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USING VALUE ANALYSIS IN MECHANICAL ENGINEERING DESIGN PRODUCTION COSTS REDUCTION

Florina ANGHEL, Dragoş Alexandru CAZACU

Abstract: *Our main objective is to reduce the production costs for the studied assembly – the main kinematic chain of a milling and drilling machine. For this we followed the steps of the economic value analyze as like: establishing functions for all parts of the assembly, finding out the usage value of each function, by giving marks (0, 1 and 2) from comparing every two functions, calculating the costs of the materials used and the manufacturing process, by the technology used to obtain each part. We considered that all technological processes would be done on classical machines.*

Key words: *production costs, usage value, economic value analyze, lowering the costs, highly evaluated.*

1. INTRODUCTION

Before starting a production of any kind it is better to know the production costs involved. These are: the material usage cost, the manufacturing cost witch contains the workers’ wages, the costs of the production site maintenance.

By summing up these costs before the production starts the beneficiary will not be surprised by unexpected extra costs, and in this way we can also take the best production solution and get the optimum price of production.

The economic value analyze is the best and the fastest way of solving this problem. With its help we can get an optimization of the technology and even a redesign of some pieces that are not so important as they seemed in our assembly.

Some other pieces can disappear if they result unnecessary.

This is the kind of analyze that we ran for our assembly.

2. FUNCTION NOMENCLATURE

After establishing all the functions that are made by the assembly marks, we attributed to each function a symbol for simplifying the next steps (Table 1). The usage value will be calculated in chapter 4.

Table 1

Function nomenclature

Symbol	Name of function	V_u
A	Gives motion	20.99
B	Fixes marks	16.05
C	Marks positioning	16.05
D	Makes tightening	3.70
E	Allows access	1.23
F	Takes shocks	11.11
G	Makes bearing	7.41
H	Takes loads	7.41
I	Centring marks	16.05

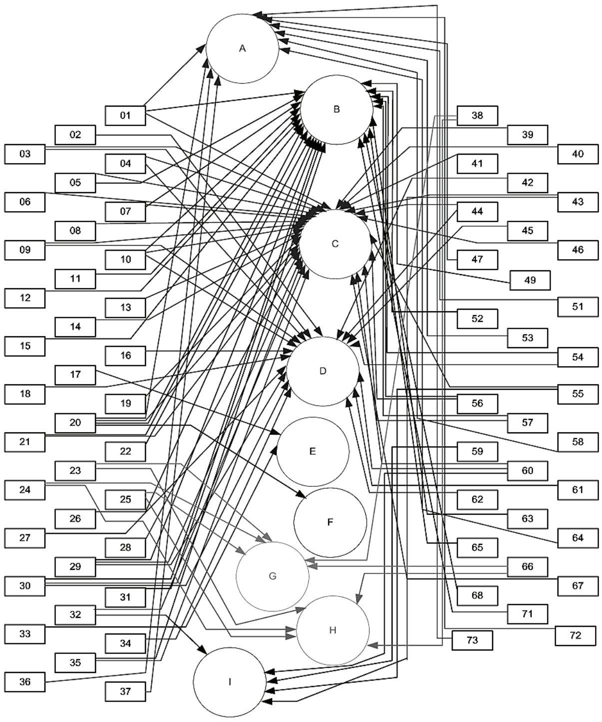

Fig. 1. Diagram of relations between assembly marks and functions.

3. DIAGRAM OF RELATIONS BETWEEN ASSEMBLY MARKS AND FUNCTIONS

On this step (Fig. 1) we materialized the relations between the functions and the assembly marks for seeing clearly these relations.

4. FUNCTIONS HIERARCHY

In order to establish the usage value we compared every two functions and gave mark according to the function’s importance in the assembly: 0 – less important; 1 – the same importance; 2 – more important. The producer is the one who sets the importance of each assembly mark. Attributing marks is subjective; there is no strict rule about doing this. After making the sum of all grades of each function, we calculated the corresponding usage value in percents (Table 2).

5. ECONOMIC DIMENSIONING

The first step of the economic dimensioning is to calculate the costs of materials used to obtain the non-standard assembly marks.

An example for this step is shown in Table 3.

In the above table (Table 4) we presented an example of the calculating the wages that ware paid to the workers in order to obtain each piece following the established technology.

Table 2

Functions hierarchy

	A	B	C	D	E	F	G	H	I	
A	1	0	0	0	0	0	0	0	0	
B	2	1	1	0	0	0	0	0	1	
C	2	1	1	0	0	0	0	0	1	
D	2	2	2	1	0	2	2	2	2	
E	2	2	2	2	1	2	2	2	2	
F	2	2	2	0	0	1	0	0	2	
G	2	2	2	0	0	2	1	1	2	
H	2	2	2	0	0	2	1	1	2	
I	2	1	1	0	0	0	0	0	1	
Σn	17	13	13	3	1	9	6	6	13	81
V_u(%)	20.99	16.05	16.05	3.7	1.23	11.11	7.41	7.41	16.05	100

Table 3

Material costs

Mark No.	STAS / Material	Volume (dm³)	Unitary cost [RON]	ρ [kg/dm³]	Price / Material Cost [RON/piece]
01	OLC 45	1.734	2.20	7.85	29.946
02	OL 37	0.306	2.00	7.85	4.804
03	OL 37	0.066	2.00	7.85	1.036
04	Fc 200	0.306	1.00	7.00	2.142
05	Fc 200	1.268	1.00	7.00	8.876
06	OL 37	0.050	2.00	7.85	0.785
07	OL 37	0.102	2.00	7.85	1.601
08	OL 37	0.045	2.00	7.85	0.707
09	OL 37	0.211	2.00	7.85	3.313
10	Fc 200	1.714	1.00	7.00	11.998
11	STAS 4372 – 78 x M5				3.00
12	OL 37	0.033	2.00	7.85	0.518
13	OL 37	0.015	2.00	7.85	0.236
14	OL 37	0.033	2.00	7.85	0.518
15	STAS 4372 – 78 x M5				2.50
16	OL 37	0.157	2.00	7.85	2.465
17	Fc 200	0.008	1.00	7.00	0.056
18	STAS 5200 – 72				2.00
19	OL 37	0.010	2.00	7.85	0.157
20	STAS 5982 – 74				30.00

Table 4

Manufacturing costs

Mark No.	Operation	Total action time [min]	Total operation time [min]	Wage [RON/month]
1	Turning	93.19	931.9	1.200
	Drilling	26.42	264.2	1.200
	Grinding	67.67	676.7	1.600
	Heat treatment	90.00	900.0	2.000
	Milling	0.45	4.5	1.600
2	Turning	13.25	132.5	1.200
	Drilling	49.50	495.0	1.200
3	Turning	2.54	25.4	1.200
	Drilling	2.20	22.0	1.200
	Grinding	6.28	62.8	1.600
4	Turning	16.31	163.1	1.200
	Drilling	31.54	315.4	1.200
5	Turning	29.50	295.0	1.200
	Drilling	2.57	25.7	1.200
	Grinding	24.84	248.4	1.600
6	Turning	1.90	19.0	1.200
	Drilling	14.70	147.0	1.200
	Grinding	4.28	42.8	1.600
7	Turning	4.21	42.1	1.200
	Drilling	24.43	244.3	1.200
	Grinding	4.73	47.3	1.600
8	Turning	3.73	37.3	1.200
	Drilling	14.14	141.4	1.200
	Grinding	2.63	26.3	1.600
9	Turning	6.42	64.2	1.200
	Drilling	39.20	392.0	1.200
	Grinding	3.42	34.2	1.600

This procedure was taken for each non-standard assembly mark.

6. GRAPHIC REPRESENTATION

Before the graphic representations can be done we need to do an economic dimensioning, in which we calculated all interfering costs for the not standard assembly marks (materials usage, workers' wages, etc.).

This was possible after we generated the technologic film of production for each piece of this assembly. After we found out the necessary times for each technological process (such as drilling time, milling time, grinding time, time of heat treatments, etc.) and knowing the wages of the operators of each machine, we have been able to calculate the total cost of the whole manufacturing process.

After doing this we distributed the costs on functions according to their usage values. In this chapter we use the results from the economic dimensioning. With those we built a series of bar charts: the bar chart of costs, the Pareto bar charts and the correlation bar chart between the production cost and the usage value.

The purpose is to find out the highest costs, the highly evaluated functions and assembly marks. Once we established these highly evaluated functions and assembly marks we can start working on reducing the costs.

6.1. The bar chart of costs on functions

Those bar charts give us important information about the most expensive costs from our production. From both bar charts of costs – in percents (Fig. 2) and RON (Fig. 3), we can easily see that the highest costs are the ones with manufacturing. In this way we can start looking for solutions of reducing the production costs focusing on the manufacturing costs.

6.2. The pareto bar chart

The Pareto bar chart on functions (Fig. 4) shows that the important functions of the assembly are A: Gives motion and C: Assembly marks positioning. The important functions are situated as seen under the 70–80% functioning line. The functions had been ordered from the most expensive one to the cheapest one, for each second function being built on top of the one before it. In the same way we can determine the important assembly marks (Fig. 5). We find them under the 70–80% line.

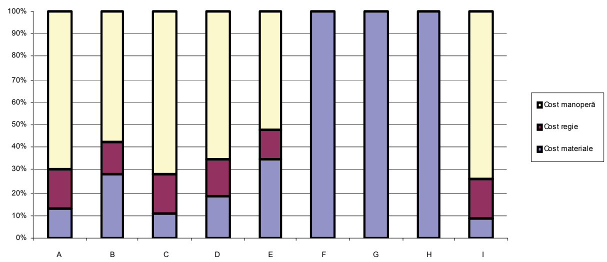

Fig. 2. The bar chart of costs on functions in percents.

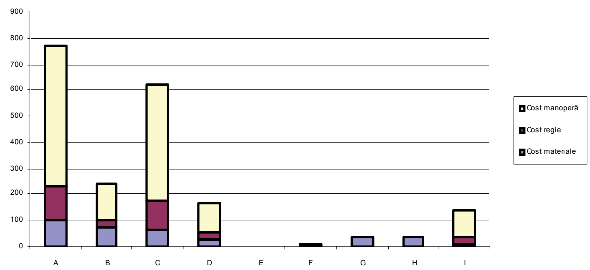

Fig. 3. The bar chart of costs on functions in RON.

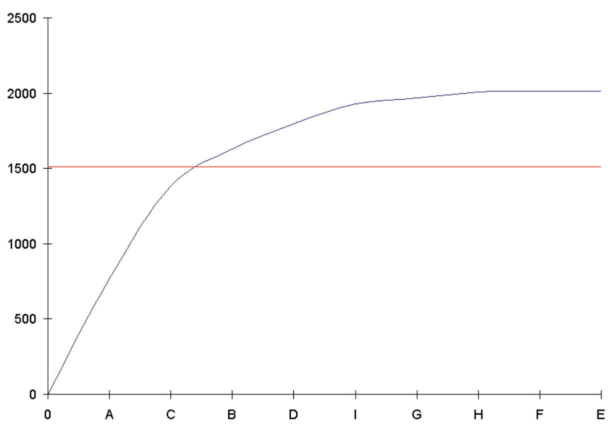

Fig. 4. The Pareto bar chart on functions.

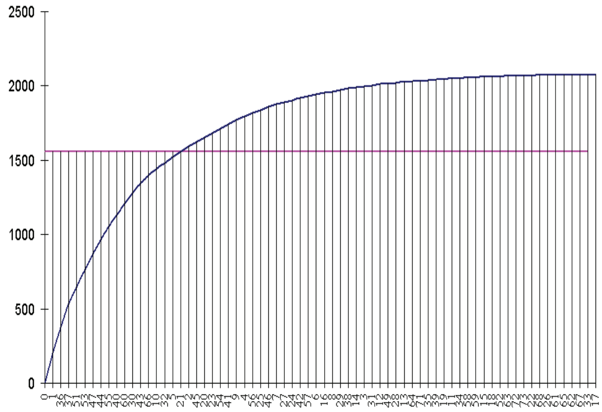

Fig. 5. The Pareto bar chart on assembly marks.

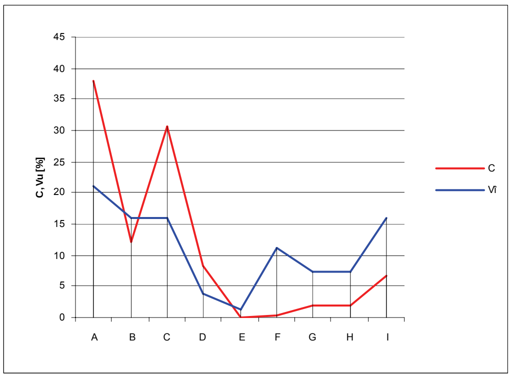

Fig. 6. The correlation bar chart.

6.3. The correlation bar chart between the production costs and the usage value

After deciding the important functions and assembly marks, we draw the correlation bar chart between the production costs and the usage value (Fig. 6). From this bar chart we can find out the highly evaluated functions of the assembly. Looking at the bar chart we can observe the three functions that are highly evaluated, this are the functions with the production costs over their usage values. Knowing these functions we also know their corresponding assembly marks.

7. THE BAR CHARTS INTERPRETATIONS

From the bar charts of costs on functions we established that the highest costs are the ones with manufacturing, so the solutions proposed for lowering the production cost are for the manufacturing costs.

The first handy solution for lowering costs is the usage of different blanks, especially for shafts where we propose as blanks tick wall tubes. From Pareto bar charts we established the important functions and assembly marks of the product. These are:

- Functions: A – Gives motion; C – Assembly marks positioning;
- Assembly marks:
  – A: 1, 20, 36, 37, 47, 51, 53, 58, 64, 72, 73
  – C: 1, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 19, 20, 21, 28, 29, 30, 32, 35, 39, 40, 41, 43, 44, 46, 55, 56, 57, 60, 67.

Table 5

Examples for solutions of lowering the production costs

Mark's number	Name of the mark	Solution for cost lowering
01	Main shaft	New blank - tick wall tube: ϕ_{out} 80 mm and ϕ_{in} 15 mm. In this way we can lower the production cost by 13.72 RON.
05	Main shaft's semi case	Casting with high precision (for large series)
10	Case's body	Casting with high precision (for large series)
21	Blank holder	Tick wall tube: ϕ_{out} 110 mm and ϕ_{in} 95 mm. In this way we can lower the production cost by 32.01 RON.
30	Case's body	Casting with high precision (for large series)
32	Bearing's case	Tick wall tube: ϕ_{out} 100 mm and ϕ_{in} 65 mm. In this way we can lower the production cost by 28 RON.
36	Shaft	Tick wall tube: ϕ_{out} 75 mm and ϕ_{in} 15 mm. In this way we can lower the production cost by 20.7 RON.
37	Shaft	Tick wall tube: ϕ_{out} 75 mm and ϕ_{in} 15 mm. In this way we can lower the production cost by 20.7 RON.
40	Clutch ring	We skip the heat treatment of carburising because of the small contact aria with the shaft. By doing this the cost is reduced by 71.02 RON
44	Cover	Casting with high precision (for large series)
47	Flat face pulley	We were not able to find any way of lowering the cost.
51	Axle	We couldn't find any way of lowering the cost.
53	Flat face pulley	We were not able to find any way of lowering the cost.
55	Bearing's case	Tick wall tube: ϕ_{out} 130 mm and ϕ_{in} 70 mm. In this way we can lower the production cost by 66.29 RON.
60	Connecting flange	Casting with high precision (for large series)

From the correlation bar chart between the production cost and the utilization value we can get the highly evaluated functions: A – Gives motion; C – Assembly marks positioning; D – Makes tightening. The functions that are highly evaluated, but also important are: A – Gives motion and C – Assembly marks positioning. The assembly marks that realize at list one of this functions are: 1, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 19, 20, 21, 28, 29, 30, 32, 35, 36, 37, 39, 40, 41, 43, 44, 46, 47, 51, 53, 55, 56, 57, 58, 60, 64, 67, 72, 73. From Pareto bar chart we found out the most important assembly marks: 1, 36, 37, 51, 53, 47, 44, 55, 40, 60, 30, 43, 66, 10, 32, 5, 21. The assembly marks belonging to both list, are: 1, 5, 10, 21, 30, 32, 36, 37, 40, 44, 47, 51, 53, 55, 60. For those assembly marks we propose solutions for lowering the manufacturing costs (Table 5). There might be better solutions then the ones that we proposed but this is just an example. Observing that the most expensive operations are the drilling ones for the shafts we tried to use a different kind of blank, holed ones.

Another possibility of lowering the costs would be using CNC technology, if available, instead of classic machines. This should decrease the costs with manufacturing and also the time of production by concentrating operations on the same machine and eliminating the auxiliary times.

8. CONCLUSIONS

The economical value analyze is probably one of the best way to an optimum price of production. This should always be done before starting a production of any kind, especially when the beneficiary imposes the maximum allowed price. From this analyze we can get all kind of important data. We can find out that some pieces that we considered important at the beginning can be disposed at all.

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Authors:

Eng. Florina ANGHEL, "Politehnica" University of Bucharest, Machines and Manufacturing Systems Department,
E-mail: florina@mix.mmi.pub.ro
Eng. Dragoş Alexandru CAZACU, "Politehnica" University of Bucharest, Machines and Manufacturing Systems Department,
E-mail: alex@mix.mmi.pub.ro