ECONOMICAL ASPECTS IN THE COMPARATIVE ANALYSIS OF TWO FINISHING METHODS FOR INTERNAL SURFACES

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Abstract: The paper presents a theoretical approach regarding some economical aspects to be considered in the comparative analysis of two finishing methods for internal surfaces, respectively grinding and broaching processes. For comparatively analyzing the manufacturing costs, the technical and organizing conditions specific for each of the considered finishing process represent the starting point. Manufacturing equipment, men work and energy consumption are the basic elements considered in the economical analysis. A particular case study within the mentioned approach is also presented and discussed in the paper.

1. INTRODUCTION. PROBLEM STATEMENT

Majority of component parts from machines, equipment, technical devices, installations and apparatus used in industry and not only, have internal revolving surfaces. The technology applied for their processing in manufacturing must provide, for such surfaces, more or less severe conditions function of the destination of the parts they belong to. These conditions are related to dimensional accuracy, to correctness of shape and relative position and also to surface quality.

As it is well known, internal surfaces are more difficult to process, being less accessible, the used tools having, generally, a more reduced rigidity and the evacuation of metal chips and of the heat resulted in the machining process being realized in harder conditions.

The technological method for machining internal surfaces is established function of the shape and dimensions of the parts, function of their material, of the dimensional accuracy, of the shape and relative position accuracy for the machined surfaces, of the quality imposed to those surfaces and, not at last, function of the machining costs. When the machining technology is established, there is also considered that internal revolving surfaces are processed starting from blind blank or from previous holes obtained by casting or die forging. Eventual heat treatment applied either to the whole part or just to the considered surfaces is also taken into account.

Grinding and respectively broaching are productive methods for finishing internal cylindrical surfaces, providing, at the same time, adequate machining accuracy and surface quality for the finished part. Depending on the requests imposed through the engineering documentation for the part, regarding the quality of surface and dimensional and shape accuracy, one of the two mentioned method can be chosen, simultaneously considering also the productivity of the machining method and the machining costs.

That is why, within a larger research approach concerning contrastive comparison of some finishing methods, initiated as a collaborative integration of scientific research from a technical university with specialists from technical high-schools, [3], [4], some economical aspects, respectively referring to specific manufacturing costs as key element in the comparative analysis of grinding and broaching for internal cylindrical surfaces, have been theoretically studied and are further on presented in the paper.

2. ASPECTS IN THE COMPARATIVE ANALYSIS OF COSTS FOR GRINDING AND BROACHING OPERATIONS

The following aspects have been considered as important to be subjected to study for comparatively analyzing, from the economical point of view, the processes of grinding and respectively of broaching for finishing internal cylindrical surfaces:

- technical-organizing conditions, necessary for each manufacturing method;
- men work consumption;
- energy or power consumption.

The technical-organizing conditions have been analyzed considering the following elements:

- Equipment, respectively machine-tools;
- Auxiliary technological devices;
- Tools;
- Operator qualification.

For comparing the specific equipment and the eventual auxiliary technical devices, the following comparison criteria have been considered:

- overall dimensions of the specific machine-tools;
- installed power of the equipment;
- constructive complexity of the equipment and of eventual auxiliary technical devices;
- equipment geometric accuracy;
- equipment's price.

As result of some case studies developed on the issue of equipment, the qualitative comparative chart from Fig. 1 has been obtained, representing a comparison of the equipment for grinding and respectively for broaching. Related to this criterion, there resulted that the overall dimensions of broaching machines are generally bigger than those of the internal grinding machines. The great size of the first category is a consequence of big forces and large working displacements specific in the broaching process. Also due to the cutting forces, the difference between the installed powers for the specific equipment is important, broaching machines needing electrical installations adequately dimensioned. Broaching machines are much simple than the grinding ones as kinematics and constructive complexity and by consequence they are cheaper.

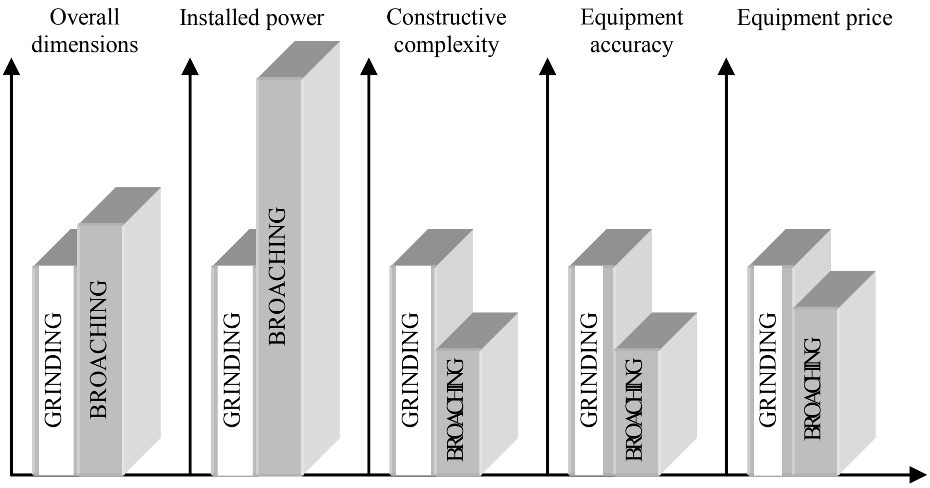

Fig. 1. Comparison of the equipment for grinding and respectively for broaching

Related to the issue of specific tools, the two analyzed finishing methods are obviously differentiated. Tools for broaching are complex and expensive, demanding special

technologies for manufacturing and finishing. Conditions regarding the shape and dimensional accuracy are generally very strict for this kind of tools. Abrasive tools used for internal grinding are simple, easy to obtain and very much cheaper.
As a comparison term, the price for a common abrasive tool for internal grinding, in the usual dimensional range, is situated approximately between 4÷15 Euros but the price for a broaching tool for usual dimensional range of internal cylindrical surfaces is situated approximately between 300÷500 Euros. The ratio is about 30÷75 times. From the tool price point of view, grinding appears to be much cheaper than broaching.
But, on the other hand, durability prescribed for broaches for internal cylindrical surfaces processing is about 180÷270 min, much bigger than the durability of abrasive tools for grinding the same type of surfaces, which is about 5÷10 min. The ratio is now about 27÷36 times. Considering also the machining times, which are significantly smaller for broaching than for grinding, there has resulted that, for repetitive manufacturing and mainly for mass production, broaching becomes economic also from the point of view of tooling expenditure.
Similarly, the qualitative comparative chart from Fig. 2 has been obtained, representing a comparison of the men work consumption and expenditure for grinding and respectively for broaching operations. Grinding operations usually involve complex equipment setting activities, requiring operators with higher level of qualification than for broaching operations. Times necessary for auxiliary activities are also bigger for grinding operations, which, in addition to those mentioned above for the machining times, lead to conclusion that time standard per operation is always bigger for grinding than for broaching.

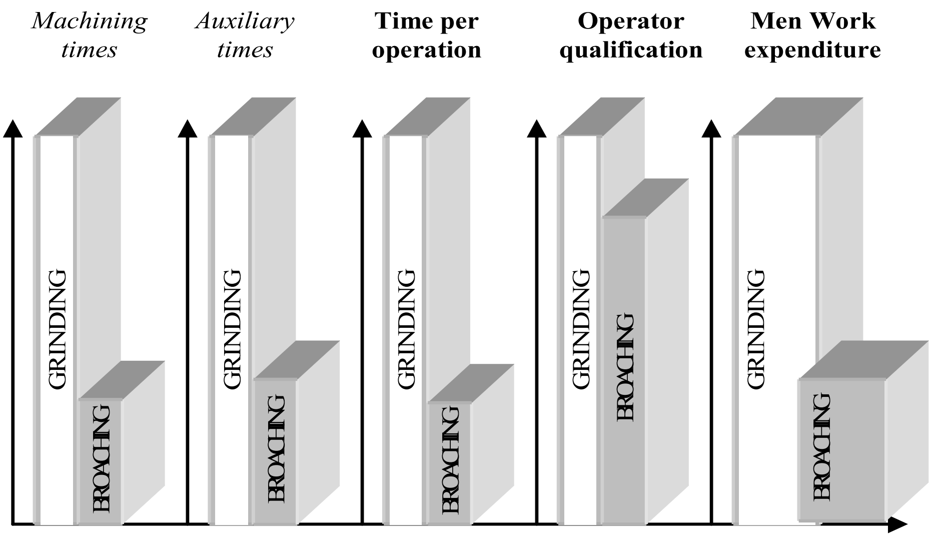

Fig. 2. Comparison of the men work expenditure for grinding and respectively broaching of internal cylindrical surfaces

Finally, the specific energetic consumption for the two analyzed finishing methods and the corresponding costs can be put in relation with the forces in the process which determine the required installed power, significantly bigger for broaching but also with the machining times, where the relation is reversed. In Fig. 3 a qualitative comparative chart obtained for the energetic consumptions for grinding and respectively broaching of internal cylindrical surfaces is presented.

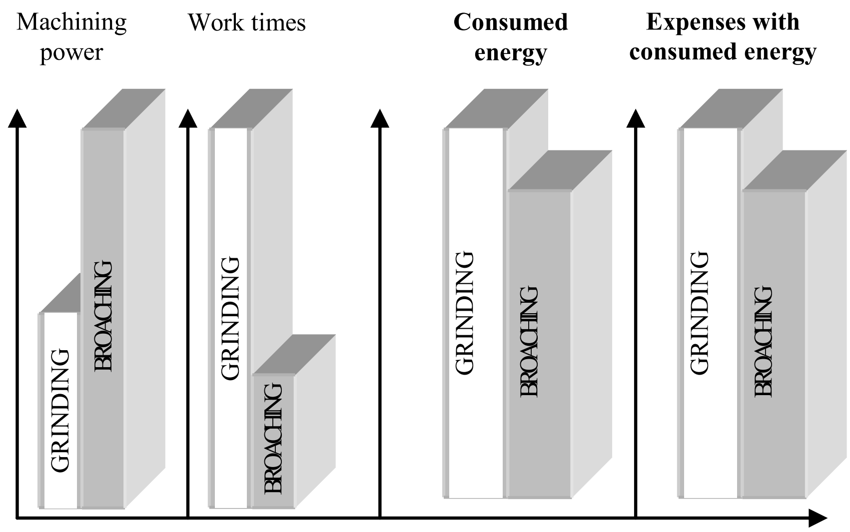

Fig. 3. Comparison of the energetic consumptions for grinding and respectively broaching of internal cylindrical surfaces

3. CASE STUDY OF COMPARATIVE COST ANALYSIS FOR GRINDING AND FOR BROACHING OPERATIONS

For sustaining, by exemplification, the above presented comparative considerations, a case study is further on presented, regarding the costs per operation for processing, by grinding and respectively by broaching, an internal cylindrical surface on a certain part from bushings category. Particular data used for the elaboration of the respective case study as well as the calculation methodology have been obtained as result of a collaboration with the Pricing Department from a manufacturing enterprise from Iasi area.

In Table 1, the initial data used in the calculation developed for solving the approached case study is presented. In Table 1, the parameters of the working regimes, with the corresponding notations, represent as following:

- for grinding:
  - n_p – number of revolutions per minute of the part's revolving motion;
  - S_t – transversal feed rate;
  - S_l – longitudinal feed rate.
- for broaching:
  - v_a – cutting speed;
  - f_z – feed rate per tooth.

Starting from the mentioned initial data and applying well known calculus relations and standard calculation algorithms got from particular manufacturing enterprises, there was calculated, both for the case of grinding and for the case of broaching operation, a set of parameters as following:

- machining power;
- machining time;
- time standard per operation, [5];
- tooling expenditure.

The corresponding obtained results are presented bellow, in Table 2.

Table 1. *Initial data, used in calculation for case study solving*

Initial data	**Grinding**	**Broaching**
Characteristics of the part	*Material*: OLC45 *External diameter*: D_e= 52 mm *Internal diameter* (surface to be obtained): D_p=25 mm *Length of the part*: L_p=24.5 mm	
Machine-tool	Grinding machine RI 80	Horizontal broaching machine MB 1,5-15A
Characteristics of the tool (involved in calculus)	Abrasive tool with core bar *Diameter*: 20 mm *Length*: 25 mm *Durability*: 6 min *Cost*: 6 Euro	Cylindrical broach *Length of the broach*: 400 mm *Broach teeth pitch*: 7 mm *Durability*: 180 min *Cost*: 360 Euro
Working regime	n_p=220 revolutions/min S_t=0,008 mm/double-stroke S_l=8,3 mm/revolutions of part	v_a=4 m/min f_z=0,03 mm/tooth
Qualification (category) of operator	4/2	3/2
Basic wage, T_h (for operator)	2.1 Euro/hour	1.8 Euro/hour

Table 2. *Calculated data, used for case study solving*

Calculated data	**Grinding**	**Broaching**
Machining power	1,8 kW	3,3 kW
Machining time	0,4 min	0,1 min
Time standard per operation, N_t	5,28 min	1,5 min
Tooling expenditure (for one part)	0.4 Euro	0.2 Euro

Further on, based on the algorithm presented in Table 3, the expenditure related to the men work consumption, which contributes as component in the production cost of the considered part, was calculated both for the situation of finishing by grinding operation and for the situation of finishing by broaching, [1], [6]. The numerical obtained results are comparatively presented in the same Table 3.

Table 3. *Calculation algorithm for men work expenditure, within production costs*

Nr.	Calculation article	Explanation	Value (Euro)	
			Grinding	**Broaching**
1	Men work expenditure	N_t x T_h / 60	0.185	0.045
2	Direct salary expenditure (duties)	32,75% of (1)	0.060	0.015
3	Manufacturing overhead expenses	400% of (1)	0.74	0.18
4	Manufacturing cost	(1)+(2)+(3)	0.985	0.24
5	General overhead expenses	12% of (4)	0.118	0.029
6	Production cost	(4)+(5)	1.103	0.269

4. CONCLUSIONS

Particular values obtained by calculation, as those presented in Table 2 and in Table 3 and also the above presented considerations allowed to formulate the following conclusions regarding the comparative analysis developed upon the two considered finishing methods:

- Machining power is definitely bigger, almost double for the presented case study, at broaching than at grinding operations.
- Machining time for the operation is much smaller – four times in the presented case study – at broaching. Time standard per operation, N_t, is also much smaller – almost four times in the presented case study – at broaching.
- Tooling expenditure, for one part, are bigger at grinding - almost double in the presented case study, although the price of a broaching tool is about 66 times bigger than the price of an abrasive tool. This happens only in the situation of repetitive or mass manufacturing, where the bigger durability of the broaching tool can be adequately exploited.
- Corresponding cost components related to men work consumption, within the total production cost, are definitely bigger for grinding than for broaching.

All the conclusions above formulated determine broaching as economic finishing method for processing internal cylindrical surfaces like that considered in the presented case study. The results of the case study presented in the paper can found their explanation in the comparative considerations above mentioned regarding the manufacturing costs at grinding and at broaching of internal cylindrical surfaces and come to exemplify and sustain those considerations.

REFERENCES:

[1] Accounting Coach (2010), *Manufacturing Overhead Costs*, Available from: http://www.accountingcoach.com/online-accounting-course/36Xpg01.html, Accessed: 03/03/2010

[2] Creţu Gh., Varvara G., Merticaru V.jr., (2000), *Metode de cercetare experimentală*. Editura Tehnica-Info, Chişinău, 2000.

[3] Hîncu C., (2005), *Studiu comparativ teoretic şi experimental asupra prelucrării prin rectificare şi broşare a suprafeţelor cilindrice interioare*. Teză de doctorat, Universitatea Tehnică "Gh. Asachi", Iaşi, 2005.

[4] Merticaru V.jr., Hîncu C., Merticaru E., Sava A., (2006), *Contrastive Theoretical Comparison upon Grinding and Broaching of the Internal Cylindrical Surfaces,* BUL. INST. POLIT. DIN IAŞI, Tom. LII (LVI), Fasc. 5A, 2006, ISSN 1011-2855, pp.183-186;

[5] Picos C., s.a., (1982), *Normarea tehnica pentru prelucrari prin aschiere*, Editura Tehnica, Bucuresti, 1982.

[6] Simple Studies (2010), *Manufacturing and Non-manufacturing Costs*, Available from: http://simplestudies.com/manufacturing-nonmanufacturing-costs.html, Accessed: 03/03/2010.