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THE INFLUENCE OF CUTTING SPEED v_a AND PROCESSED MATERIAL ON CIRCULARITY DEVIATIONS AT CYLINDRICAL SURFACES BROACHING

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Broşarea este unul dintre procedeele de prelucrare prin aşchiere a suprafeţelor interioare, profilate sau neprofilate, care asigură o calitate a prelucrării, din punct de vedere al preciziei dimensionale şi de formă, rugozităţii suprafeţei etc., corespunzătoare operaţiilor de finisare. Lucrarea prezinta influenta vitezei de aschiere asupra abaterilor de la circularitate la brosarea suprafetelor cilindrice. În ceea ce priveşte sculele, în experimentele dezvoltate în această fază a cercetărilor, au fost utilizate broşe cilindrice cu partea tăietoare executată din oţel Rp3 tratat la (63÷65)HRC şi corpul din oţel 40Crl0 cu (35÷40)HRC, având dimensiunea diametrală pe dinţii de calibrare Dc=(25,03-0,05)mm. Pentru lucru, broşele au fost prinse cu ajutorul unui dispozitiv tip bucşă elastică. Piesele semifabricat pentru realizarea probelor experimentale au fost executate din trei materiale curent utilizate în construcţia de maşini şi care au fost supuse studiului şi în cadrul cercetărilor privind rectificarea suprafeţelor cilindrice interioare, respectiv: OLC45; 90VMoCrl 80; 40BCrl0. In ceea ce priveşte descrierea matematică a influenţei vitezei de aşchiere, asupra abaterilor de la circularitate al pieselor prelucrate prin broşare, au fost stabilite funcţii de dependenţă unidimensională, sub forme matematice de complexitate medie, de tip polinomial de ordinul 3, respectiv de ordinul 6 şi în cazuri izolate de ordinul 2, respectiv 4. Abaterile de la circularitate, A_c, ale suprafeţelor cilindrice interioare prelucrate prin broşare, în cadrul cercetărilor experimentale, s-au încadrat în limitele globale (5÷20)μm, respectiv între (5÷14)μm pentru oţelul OLC45, între (7÷16) μm pentru 40BCrl0 şi între (6÷19)μm pentru materialul 90VMoCrl80.

Cuvinte-cheie: broşare, viteză de aşchiere, precizie dimensională, rugozitate.

Broaching is one of the cutting processes of inner surfaces profiled or deadlock, which provides a quality of processing, in terms of dimensional and shapes precision, surface roughness, etc., corresponding to finishing operations. This paper presents the influence of cutting speed on deviations from circularity in Broaching cylindrical surfaces. In terms of tools, the experiments developed in this research were used cylindrical brooches made from steel cutting Rp3 treated at (63÷65)HRC and steel body from 40Crl0 with (35÷40)HRC, with the diameter of teeth calibration Dc = (25.03-0.05)mm. For work, brooches were caught with a device type collet. Blank pieces of experimental evidence for achievement was made of three materials commonly used in machine manufacturing and were surveyed in the research on inner cylindrical surfaces rectification, namely: OLC45; 90VMoCrl 80; 40BCrl0. In terms of mathematical description of the influence of cutting speed, the deviations from circularity of parts processed by broaching were established functions depending dimensional form complex mathematical average of polynomial type of order 3 and order 6 in isolated cases of order 2 or 4 of roundness, Ac, of the inner cylindrical surfaces machined by broaching, within experimental investigations were within its overall (5-20)μm and between (5-14)μm for steel OLC45, from (7-16)μm for 40BCrl0 and (6÷19)μm for 90VMoCrl80 material.

Keywords: broaching, cutting speed, dimensional precision, roughness.

1. INTRODUCTION

Broaching is one of the processes of machining the inner surfaces profiled or deadlock, which provides a quality of processing, in terms of precision dimensional and shape, surface roughness, etc., corresponding to finishing operations.

To locate the broaching applicability as finishing process noted that processed by broaching inner surfaces range is quite large, [1] and can illustrate: round holes, polygonal holes, grooves, with keyways, inner teeth, holes profiled.

In industrial manufacturing processes, broaching operation is performed in one of two technological variants: by pulling the spindle, which is normal, and with pushing the spindle.

Kinematics of generating inner cylindrical surfaces by stitching entails a single continuous rectilinear movement to broach the song being immobile, [2]. This movement is the main movement of the cutting, whereby the machining allowance is removed, in a single pass. In some special broaching machines, spindle is fixed and the main motion straight running track.

For stitching inner cylindrical surfaces, running, first, in part a round hole with a diameter smaller than the final hole. By entering the broaching in this hole, track focuses on the leading portion and then the spindle is driven by machine, traveling to play until all the teeth to come in contact with the borehole wall it off from the chips. Each tooth of the spindle works as a planning knife. A tooth height is larger than the previous tooth height, height difference between two consecutive teeth constituting maternal thickness of each tooth removed [3].

In relation to the matters referred to immediately above, it can say that the way to solve them is the undoubtedly scientific experiment, but this captures only cliches of reality investigated process because the study does not allow for the totality of phenomena, all factors and legalities involved.

Experimenting requires the introduction of simplifying assumptions, which, if not well chosen and rigorously defined as a field of action, can remove the researcher scientific truth, may lead to results that do not match with reality and not thus practical utility.

2. EXPERIMENTAL TESTS PLANNING

To establish the clear objectives of experimental research, as well as to parameterize the variables studied processes, theoretical studies have proposed to conduct a systemic analysis of processes of stitching and inner cylindrical surface grinding respectively, to highlight the factors involved in generating a certain processing accuracy and a certain surface quality, namely: inner cylindrical surface schemes generation by broaching and grinding respectively; equipment's and tools used in each case; auxiliary equipment's eventually; cutting environment and leading its way into the cutting area; thermal phenomena and elastic deformations of the system during the process, etc.

Given the basic criteria that must comply with experimental data acquisition approach, namely: minimizing of the experimental tests; providing the best precision data; providing the results easy to interpret.

It was imposed the following: introduction some simplifying assumptions, rigorously selected and designated as a major action to remove the researcher not scientific truth, not lead to results practically unusable; research substantiation on a good knowledge of the processes studied, their way of progress, the factors involved, using as a starting point and as a benchmark for comparison to previous research or / and data and conclusions resulting from the theoretical studies relating to your access theme.

To analyze the cylindrical inner surface broaching, viewed as a system transformation process, bowed, in principle, the scheme shown in figure 1.

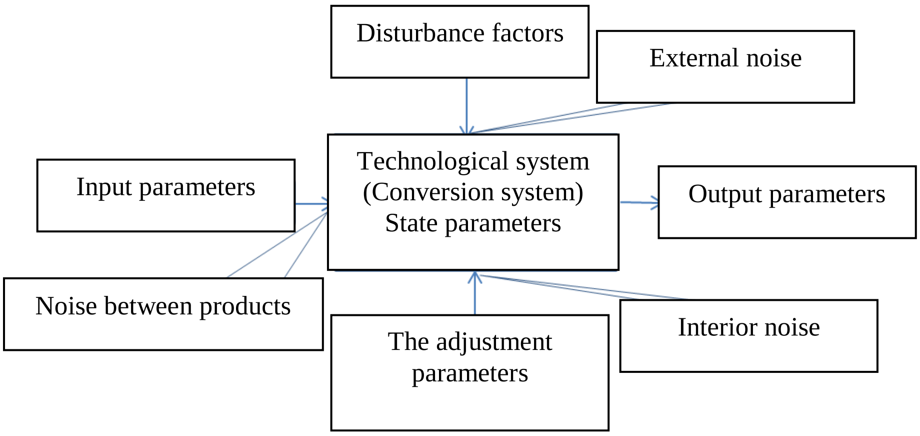

Fig. 1. Scheme of technological system as a system transformation

The scheme presented in figure 1 enables to identify of the following categories size involved in the technology operation, in the general case:

- Input parameters, which refers to the features that you have thought the process products intended for processing before transformation;

- Condition parameters, they are system-specific parameters that affect the trials but cannot be changed during operation;

- Piloting parameters (control), represented by the sizes that allow the operator to control the operation of the system;

- Parameters of disturbance (noise), ie sizes that occur beyond the control of the system operator (as an example: outside temperature, vibrations from the environment, etc.).

- Output parameters, which relate to the results of the relative both to the performance, quality and the phenomenon of thermal energy, etc.

3. RESULTS AND DISCUSSIONS

The processing carried out in experiments conducted in the inner cylindrical surface broaching were carried out in a horizontal broaching machine M.B.1.5-15 A type. In terms of tools, the experiments developed in this research were used cylindrical brooches made from steel cutting Rp3 treated at (63÷65)HRC and steel body 40Crl0 with (35÷40)HRC and the diameter of teeth calibration Dc = (25.03-0.05)mm. For work, brooches were caught with a device type collet. Blank pieces of experimental were made from three materials commonly used in machine manufacturing and were surveyed in the research on inner cylindrical surfaces rectification, namely: OLC45; 90VMoCrl 80; 40BCrl0.

Chemical compositions of the three materials, determined by spectrographic analyser SPECTRUM as shown in table 1, and the HB hardness values of the same material, are given in table 2.

Table 1

Chemical composition of materials used in experiments test pieces

Material	Chemical composition, [%]								
	Fe	C	Mn	S	P	Si	Cr	Mo	B
OLC45	97.9	0.47	0.66	0.025	0.01	0.30	0.18	0.03	-
90VMoCr180	78.3	0.92	0.98	0.03	0.012	0.96	17.4	1.12	-
40BCr10	96.6	0.41	0.62	0.038	0.035	0.35	1.2	-	0.003

Table 2

HB mechanical characteristics of pieces material used in experiments

Mechanical characteristics	Processed material		
	OLC45	90VMoCr180	40BCr10
HB	207	265	217

Processed sample pieces of stitching experiments were bushing type the following dimensions: outer diameter-52mm; inner diameter-25mm; sleeve length-24.5mm.

The inner cylindrical surface of the work piece has been machined parts before broaching, drilling and turning through the inner diametrical share φ24 + 0.210.

As objective functions represented performance parameters of the process of stitching the inner cylindrical surfaces, of quantities describing the processing accuracy of such surfaces and surface quality obtained respectively, it was opted to take the study of: circularity deviation of the circular cylindrical inner surface paperbacks; the inner cylindrical surfaces roughness processed by roughness parameter Ra; hardness in the surface layer of the inner cylindrical surfaces machined by broaching. Please note that the results measured in experimental research developed for the inner cylindrical surface finishing by broaching, were statistically processed in the computer system, using for this purpose the DataFit 6.1 software running under Microsoft Windows operating environment and provides a number of facilities. For further processing, the Microsoft Excel was used.

The experimental data results as the average of the values of the deviations from circularity Ac, to the data points considered are presented in table 3.

Table 3

The experimental data obtained by measuring the deviations from circularity, Ac

Experiment number	v_a [m/min]	A_c [mm]		
		OLC45	90VMoCr180	40BCr10
1	2	0.008	0.009	0.006
2	2.5	0.008	0.009	0.008
3	3	0.006	0.007	0.010
4	3.5	0.005	0.009	0.015
5	4	0.008	0.013	0.016
6	4.5	0.011	0.015	0.019
7	5	0.014	0.016	0.019

Mathematical forms of regression functions obtained with DataFit program and chosen as the best models dependence parameter values needle stitching cutting speed at will, for strings corresponding data obtained from experimental measurements carried out for the three materials studied, together with the values of the coefficients of the multiple regression R^2 are presented in table 4.

Table 4

Mathematical forms of $A_c=A_c(v_a)$ dependency

Material	Regression function	R^2
OLC45	$A_c=2.22\times10^{-4}\times v_a^3-4.76\times10^{-5}\times v_a^2-6.36\times10^{-3}\times v_a+1.96\times10^{-2}$	0.9286
90VMoCr180	$A_c=-1.11\times10^{-4}\times v_a^3+1.3\times10^{-2}\times v_a^2-4.57\times10^{-2}\times v_a+5.77\times10^{-2}$	0.9402
40BCr10	$A_c=-8.88\times10^{-4}\times v_a^3+8.71\times10^{-5}\times v_a^2-2.19\times10^{-2}\times v_a+2.22\times10^{-2}$	0.9854

The DataFit program allowed and plotting the data points and curve fitting response for each model Ac=A (Va). By exporting the results to Microsoft Excel of data processing with DataFit program was possible to trace in the same graph, the curves of mathematical models presented in table 4 for comparison.

The points plotted on the curves from figure 2 illustrate the corresponding responses of the models on the experimental points.

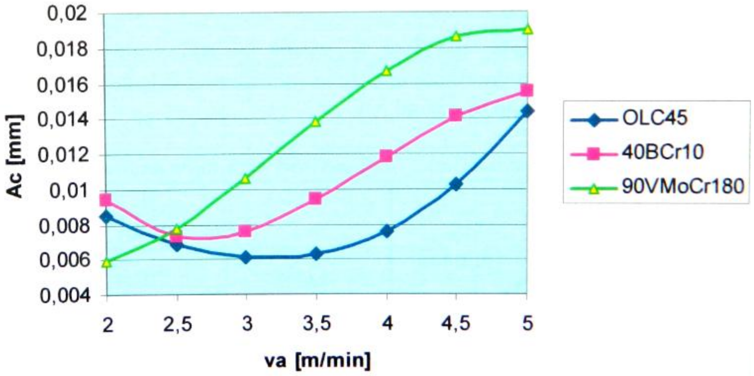

Fig. 2. The models curves Ac=Ac(Va) for the three studied steels

The results presented, allowed the following observations and conclusions on the influence of the working speed and processed material on the deviations from circularity for cylindrical inner surface broaching:

-for OLC45 steel were obtained minimum values of the deviations from circularity, by placing the working conditions within the range of Va = (3-3.5)m/min;

-for 40BCrl0 steel, resulting minimum values of the deviations from circularity, for value of work speed Va=(2.5÷3)m/min;

-for 90VMoCrl80 steel on the study of cutting speed values, resulted in a continued increase in deviations from circularity values.

The above conclusions can be explained by considering the fact that the processing of steels with higher mechanical properties, i.e.

cutting forces and dynamic loading are higher broaching machine, which leads to increased vibration size, especially with increasing speed work.

For 40BCrl0 alloy steel with mechanical properties only slightly higher than steel OLC45 have resulted in the lowest values of the deviations from circularity, thus highlighted good machinability of the material under the circumstances.

Significantly higher values obtained for deviations from circularity, if 90VMoCrl80 steel shows a smaller machinability of the material in the working conditions experienced in view here and qualities of the cutting tool or the spindle used.

CONCLUSIONS

The research was conducted as a pilot program based on the systemic analysis of the process of stitching the inner cylindrical surfaces that allowed highlighting the factors involved in the process and the selection of independent influence factors, which were subjected to research.

The aim was thus to determine the influence of experimental work speed and processed material on some objective functions represented by a series of performance parameters of the process of stitching the inner cylindrical surfaces, which describe the processing accuracy and surface quality obtained that were investigated influences on deviations from circularity of the inner cylindrical surfaces processed.

The program of experimental research has been carried out and then processed by stitching, three pieces of material evidence (OLC45, 40BCrl0 and 90VMoCrl80) equipment, devices and tools used for this purpose are chosen and carefully prepared to ensure clear results.

Also, the measurements of performance parameters studied were achieved by applying the appropriate methods and using modern devices, thus ensuring the quality of data collected.

It must be remembered here that the experimental data was performed under computer using programs (Microsoft Excel, DataFit) and special tools developed by the author for this purpose (spreadsheet in Microsoft Excel)

In terms of mathematical description of the influence of cutting speed, the deviations from circularity of parts processed by broaching were established functions depending dimensional form complex mathematical average of polynomial type of order 3 and order 6 in isolated cases of order 2 and 4.

The circularity deviations, Ac, of the inner cylindrical surfaces manufactured by broaching, within experimental investigations were within its overall (5-20) μm and between (5-14)μm for steel OLC45, between (7-16) μm for 40BCrl0 and (6÷19)μm for 90VMoCrl80 material.

The results of the research showed that with the increasing of mechanical characteristics of steel processed due to increased dynamic load broaching machine, effort and vibration in the system, resulting largely with increasing cutting speed value, the minimum point in the evolution of deviations from circularity moves to the lower values corresponding to the working speed.

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