different input data [3], [4]. The computed values of the manufacturing duration as well as the values of the economic efficiency indicators are presented in table 1. In this application  $D_a=D_n=D_i=0$ . The measure unit of the manufacturing duration is minute or can be any other measure unit for time.

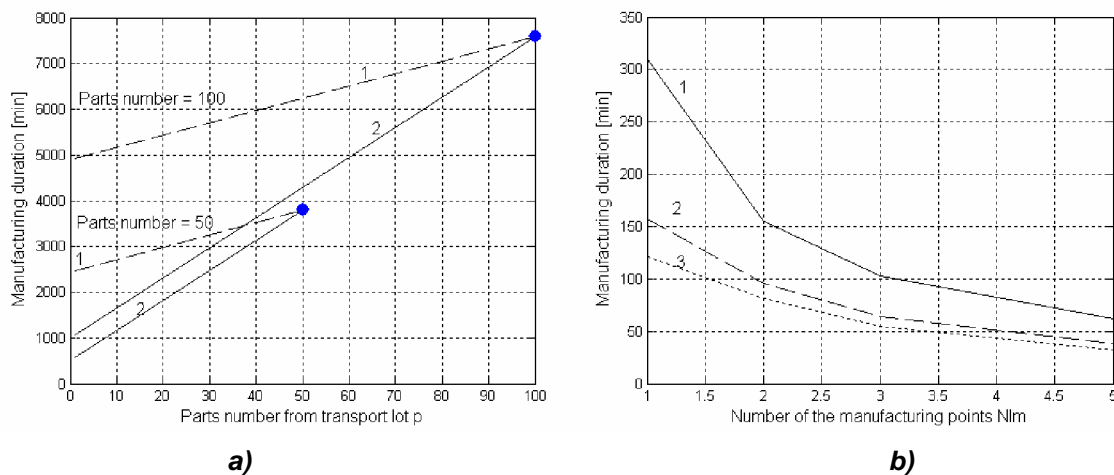
Table 1 Computed values of the manufacturing duration, parameter p

n = 50 m = 8 Nlm = 1 tn = [5 10 3 20 6 12 2 18]												
p	Successive method				Simultaneous method				Mixed method			
	DCPs	v	1/v	cps	DCPp	v	1/v	cpp	DCPm	v	1/v	cpm
1	3800	0.013	76	1	566	0.088	11,32	6,71	2477	0,0200	49,54	1,53
2	3800	0.013	76	1	632	0,079	12,64	6,01	2504	0,0199	50,08	1,51
5	3800	0.013	76	1	830	0,060	16,6	4,57	2585	0,0193	51,7	1,47
10	3800	0.013	76	1	1490	0,033	29,8	2,55	2855	0,0185	57,1	1,33
12	3800	0.013	76	1	1292	0,038	25,8	2,94	2874	0,0173	57,48	1,37
20	3800	0.013	76	1	1820	0,027	36,4	2,08	2990	0,0167	59,8	1,27
25	3800	0.013	76	1	2150	0,023	43,0	1,76	3125	0,0160	62,5	1,21
35	3800	0.013	76	1	2810	0,017	56,2	1,35	3395	0,0147	67,9	1,12
40	3800	0.013	76	1	3140	0,016	62,8	1,21	3530	0,0141	70,6	1,07
45	3800	0.013	76	1	3470	0,014	69,4	1,09	3665	0,0136	73,3	1,03
50	3800	0.013	76	1	3800	0,013	76,0	1,00	3800	0.013	76	1

$$n = 100 \quad m = 8 \quad N_{lm} = 1 \quad t_n = [5 \ 10 \ 3 \ 20 \ 6 \ 12 \ 2 \ 18]$$

p	Successive method				Simultaneous method				Mixed method			
	DCPs	v	1/v	cps	DCPp	v	1/v	cpp	DCPp	v	1/v	cpm
1	7600	0,013	76	1	1066	0,093	10,66	7,12	4927	0,020	49,27	1,54
10	7600	0,013	76	1	1660	0,060	16,60	4,57	5170	0,019	51,7	1,47
50	7600	0,013	76	1	4300	0,023	43,00	1,76	6250	0,016	62,5	1,21
100	7600	0,013	76	1	7600	0,013	76	1	7600	0,013	76	1

The program has been run considering  $m$ ,  $n$  and the  $t_n$  vector as being given and the  $p$  parameter is variable. Analyzing the computed data from the table 1 one noticed that: using the successive method the manufacturing duration is constant as the  $p$  parameter is changed; corresponding to the simultaneous method, as the  $p$  parameter increases the manufacturing time increases also; the same thing is noticed for the mixed method, but the computed values are bigger then the values obtained using the simultaneous method and smaller then the values obtained using the successive method. This conclusion can be observed from figure 3a, where the manufacturing duration depending on the parts number from transport lot  $p$  is represented, having  $n$  as parameter. The marker from figure corresponds to the successive method.



**Figure 3 a) The manufacturing duration vs parts number from de transport lot : 1 – mixed method, 2 – simultaneous method, parameter  $n$ , b) The manufacturing duration vs manufacturing points number 1-successive method, 2 - mixed method, 3- simultaneous method**

In order to emphasize the influence of the component values of the  $t_n$  vector over the manufacturing duration the program has been applied for two special cases: a) when the unitary fabrication time of the current operation is bigger then the next one and the result are shown in table 2a; b) when the unitary fabrication time of the current operation is smaller then the next one; the results are presented in table 2b. It can be observed that the structure of the vector  $t_n$  has the impact only on the manufacturing time computed using the mixed method, the smaller values of the manufacturing duration being obtained in case b. In table 3 the computed values of the manufacturing times when the parameter is the number of the manufacturing points  $N_{lm}$ . It can be noticed that as the  $N_{lm}$  increases the manufacturing time value decreases.

In figure 3b is displayed the manufacturing duration depending on  $N_{lm}$ .

Table 2 Computed values of the manufacturing duration, parameter p and different structure of the flow sheet

n = 10 m = 6 Nlm = 1	tn					
	a)			b)		
	[10 2 8 4 6 1]			[2 10 4 8 6 1]		
p	DCPs	DCPp	DCPm	DCPs	DCPp	DCPm
1	310	121	193	310	121	157
3	310	163	219	310	163	191
6	310	226	258	310	226	242
8	310	268	284	310	268	276
10	310	310	310	310	310	310

Table 3 Computed values of the manufacturing duration, parameter Nlm

m = 10 m = 6 p = 3 tn = [10 2 8 4 6 1]			
Nlm	DCPs	DCPp	DCPm
1	310	121	157
2	155	81,5	95,5
3	103,33	54,5	63,7
5	62	32,6	38,2

The variation of the average duration depending on the parts number from transport lot p is displayed in figure 4.

The program has been applied to graphical determine the manufacturing cycle duration. The same values, presented in table 2, have been obtained using the graphical method, for n=10, m=6, Nlm=1, tn=[10 2 8 4 6 1], p=1. In figure 5 the graphical procedure for the simultaneous method is presented where DCPp=121 min. In figure 6 the graphical procedure for the successive method is presented where DCPs=310min. In figure 7 the graphical procedure for the mixed method is presented where DCPm=193min.

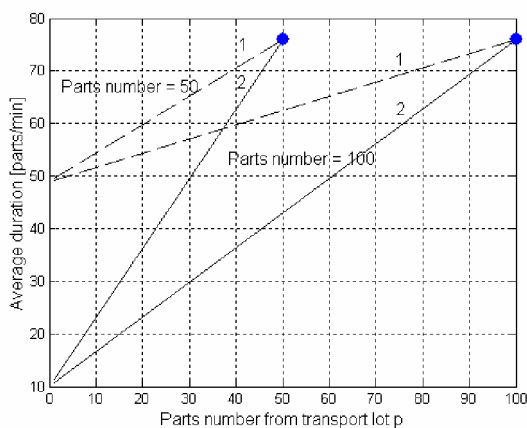


Figure 4

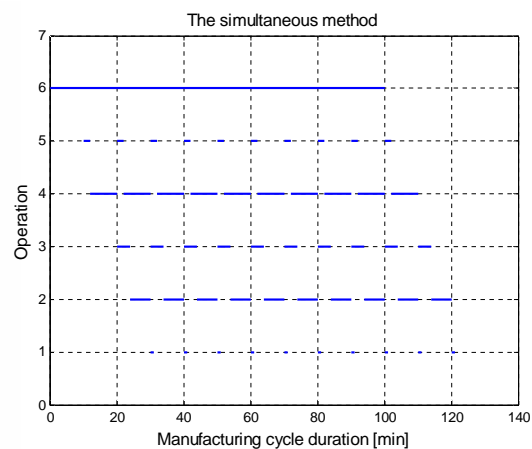


Figure 5

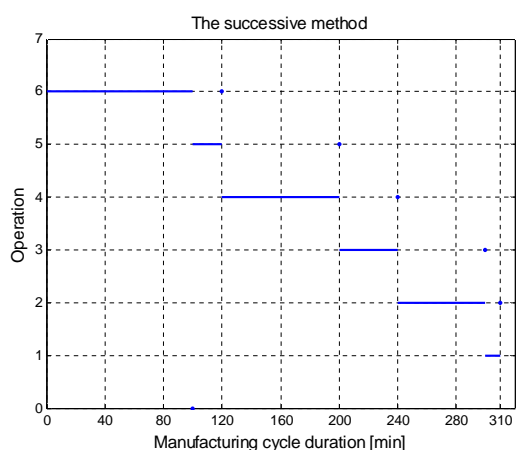


Figure 6

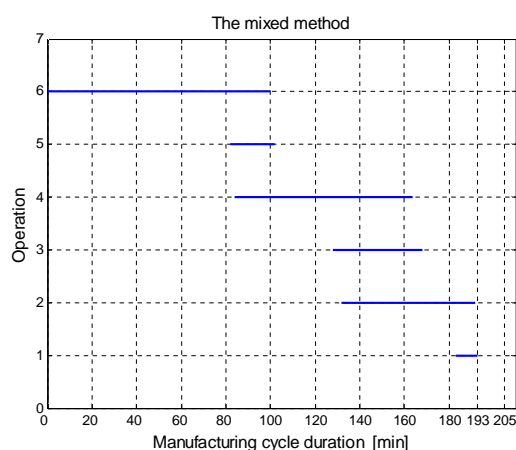


Figure 7

#### 4. CONCLUSIONS

A Matlab application dedicated to the computation of the production cycle duration is developed and presented in this work. The computation of the manufacturing cycle duration as well as the computation of the economic efficiency indicators is made using three analytical methods and three graphical methods also. The application is developed in an interactive and flexible manner in order to allow enter input data from keyboard or from the data files accordingly to the different production processes. The computed values allow the comparison of the obtained results applying all three methods. The impact of the parts number from transport lot  $p$ , the number of the manufacturing points  $N_{lm}$  and the number of the technological operation from flux over the manufacturing duration value and over the economic indicators is pointed out. The user can applied this program for any other input data so that a correct choice of the method must be made, in order to obtain the minimum value of the manufacturing duration.

#### 5. BIBLIOGRAPHY

1. Maynard, B. H., *Manual de inginerie industrială*, Vol.I,II,III, Editura Tehnică, București, 1975.
2. Brojboiu, M., Ivanov, V., *Ingineria sistemelor industriale*, Tipografia Universității din Craiova, 2003.
3. Etter D.M., *Engineering Problems solving with Matlab*, Prentice Hall, New Jersey, 1993.
4. Ghinea M., *Matlab – Calcul numeric, grafica, aplicatii*, Editura Teora, Bucuresti, 1995.