The Investigation of Operating Properities of the Surface after Hammering

T. Barski, Institute of Technology in Opole, Poland

Introduction

Vibratory burnishing also known as hammering is one of uncommon and rarely applied methods of surface treatment as regards cold work. This process is aimed at improving exploitation proper - ties of the surfaces subjected to the treatment and is applica-ble in hardening of pivots, shafts, arbors and the like.
The essence of this method lies in hammering succeeding frag - ments of the treated surface area by means of a burnisher set in vibrations of the definite amplitude. The stereometry of the surface being under the treatment is determined by the shape of the burnisher's tip as well as by the treatment parameters. Specific feature of the surface that has been subjected to ham-mering is a regularity of recurrence of micro-unevennesses which differ, however, in form and spacing-from those produced in the course of turning or grinding (1 - 2).
For several years now, the investigations on the operating pro-perties of the surface after vibratory burnishing have been car-ried out in the Institute of Technology in Opole, Poland.

The Test Stand

A stand for shaft burnishing test used in the investigation is shown in Fig. 1.
The workpiece / 1 / is fixed in the lathe chuck. The burnisher's / 2 / strokes against the workpiece are induced by forced vi - brations from a pneumatic hammer / 3 /. Required frequency and impact force values are obtained by changing the air pressure conveyed from the compressor /4 /. A static thrust force of the burnisher is provided by the hydraulic servomotor / 5 /. The readings of the pressure produced in the servomotor are taken from the manometer / 6 /.
In the test an optimum - for its service facility and economy - pneumatic hammer was employed /type: 0035, GDR make/.
Burnishing elements were made of nickel-chromium steel NC6 /Po-lish Standard/, the working tip being of a spherical shape.
In the preliminary tests flat and spherical surfaces of the working tips were used of 10; 15; 20 mm and 5; 7,5; 10 mm in diameter respectively. The way of fixing the pneumatic hammer on-to the lathe / TUM / is shown in Fig. 2.
In order to estimate precisely the value of the burnisher's impact force against the workpiece a hydraulic gauge was used, serving for measuring the pressure induced by the static and dynamic force. The indication error of a unitary pressing force, as established experimentally, never exceeded 5 per cent /of the indicator oscillation/.

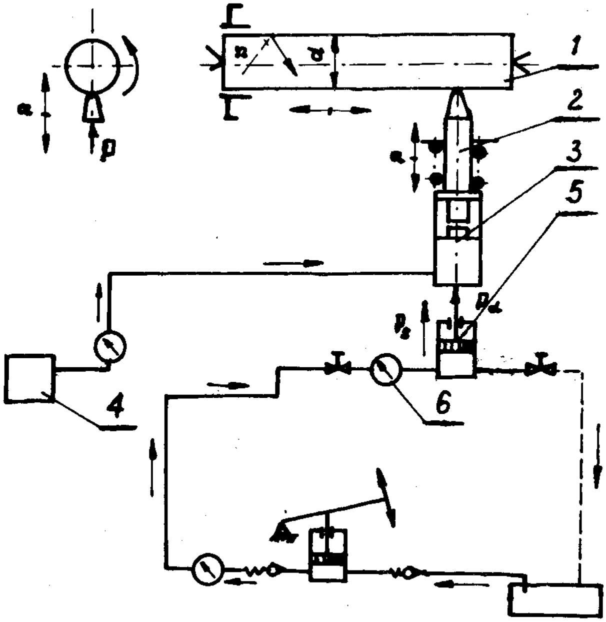

Fig. 1: The test stand.
P_s - static force, P_d - dynamic force.

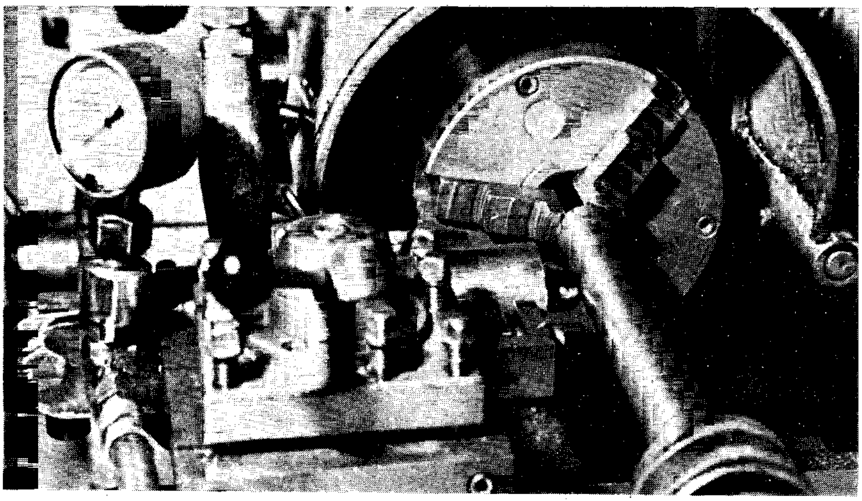

Fig. 2: The way of fixing the pneumatic hammer onto the TUM - 25 lathe

The course and results of the investigation

The tests were carried out on carbon steel 55, cylindrical test pieces Φ30x200 mm with three separate measure areas 50 mm long each. Their surfaces were finish turning machined to obtain the initial roughness R_a = 0,9 μm and then hammered.

The range of changes in the treatment parameters was esta - blished on the basis of preliminary tests and comprises the va - lues as shown below:

- longitudinal feed p= 1; 1,5; 2 mm/2π rad,
- speed of burnishing v= 0,04; 0,06; 0,08 m/s,
- impact force P= 120,3; 207,4; 294,5 N.

The burnishing was performed in one pass only, since the next ones hardly improve the surface hardness but considerably impair the obtained surface layer quality by causing skin lamination and formation of micro - cracks.
In the fundamental test there was used an optimum, spherically tipped /R = 7,5 mm/ burnishing element that enables to obtain a surface of the best properties(2). In order to determine the influence of the treatment parameters /P,p,v/ on the surface roughness / R_a / and on value of diameter plastic strain /Δ d / / Fig. 3 / a statistic method of experimental design was here applied - plan 3^3 type /three parameters changed on three le - vels /.

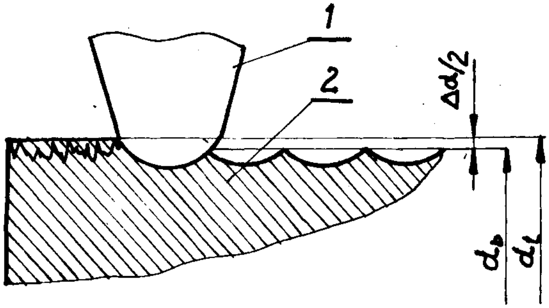

Fig. 3: Value of diameter plastic stain /Δ d /
1 - burnisher, 2 - workpiece

The final measurements of the surface roughness and change of diameter were made by means of a profile measurement gauge KALIBR 201 and ABBE vertical metroscope respectively; the la - tter being measured with an accuracy of ± 1 μm.
The 3^3 type design of experiments resulted in obtaining the fol- lowing relations /Equ. 1, Equ. 2/:

$$R_a = 0,852 - 0,002P + 0,254p + 3,405v - 0,00007Pp - 0,003Pv + 0,3pv + 0,000002P^2 + 0,1p^2 + 42,5v^2 \qquad \text{Equ. 1}$$

$$\Delta d = 120,69 + 0,2P - 98,199p - 1982,4v - 0,011Pp - 50pv - 0,00004P^2 + 32,86p^2 + 16520v^2 \qquad \text{Equ. 2}$$

The investigation shows that together with an increase of:

- force P, surface roughness decreases/ surface quality improves / up to the value P where skin lamination occurs.
- longitudinal feed p, surface roughness slightly increases up to the value p where unburnished spots occur / over 2 mm/2πrad /.
- speed of burnishing v, surface roughness increases too.

The best results as for surface quality / R_a = 0,26 µm / using carbon steel 55 were obtained with the impact force value P = 276,8 N when spherically tipped / R = 7,5 mm/ burnisher was used.

References

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