A FELÜLETVASALÁS FELKEMÉNYEDÉSRE GYAKOROLT HATÁSÁNAK VIZSGÁLATA

EXAMINATION OF THE EFFECT OF SURFACE BURNISHING PROCESS ON HARDENING OF PHENOMENON

Ferencsik Viktória, egyetemi tanársegéd
Dr. Varga Gyula, egyetemi docens

ABSTRACT
This paper deals with the examination of changing of surface micro-hardness caused by diamond burnishing process. We examine how the different technological parameters of burnishing, such as the feed rate, speed and the burnishing force have effect on hardening of phenomenon for a lower (EN AW-2011) and a higher hardness (hardened C60) material. The experiments we designed and executed using full factorial experimental design method.

1. INTRODUCTION

During recent years, considerable attentions are being paid to the post finishing operations, such as burnishing process. The aim of this process is to achieve a surface quality with appropriate roughness, micro-hardness, wear and corrosion resistance [1-2]. Moreover, it improves resistance against fatigue strain by causing residual stress in the subsurface area which can be one of the quality requirements in industrial practice [3].

To design and execute the experiments of burnishing of external cylindrical surfaces, full factorial experimental design method [4-5] was chosen which is an active, effective experimental technique and the purpose of it is to determine function relationship between dependant and independent variables that are called factors, which can take more levels. In the present experiment the examined parameters, so the independent variables were the burnishing force (F), feed rate (f) and burnishing speed (v_b) for two types of material: C60 hardened steel and EN-AW-2011 low alloyed aluminium.

Measuring of the surface micro-hardness of the specimens was realized with Wilson Instruments Tukon 2100B measuring equipment in Vickers hardness.

2. BURNISHING OF EXTERNAL CYLINDRICAL SURFACES

In burnishing, the working part of the tool is pressed under a force onto the workpiece surface and this pressure is generated by the ball exceeds the yield point of the softer piece part surface at the contact area, resulting plastic deformation on the surface structure [2, 6-7]. The range of this deformation and as the hardening layer of the material is quite high, and changes in the structure of the surface layer occur at a significant depth [8].

The operation was performed with PCD spherical burnishing tool with 3.5 mm radius, attached to a CNC lathe produced by firm OPTIMUM type OPTIturn S600. This lathe was installed in the workshop of the Institute of Manufacturing Science at the University of Miskolc. The lubrication was solved by manually and the applied oil's kinematic viscosity was 70 mm^2/s. The practical implementation can be seen in Fig. 1.

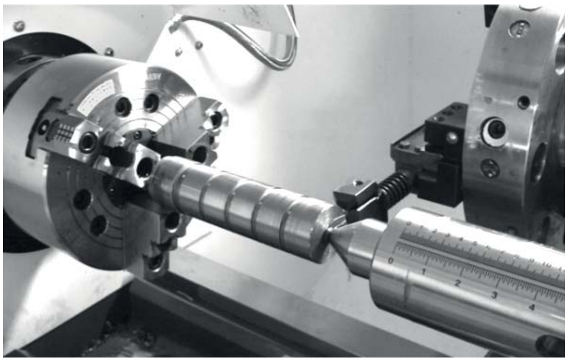

Figure 1. Executing of burnishing process

This process is applied in machine-building, automotive and aircraft industries in machining of various sorts of materials. For the experiments low alloyed aluminium and C60 hardened steel was chosen in order to compare the process applying in a low and higher density material.

3. EXPERIMENTAL CONDITIONS

3.1. Burnishing parameters

The effect of different burnishing parameters (burnishing force, feed rate, burnishing speed) on heat-treated steel [9-13] and on aluminium alloy workpieces [14-18] was investigated by many researchers.

To obtain the optimum value of these parameters for these two kinds of materials, require many experiments.

Based on literature review and preliminary experiments different values were determined for hardened steel than the low alloyed aluminium which was also justified by the difference in density between them.

The matrixes of these are shown in Table 1 that contains the pre-experimental testing parameters for both the natural and transformed dimensions.

Table 1. Applied burnishing parameters

C60

No.	Burnishing parameters			Transformed parameters		
	F [N]	f [mm/rev]	v [m/min]	x_1	x_2	x_3
1	50	0.05	40	-1	-1	-1
2	100	0.05	40	+1	-1	-1
3	50	0.1	40	-1	+1	-1
4	100	0.1	40	+1	+1	-1
5	50	0.05	80	-1	-1	+1
6	100	0.05	80	+1	-1	+1
7	50	0.1	80	-1	+1	+1
8	100	0.1	80	+1	+1	+1

EN AW-2011

No.	Burnishing parameters			Transformed parameters		
	F [N]	f [mm/rev]	v [m/min]	x_1	x_2	x_3
1	10	0.001	15	-1	-1	-1
2	20	0.001	15	+1	-1	-1
3	10	0.005	15	-1	+1	-1
4	20	0.005	15	+1	+1	-1
5	10	0.001	30	-1	-1	+1
6	20	0.001	30	+1	-1	+1
7	10	0.005	30	-1	+1	+1
8	20	0.005	30	+1	+1	+1

3.2. Measuring of surface micro-hardness

The applied measuring equipment - Wilson Instruments Tukon 2100B - has the same measuring principle as all other hardness measurement equipment. It examines how a material is subject to plastic deformation by using a standard force. In this investigation a 136° diamond pulley is pressed with a specific force, 10 N for 10 seconds on the surface for both materials to be measured on 3 points with 120° rotation. Fig. 2. shows a measuring state during measurement.

Figure 2. Executing of measuring process

4. RESULTS

For evaluation of measured data improvement ratios were introduced, which are shown in formula (1) and (2):

$$\rho_{HV} = \frac{HV_{after}}{HV_{before}} \tag{1}$$

$$\rho\% = (\rho - 1) \cdot 100\% \tag{2}$$

, where:

- ρ_{HV} Improvement ratio of surface micro-hardness (HV). This is a dimensionless ratio, which textures the changes occurring because of manufacturing,
- HV_{after} Surface micro-hardness remain after burnishing,
- HV_{before} Surface micro-hardness before burnishing,
- $\rho\%$ The percentage value of the improvement ratio.

The higher the values of ρ_{HV}, the greater the improvements due to burnishing.

The measured data and the calculated improvement ratios are summarized in Table 2.

Table 2. Measured values and calculated improvement ratios

No.	HV_{C60} Before	HV_{C60} After	ρ_{C60} [%]
1	882.4	985.5	**11.68**
2		914	**3.58**
3		977	**10.72**
4		1059	**20.01**
5		1024	**16.05**
6	883	860	**-2.60**
7		832	**-5.77**
8		854.5	**-3.23**
No.	$HV_{EN\ AW\text{-}2011}$ Before	$HV_{EN\ AW\text{-}2011}$ After	ρ_{EN} [%]
1	160.7	169.3	**5.35**
2		180.3	**12.19**
3		160	**-0.44**
4		162	**0.81**
5		181	**12.63**
6	162.7	170	**4.49**
7		158	**-2.89**
8		170	**4.48**

Application of Factorial Experiment Design method empirical formulas (3) and (4) were determined from the calculated values. Calculations and axonometric figures (Fig. 3-4) were created by using MathCAD software.

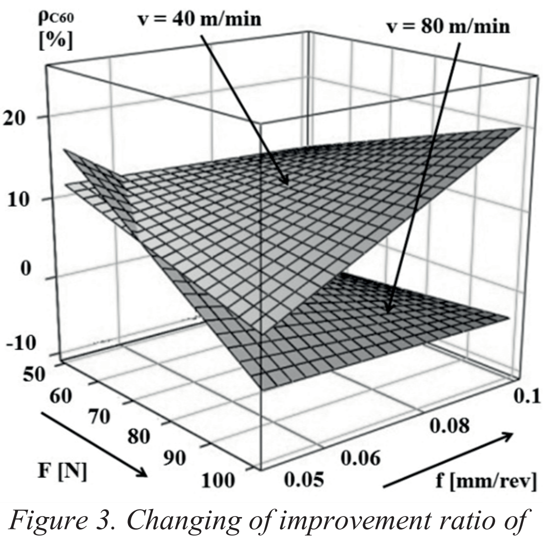

Figure 3. Changing of improvement ratio of C60 surface micro-hardness

$$\rho_{C60} = -1.45 - 0.223 \cdot F + 126.2 \cdot f + +0.989 \cdot v + 5.436 \cdot F \cdot f - 7.175 \cdot 10^{-3} \cdot F \cdot v - - 12.33 \cdot f \cdot v + + 0.038 \cdot F \cdot f \cdot v \quad (3)$$

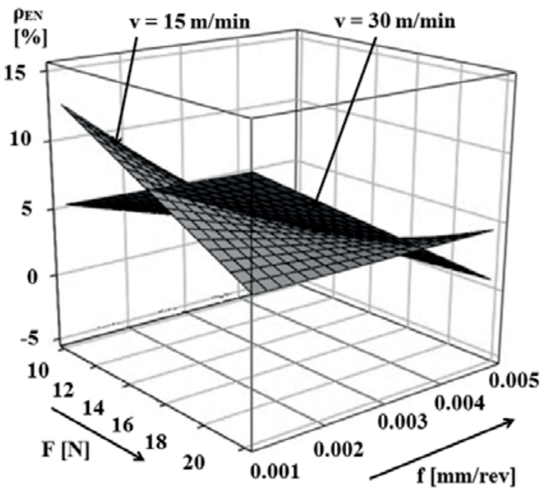

Figure 4. Changing of improvement ratio of EN AW-2011 surface micro-hardness

$$\rho_{EN} = -31.408 + 2.849 \cdot F + 7.657 \cdot 10^{-3} f + +1.998 \cdot v - 667.25 \cdot F \cdot f - -0.135 \cdot F \cdot v - 513.833 \cdot f \cdot v + 35.167 \cdot \cdot F \cdot f \cdot v \quad (4)$$

5. SUMMARY

The paper deals with the investigation of diamond burnishing process on hardened steel and low alloyed aluminium cylindrical components. The purpose of this study was to determine how the chosen burnishing parameters have effect on the changing of surface micro-hardness. The experiments and the evaluation of the measurement results were performed by using the full factorial experimental design method. According to the measured, calculated and illustrated results the following conclusions can be stated:

- In case of hardened steel among the examined parameters, the effect of feed rate is the most dominant and it has a strong interaction with the burnishing speed; parameters that resulted the most favourable surface micro-hardness were follows:
  F = 100 N
  f = 0.1 mm/rev
  v = 40 m/min
- In case of low alloyed aluminium also the influences of feed rate and force are significant and higher improvement was caused by the application of these burnishing parameters:
  F = 10 N
  f = 0.001 mm/rev
  v = 30 m/min

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