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1. Roman ŠŮSTEK

SELECTION OF DETERMINING PARAMETERS USING THE ECM MODEL

1. Brno University of Technology, Institute of Forensic Engineering, Brno, CZECH REPUBLIC

Abstract: The paper solves the way of selecting pricing parameters for valuation of forming machines. Author of the paper suggests using three-level model, which explains in detail the process of reducing the basic parameters of the forming machine. Before the reduction begins, it is necessary to categorize the technical parameters. These parameters are commonly available from the forming machine catalogue. The solution of the ECM (Expert Analysis, Correlation Analysis and Multi-criteria Variant Evaluation) model design consists in reducing these parameters and selecting of determining parameters, which are further used in the calculation algorithm for valuation of the forming machine.
Keywords: parameter selection, valuation, forming machines, analysis

1. INTRODUCTION

In current valuation practice, the choice of pricing parameters depends on the subjective view of the expert. This often leads to inaccurate valuation conclusions. This can be a big problem because other institutions such as the police, courts, attorneys etc. work with these conclusions.

The issue of determining the default value of machines is dealt with by Borg, which has compiled price functions for mass-produced goods, dependent on the performance parameters of the goods and the offer prices. A pricelist function is compiled from the above parameters, most often using regression analysis. The price data of machines of various parameters can be obtained using this function. The price figure can be derived from the diagram, or it can be calculated by inserting the performance characteristic into the respective formula [1].

Other experts from the ranks of experts monitored the dependence of selected operational parameters on the market value of transport aircraft. The experts carried out comparative analyses of airliners, which monitored their characteristics, namely range, flight speed, number of passenger seats installed, cabin space, take-off length, fuel consumption, and based on these parameters they determined the parametric cost function reflecting the market value of the aircraft [2].

As Krhanek states, the quantitative determination of the technical level of the machine can be carried out by collective professional evaluation of the significance of individual numerical parameters and by poll evaluation of the ordered sequence of numerical parameters of the evaluated machine [3].

Contributions and publications are devoted to the use of multicriteria evaluation methods in connection with the assessment of the technical level in the evaluation of machines [4, 5 and 6]. The authors compare a larger number of technical parameters of the machine, which variously affect its technical level and thus the starting price of the machine. The scoring basis method, based on the comparison of the properties of the evaluated object with the properties of the basic design, is used with advantage.

Methods of creative thinking are offered by the authors of a publication that deals with problem solving techniques. They deal in detail with methods of intuitive way of creative thinking as well as methods and techniques that are based on a systematic way of creativity or on a combination of both principles of creative thinking [7].

The analysis of the current situation shows that the approaches to valuing machines are well established and generally known. But solving these problems is not easy. These are always complex problems where the level of solution is very significantly influenced by the expert level of the expert, i.e., subjectively. Considering the scale of engineering output in the area of production machinery, it is very difficult to ensure that all experts have the same level of knowledge about all types of machinery, and it is therefore appropriate to undertake research aimed at specifying valuation procedures for specific groups of asset types so that more possibilities are exploited in the area, which are offered by methods for solving complex problems based on the application of a generalised system approach.

The properties of the forming machine are described by many parameters and due to technical progress and development of new technologies and functions, it is a dynamic set of parameters. As a rule, the expert does not have enough information about their materiality in relation to the achievable price of the machine. Some information significantly affects production costs, others less, some significantly affects user benefit, others less. It is always a multi-criteria assessment, which is difficult to implement and is significantly influenced by expert knowledge of the expert, whose sufficient level about the scope of production of individual manufacturers cannot be sufficiently well ensured for all types of machines that experts encounter.

2. RESULTS

Forming machines are described by several technical parameters. These parameters can be categorized into groups:

- workspace (bending length, throat depth, table height, stroke, distance between columns, max day light),
- capacity (pressing force and motor power),
- effectiveness (speed of stoppers, feed of the upper cross),
- machine size (length, height, width, weight of the machine),
- unclassified (accuracy, degree of automation, or other unspecified parameters can typically be included).

This categorization of technical parameters will allow further reduction. A three-level reduction of technical parameters is proposed below.

— Expert Analysis

Forming machines are designed to meet the high demands of users and to meet the demand in the market for forming machines (including future technological capability, e.g., use of robotics and automation in production). The technological possibilities of the forming machine can be expressed by the level of user function, which depends on its properties, e.g., functionality, technical level, durability, ecology, safety, etc. In terms of assessing the benefit of the owner (user) of the forming machine, the most important indicator is the variety of products that can be produced on the machine.

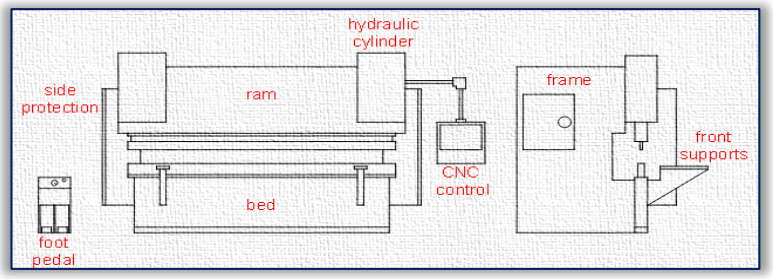

Figure 1. Some elements of a typical CNC hydraulic press brake; author

With the increasing value of some parameters, the possibilities of the forming machine change fundamentally. The value of some parameters thus affects the performance of the technological operation that is performed on the forming machine. This has a major impact on the benefits (benefit from forming machine BfFM). Forming machine consists of construction groups and elements (in Figure 1).

Some design groups and elements are used to produce each forming machine (e.g., linear guides, shifts and stops, safety elements) are rotated accordingly, but in principle do not affect utility. The increase in utility can be achieved by changing some construction groups or elements (along with this their parameters change). Suppose that each group can be quantified. Their sum is equal to the value of Benefit from Forming Machine (BfFM):

$$BfFM = A + B + C + D + E \quad (1)$$

where A is a workspace group, B is a capacity group, C is an effectiveness group, D is a machine size group and E is an unclassified group. Practical representations are shown in Table 1.

Table 1. Influence of individual groups on BfFM; author

		Press Brake		Press Brake	
Group	Parameter	PBNC		PBNC	
B	Pressing Force (ton)	30		40	
A	Bending Length (mm)	1600		2500	
A	Stroke (mm)	100		120	
A	Throat Depth (mm)	250		260	
Group					
A	Workspace	1	A	fundamental change	A+X
B	Capacity	1	B	fundamental change	B+Z
C	Effectiveness	1	C	reasonably equal	C
D	Machine size	1	D	dependent on A+B	D
E	Unclassified	1	E	individual	E
		BfFM=A+B+C+D+E		BfFM=A+X+B+Z+C+D+E	
		BfFM=5		BfFM=5+X+Z	

Expert consideration when comparing the two models (Press Brake) with different technical parameters, it is possible to conclude:

- Group A (workspace): cause (X difference when increasing the Bending Length parameter), consequence (the maximum bending length is increased).
- Group B (capacity): cause (Z difference when increasing the Pressing Force parameter), consequence (the maximum thickness of the sheet during bending is increased).

After the expert analysis, the important parameters are those in the workspace and capacity groups. Other groups have insignificant influence on utility (benefit).

— Correlation Analysis

Correlation analysis deals with mutual (mostly linear) dependencies, where emphasis is placed on the intensity (strength) of the mutual relationship rather than on examining variables in the direction of cause-effect.

Dependency is assessed by the value of the correlation coefficient [8]. Data from usual information sources are used to verify dependence (Table 2).

Table 2. Technical parameters of HACO press brakes; author

Model HACO	Pressing Force (ton)	Bending Length (mm)	Stroke (mm)	Distance between Columns (mm)	Max Day Light (mm)	Throat Depth (mm)	Motor Power (kW)	Table Height (mm)
Group	B	A	A	A	A	A	B	A
16040	40	1600	100	1100	295	195	4,1	830
20075	75	2100	100	1600	280	200	7,5	840
30100	100	3100	200	2600	400	250	11,4	880
30150	150	3100	200	2600	400	250	15,0	915
36175	175	3600	200	3150	450	300	15,0	965
40220	220	4100	200	3150	450	300	18,7	965
40320	320	4100	250	3150	500	330	22,5	890
50320	320	5000	250	4050	500	330	22,5	940

The parameter Table Height is an ergonomic parameter and is not further evaluated.

Figure 2 illustrates possible interdependencies of parameters. These are the parameters of Bending Length and Distance between Columns, Stroke and Max Day Light, Pressing Force and Motor Power. Parameter pressing force expresses the force caused by the movement of the ram in a vertical direction, linear dependence of parameters, author.

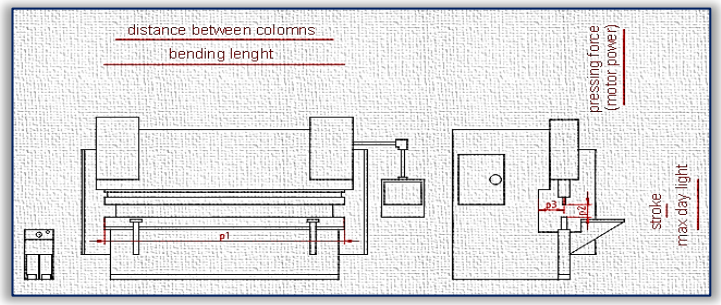

Figure 2. The parameters of Bending Length (p1), Stroke (p2) and Throat Depth (p3)

The results of the correlation analysis are shown below in Table 3, 4 and 5. The correlation coefficients are a very strong correlations. The correlation coefficient is 0.97303451, this is a very strong correlation. After correlation analysis, Pressing Force, Bending Length, Stroke and Throat Depth are essential parameters.

Table 3. Parameters Pressing Force vs. Motor Power; author

	Pressing Force (ton)	Motor Power (kW)
Pressing Force (ton)	1	
Motor Power (kW)	0,97493686	1

Table 4. Parameters Bending Lenght vs. Distance between Colomns; author

	Bending Length (mm)	Distance between Columns (mm)
Bending Length (mm)	1	
Distance between Columns (mm)	0,98659841	1

Table 5. Parameters Stroke vs. Max Day Light; author

	Stroke (mm)	Daylight (mm)
Stroke (mm)	1	
Daylight (mm)	0,97303451	1

— Multi-criteria Variant Evaluation

Multi-criterion analysis is a method used to decide between several alternatives, not allowing multiple resulting alternatives at the same time, and the conclusion of the analysis should always be a single alternative. A prerequisite for using multi-criterion analysis is a larger number of quantifiable criteria that are included in the decision-making process. If this prerequisite is not met, it is the case of one variant multi-criterion assessment.

The results of the multi-criteria analysis were successfully published by the author [9]. In this part of the paper, the author only gives a summary of the results. From the point of view of the manufacturer of the forming machine, the costs of its production are always important. In simple terms, these costs can be divided into costs incurred for own production (costs incurred directly at the manufacturer), costs incurred for supplies from a subcontractor (purchase of components) and costs of assembly of the forming machine. The costs of production of the forming machine can be expressed:

$$C_T = C_{OP} + C_S + C_A \ [€, \$] \quad (2)$$

where CT is a total cost, C_{OP} is a cost of production itself, C_S is a subcontractor cost and C_A is an assembly cost. This consideration can be used to the advantage in determining the assessment criteria.

The significance of each of the parameters (pressing force, bending length, stroke, and throat depth) will be assessed and evaluated according to its effect on cost of production itself, subcontractor cost and assembly cost.

≡ Impact of parameters on cost of production itself (including co-operation)

The press brake is made from various parts and components. Parts and components are assembled into construction groups (in Figure 1). Parameters pressing force, bending length, stroke and throat depth are decisive to produce the ram, the bed, and the frame, i.e., parameter size determines dimensions of the construction groups (in Figure 2). From the point of view of material consumption and the execution of techno-logical operations can be concluded that the essential parameter is pressing force (e.g., robust construction

with increasing range) and bending length (e.g., bed and ram length with increasing range). The parameters of stroke and throat depth are not that significant.

≡ Impact of parameters on subcontractor cost

Purchased components have an important presence in the design of forming machines. An important group consists of an engine, an electrical power distribution, hydraulics including accessories, stop and feed mechanisms, linear motion systems, CNC, upper and lower toolbar, sensors, and safety features. Increasing the value of the pressing force parameter will increase the cost of purchasing the engine, electrical power distribution, hydraulics including accessories. Increasing the value of the bending length parameter will increase the cost of purchasing mechanisms of stops and feeds, linear motion systems, upper and lower toolbar. The throat depth parameter affects the extent of stop and feed mechanisms (in the x-axis direction). The stroke parameter is not relevant to the assessment of this significance.

≡ Impact of parameters on assembly cost

Other important factor that affects costs is the installation of a press brake. Connecting and tuning the press brake also increases these costs. The dimensions of the press brake are crucial for assembly. The crucial parameter is the bending length. The larger the parameter, the greater the assembly time (e.g., assembly of stop and feed mechanisms). Pressing force is also a significant parameter. This parameter is related to the drive (engine and electrical power distribution), hydraulic equipment (pumps and tanks). The stroke and throat depth parameters are not significant.

Table 6. Criterial matrix evaluation; author

	Criterion-cost of own production	Criterion-subcontractor cost	Criterion-assembly cost	Score
Pressing Force	1	1	1	3
Bending Length	1	1	1	3
Stroke	0	0	0	0
Throat Depth	0	1	0	1

Given the problem under consideration, the use of a nominal (binary) scale seems best. The method of rating variants by nominal scale [10] is based on the application of a match or non-match (difference), which is defined by a binary logical value of 1 (match) and 0 (non-match). This method does not consider the preferences of individual criteria, weightings of individual criteria are not considered. The order of variants is determined based on the sum of the values given in the criterion matrix. A criterial matrix can also be shown in table form (in Table 6).

Changing each of the parameters pressing force, bending length, stroke and throat depth affects the amount of the cost of producing the press brake. An increase in the value of one of these parameters will also be reflected in the cost of producing the press brake. Highest scores were achieved by pressing force and bending length parameters (in Table 6).

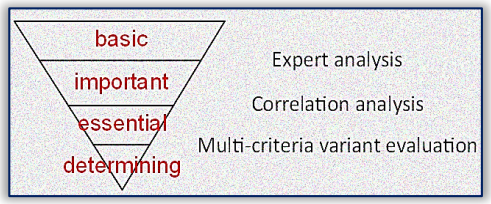

Figure 3. Method ECM; author

3. CONCLUSION

The choice of pricing parameters is often based on the subjective estimates of an expert. For objective evaluation, a method based on three levels of parameter reduction is proposed. Expert analysis is used to select important parameters, correlation analysis is used to reduce parameters to essential parameters (Correlation analysis) and for the selection of the determining parameters, the methods of multi-criteria evaluation of variants shall be used, thus the method ECM (in Figure 3).

Determining parameters in terms of price formation are for brake presses – Pressing Force and Brake Length. The ECM method uses expert methods and can be used not only for forming machines. The applicability of this method will be further verified on other types of machines or other assets.

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