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EXAMINATION OF MATERIAL REMOVAL PROCESS IN HONING

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Abstract: *The paper examines the possibilities of increasing of material removal rate of honing in case of use of superhard tools. Tool having superhard grains significantly increases performance of chip removal, technological process becomes more stable and the increase of tool life is meaningful. The author experimentally examined the effects of increase of grain size, cutting speed, tool pressure on changing of cutting time. The result of this is a two stage honing, in which the first stage assures removing of increased allowance, and the second stage is the final or fine stage which assures the realization of the prescribed accuracy and surface roughness.*
Keywords: *superhard tools, chip removal, honing, grain size, cutting speed, tool pressure, cutting time*

INTRODUCTION

Precision or finish machining procedures of high accuracy and good surface quality are used in automative industry (e.g. bores of cylinder and winch), bearing industry and in mass production of hidraulic elements.

The most frequent finish machining procedures of bores are: fine turning, fine drilling, broaching, reaming, fine grinding, honing (superfinishing), lapping, bore burnishing.

These procedures indispensable in machining of outer cylindrical, flat and shaped surfaces [1, 3, 4].

About the new research results of hard machining of hardened surface bores reported Kundrak [2]. Varga examines the features of diamond burnishing of outer cylindrical surfaces [4].

The primary aim of honing is

- *removing microgeometrical irregularities originating from the previous procedures,*
- *or removing the destructed surface layer which was evolved because of significant cutting forces and temperature set in machining,*
- *reduction of surface roughness,*
- *formation of micro scratch system which is favourable from the point of viev of tribology and lubrication.*

Further aim is working out of honed surface with prescribed macrogeometrical accuracy (dimension, shape, accuracy).

Very small value of allowance is removed in finish or fine honing, 2 $R_{max \cdot e}$ = 5-20 μm in each side. $R_{max \cdot e}$ is the maximum value of surface roughness made by careful cutting operation before honing. The obtainable average roughness is R_a = 0,09-0,02 μm.

Pre-honing, executed in between the finish or fine honing and the previous machining operation, of course, applies that type of tool and technological parameter, by which larger volume of material, and allowance can be removed.

This paper shows the results of newer research results of honing of bores, particularly detailing of material removal, economically removable allowance.

GRINDING OR HONIG OF BORES?

The technologist must decide in many cases and has to anwser the question above. Assuming that both machine tools are avaitable. We know the difficulties of grinding of bore, the small grinding spindle stiffness is the main problem, which limits the accuracy and material removal [1]. The Table 1 summarizes the comparison of the two procedures.

Symbols in table: d_f and d_s – bore and tool diameter, B_s – width of grinding tool, L_h – prism length, 1_f – bore length, a – the dept of cut, d_{eq} – equivalent bore diameter, n_h – number of columns, B_h – column width, d_s – grinding disc diameter.

Bore grinding equivalent bore diameter:

$$d_{eq} = (d_s + d_f)\ (d_f - d_s)^{-1} \qquad (1)$$

The Table 1 also shows the anwser that honing at low cutting speeds, low cutting temperature and design of the tool is there fore balanced and works *with equilibrium positions and radial cutting forces. Consequence of the foregoing: damaged, remove the surface layor being transformed and does not cause. Substantially similar changes in the surface layor.*

If the

$$l_f / d_f > 1 \quad (2)$$

then it is recommended to choose honing, if no other restrictions preclude.

Table 1. Comparison of methods

Characteristic	Grinding of Bore	Honing
cutting speed	$v_c \geq 25$ m/s	$v_c \geq 45$ m/min
tool diameter tool length	$d_f > d_s$ $l_f <$ or $> B_s$	$d_f = d_s$ (adjustable) $l_f \geq L_h$ (stroke adjustable)
ratio of bore length and diameter	$l_f / d_f \leq 1{,}5$	1,0…20
length contact of tool and bore	$i = (a.d_{eq})^{0,5}$; (small)	$i = n_h.B_n$; (large)
cutting temperature	> 700°C	< 120°C
characteristics of removed chips: length, form, temperature	short „mustache" shaped (melting, oxidation)	cast iron, hardened steel: broken short chip; soft, ductile materials: long continuons chip in cold state

INCREASING MATERIAL REMOVAL RATE OF PRE-HONING

If the allowance of machining should be increased, because of the amount of inaccuracies of machining before honing, then a two-stage honing is planed. Pre-honing provides the majority of separation, in this case the material removal rate should be increased. Following by finishing, or fine honing.

If the bore is measured directly in the plant or growth experiments, the data obtained can be used immediately. The accuraly diameter of bore can be measured in different ways: 3- point micrometer gauge; air gauge; while working built in air jets in the honing tool.

In experiments we used the first and third method. The honing material removal rate increase is possible in several ways important opportunities for increasing:

Machine tools:

- *chousing a machine to make it clear that a force – locking or shape locking to the die pressure adjustment and regulation;*
- *v_c cutting speed and p die pressure adjustment range;*
- *two – (pre – and fine honing) or multispindle machine tool needs;*

Tools:

- *choosing of best tool construction for workpiece;*
- *hon-tool - good, choise to the material being machined quality, grain size of the active formation;*
- *application of super-hard grain size, grain concentration, bond-material; etc.*

Technology data selection:

- *v_c cutting speed the right to establish and v_a axial v_t tangential components, increase the possibility of;*
- *p tool to increase the allowance pressure, economical tool wear of value;*
- *t honing time setting, taking in to account of the allowance amount;*
- *choose coolant fluid, ensure filtration and flow rate, compliance with fluid replacement time.*

The optimal solution when serial and mass manufacturing – the workpiece can be reached in this case, next to machine tools, tools and technology designed consistency of data. The so called universal honing machines fills individual and small series production needs, next to compromisation.

EXPERIMENTAL STUDIES

In order to favourable hedge in the technical data. I made honing experiments at University of Miskolc on a SzFS 63x315B type of machine tool. The machine features a range of test limits.

The experiment aims at examining the material removal rate. Mesured attributes: Δ detached allowance (diameter), R_a roughness (arithmetical mean deviation of the profile) and other surface parameters, H – cyrcularity error, Δ_s tool wear (radial direction). In the experimental tests v_c cutting speed, p tool pressure and t machining time was varied using a variety of synthetic, superhard grains tools. The figures 1 and 2 show the experiments according to the results of experimental work the presented experiments happened on bores made of cast iron materials (GG. 25, Hungarian norm, HB=170…240).

The tool pressure increasing, according to a linear equation, increases the material removal rate. The

Figure 1 ACB 160/125-100 %-M1 synthetic diamond grains-tool (8 x 100 mm, 3 parts) the pre-honing measurement results are shown, in the t honing time funtion. The Δ(t) detached allowance (diameter) after 10-15 s increases linearly. Increase is significant.

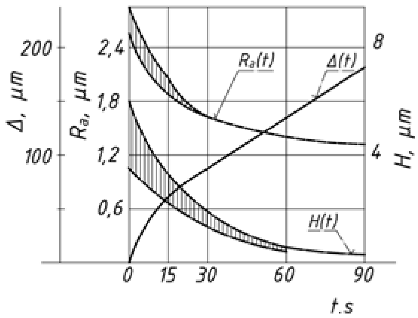

Figure 1. Pre-honing: t machining time changes depending on the important characteristics. Data: v_t=44 m/min; v_a=14 m/min; p=0,9 MPa; cooling lubricant: honilo 460.

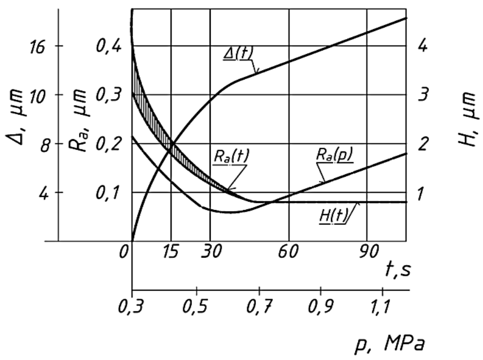

Figure 2. Finishing or fine – honing: t machining time and p tool pressure function changes and important characteristics. Data from the t – dependence curves: v_t = 40 m/min; v_a = 12 m/min; p = 0,5 MPa; Data from the p – dependence curves: t = 60 s, other data as described above.

The non-linear stage of careful machining and finishing a relatively high roughness, caused by the roughness peales of intense isolation.

The H(t) circularity error and $R_a(t)$ average speed decreased rapidly.

Figure 2 shows Δ(t) removed allowance (diameter), $R_a(t)$ and $R_a(p)$ average roughness change ACM 28/20-100%-M1 tool as the function of honing time t and tool pressure p.

Metal removal rate decreased by an order of magnitude. The surface roughness R_a = 0,09 µm decreased after t = 40–45 s. The $R_a(p)$ curve minimum place developed between t=32–36 s, where shows a value of R_a=0,07–0,08 µm. This value is a positive indicator for fine finishing or honing.

Futher experimental studies, some important results in the following: cast iron under optimized process conditions when working with a specific dramond use. ACB 160/125 és ACP 125/100, ACP 100/80, ACM 28/20 particle sizes (-100 %-M1) 0,05-0,07; 0.03-0,04; 0,02-0,07 mg/g I valued. These values are compared with international standards are very favorable.

I have established some important conclusions based on experimental results: on cast iron ACP 125/100; ACB 160/125 etc. when honing with particle sized tools high stock removal performance can be achieved, such as (100x8 mm, 3 parts) ∅42x65 mm bore in 60 s 0,4-0,5 mm (2 sides) allowance can be separated.

Improve the quality of the surface – reduced roughness R_a = 0,06-0,04 µm – with fine – gains tool (eg. ACM 28/20; 20/14-100 %-M1) can be ensused.

With hardened steel (100Cr6, Hungarian norm, HRC=60±2) compared to the previous ones less stock removal performance, but still can replace grinding of bore. The two – stage (pre-and fine) honing it is beneficial for use of burden-sharing tribology and lubrication or plateau honing process pre-honing is happened with a bigger graning tool and established high roughness peales with fine honing and a super-hard microdust material removal tool cumed at the development of the platform (Figure 3). The microdust's particle size 63…10 µm is anwsered in province. The surface of machined parts such as residnal crossing micro scrathes are excellent lubricant reservoirs, a fine platform, cross scrathes hydrodynamic lubrication system, to ensure long-term oil film formation. The Figure 3 illustrates the formation of micro-geometry of the workpiece surface while using plateau honing [7].

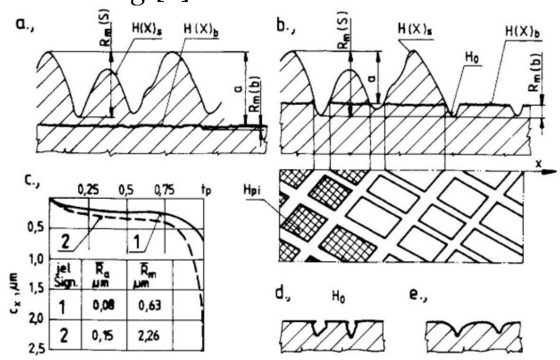

Figure 3. Microtopography after plateau-honing

The Figure 3/a and b, shows a detailed version of the roughness profile. The $H(x)_b$ profile. Int he case of a completeln int he case of b, only partly separated using pre-honing, the H_o double oil storage systems and H_{pi} platforms (plateaus) are converted. The d, and e, details show the H_o scratches-edge after using metal bonding, and bonded flexible tools (plastic, scratehes burssed edges, In, e case (flexible binder) it is rounded. The tool used in figure 3/c t_p relative bearing surface curves and the corresponding values R_a and R_m are shown. After pre-honing the curve 2. and the curve 1. after plateau-honing, the t_p support development of the specific length. The gauge: Perthometer 58 with FOCODY, laser detektor.

SUMMARY AND CONCLUSIONS

We have seen that material removal rate Q (mm^3/s) of the honing can be increased in several ways. This way the economically seperated margin can be increased. The superhard grain material, larges grain tools provide significant productivity and accuracy compared to traditional grain material tools.

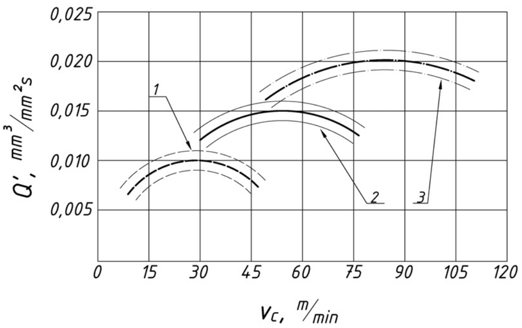

Figure 4. The different types of grain material honing tools Q′ specific material removad rate in the v_c cutting speed function. Symbols: 1-Al_2O_3, SiC; 2 – diamond; 3 – CBN

The tools have a high stability and life. During serial and mass production using these tools is economical. More specific metal removment rate increase, takes place by increasing the cutting speed and die pressure. Two-staged honing should be used. Pre-honing detaches a relatively large masgin, fine-honing decreases roughness and improves the surface and a combination of the two gives plateau-honing. Longer processing of the results of research work and literature (de Beers data, etc.) data allowed the approximate nature of the 1 – traditional grains (Al_2O_3, SiC, etc.); 2 – diamond, 3 – cubic = boron nitride – can be avaitable using grain material honing, a specific material removal rates Q′ ($mm^3/mm^2.s$) simplified mapping of the v_c cutting speed. This is shown in figure 4.

Using the CBN the material removal rate is more productive than using diamond grain tools. Increasing the particle size, increuses the material removal performance. The quality of the workpiece material, technical data and working conditions are different, therefore the a scattering is large as indicated in the figure. The v_c cutting speed range of modern machines towards higher speeds increased significantly [6] of course the adjustable p die pressure values are larger. The superhard particle material and those developed metal bonding (tin-bronze, nickel, etc.) makes this possible. Required to do so: large cutting speed and larger tool pressure insured honing machine, automotive honing machine and new tool constructions and procedures [3,5,6].

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