

SURFACE FLATNESS CONTROL IN SINGLE PLATE LAPPING

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Abstract: Flatness of an active surface of the lap has an essential influence on the shape accuracy of lapped surfaces. Profile wear of the tool is not uniform along the radius because of the kinematics of lapping process. Changing the kinematic parameters, e.g. rotational velocity of the lap or position of the conditioning rings together with the workpieces can be used for correcting the profile of an active surface of the lap or for obtaining required convexity or concavity. This paper presents results of a study into the influence of conditioning rings positioning on the wear of the lap as well as the influence of the shape of an active surface of the lap on the flatness of lapped surfaces. Vickers impressions were the bases for measuring the profile wear of the tool and the optical method, based on fringe pattern analysis, was used for measuring the shape of lapped surfaces.

Keywords: flatness, lapped surface, fringe pattern analysis

1 INTRODUCTION

Fine surface finish and high dimensional accuracy can be obtained in lapping with the use of relatively simple means of productions. Geometrical structure of the lapped surface has good properties in sliding joints - the valleys in the surface roughness of the contacting bodies can serve as local reservoirs for lubricants. The quality and efficiency of lapping depend on many factors related to the lap (a tool used in lapping), lapping machine and kinematic parameters [1-4]. During the process, both surfaces: active surface of the tool and the surface of the workpiece change the shape due to their wear (Fig. 1). Changing the kinematic parameters, e.g. rotational velocity of the lap or position of the conditioning rings together with the workpieces can be used for correcting the profile of an active surface of the lap.

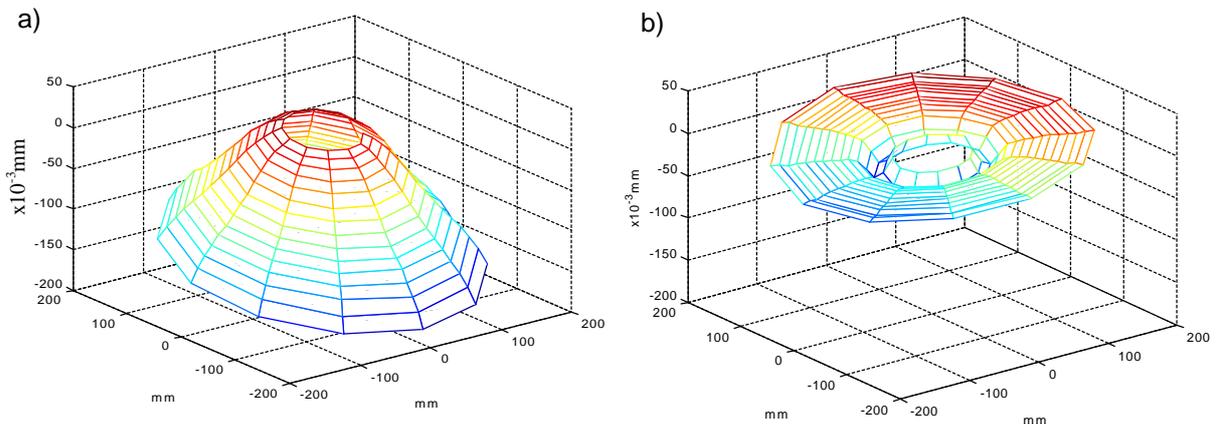


Figure 1. Examples of convex (a) and concave (b) laps obtained in single-plate lapping

2 EXPERIMENTAL PROCEDURE

Experiments were carried out on the single-plate lapping machine (Fig. 2). Placed in separators workpieces of £H15 are loaded against a rotating lap and rotate together with conditioning rings. The rotational velocity of the lap was set to $n_l=50$ rpm, and the rotational velocity of conditioning rings n_s depended on their placement on the lap (different friction forces). Abrasive particles (silicon carbide 99C F800/7) were introduced drop by drop with a base mineral oil into the contact region between the workpieces and the lapping tool. The influence of the conditioning rings positioning on the tool wear, was checked for their three positions: a) central position (Fig. 3a and 3b) moved 11 mm towards an outer diameter of the tool, c) moved 9 mm towards an inner diameter of the tool (Fig. 3b).

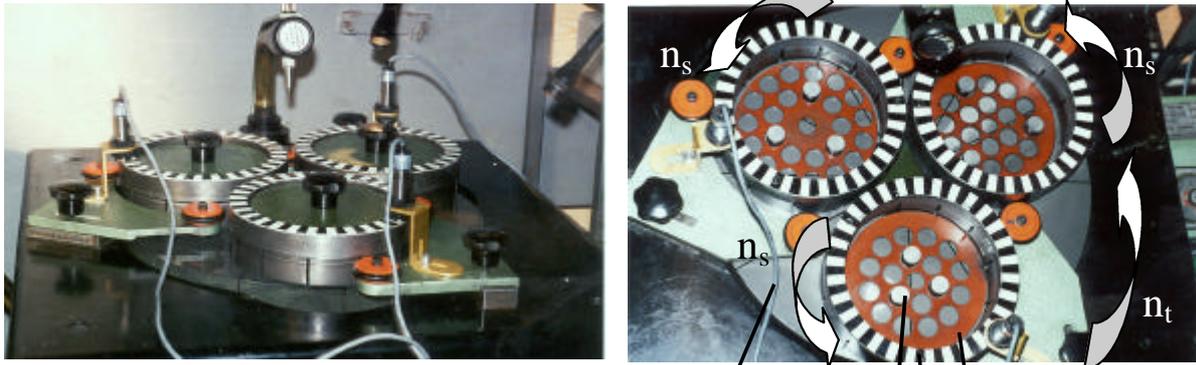


Figure 2. Single-plate lapping machine: general arrangement

a)

b)



Figure 3. Positions of the conditioning rings: a) central position on the lap, $R=115$ mm, b) moved 9 mm towards an inner diameter of the tool – inner position, $R=106$

3 RESULTS OF EXPERIMENTS

3.1 Wear of the lap

Vickers impressions were the bases for measuring the profile wear of the tool [1,2]. Impressions were obtained along the radius on an active surface of the lap. The zero reference line was assumed in the first measurement of Vickers impressions. The difference in the depth of impressions after lapping during time t is a measure of the wear W_i :

$$W_i = h_B - h_i \tag{1}$$

a)

b)

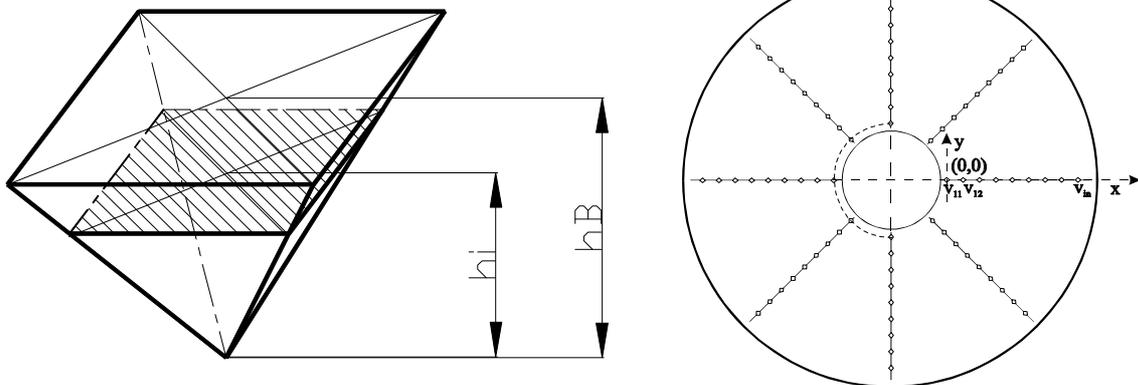


Figure 4. Measurement of the profile wear: a) change in the depth of the impression after lapping, b) bases location on a lap

Positions of conditioning rings filled with workpieces have considerable influence on the tool wear. Changing their location on an active surface affects the tool wear in a specific region as it is seen on Figure 5 a-d. The maximal wear rate near the inner diameter was recorded for the inner position (Fig. 5a and 5b). Wear rate increases in the area of the outer diameter when conditioning rings are moved towards this region (Fig. 5c and 5d). The tendency is similar for both types of initial surfaces before tests - convex (Fig. 1a and Fig. 5) or concave (Fig. 1b and Fig. 6). Obtaining particular convexity or concavity can be controlled by choosing appropriate kinematic parameters.

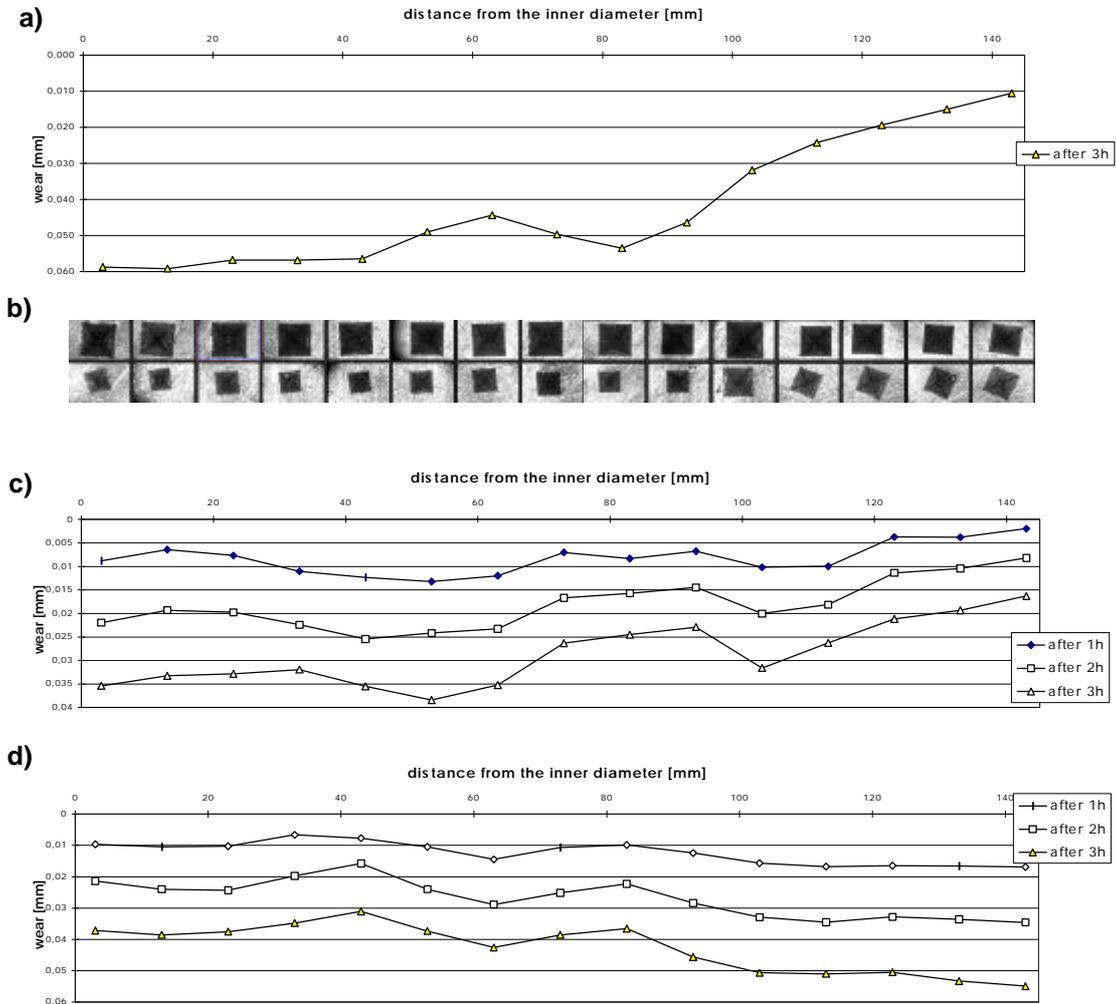


Figure 5. Influence of conditioning rings and loaded workpieces on the tool wear for: **a)** inner position, $n_s=53$ rpm; **b)** first row – impressions before testing, second row – impressions after 3h of testing for inner position; **c)** central position, $n_s=43$ rpm; **d)** outer position, $n_s=20$ rpm; initial shape on Figure 1a

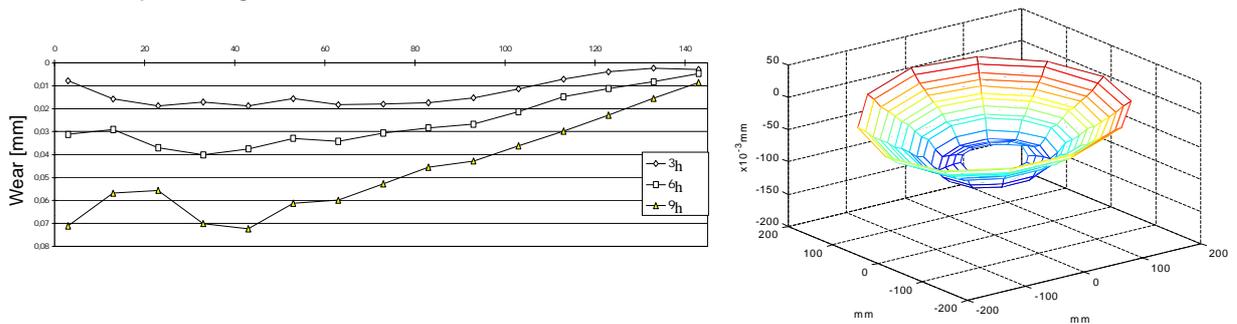


Figure 6. Influence of conditioning rings on the tool wear for: **a)** inner position, **b)** final profile with high concavity; initial shape presented on Figure 1b

3.2 Flatness of lapped samples

Optical method was used for measuring the shape of lapped surfaces. Fringe analysis refers to the full reconstruction to the original shape represented by a fringe pattern (Fig. 7). Kinematic parameters and the shape of an active surface of the lap have the main influence on the flatness of lapped surfaces. Convex surface was obtained by lapping on a concave tool (Fig. 7b). The surface with concavity in the middle and convexity on the edges was obtained by lapping using convex lap.

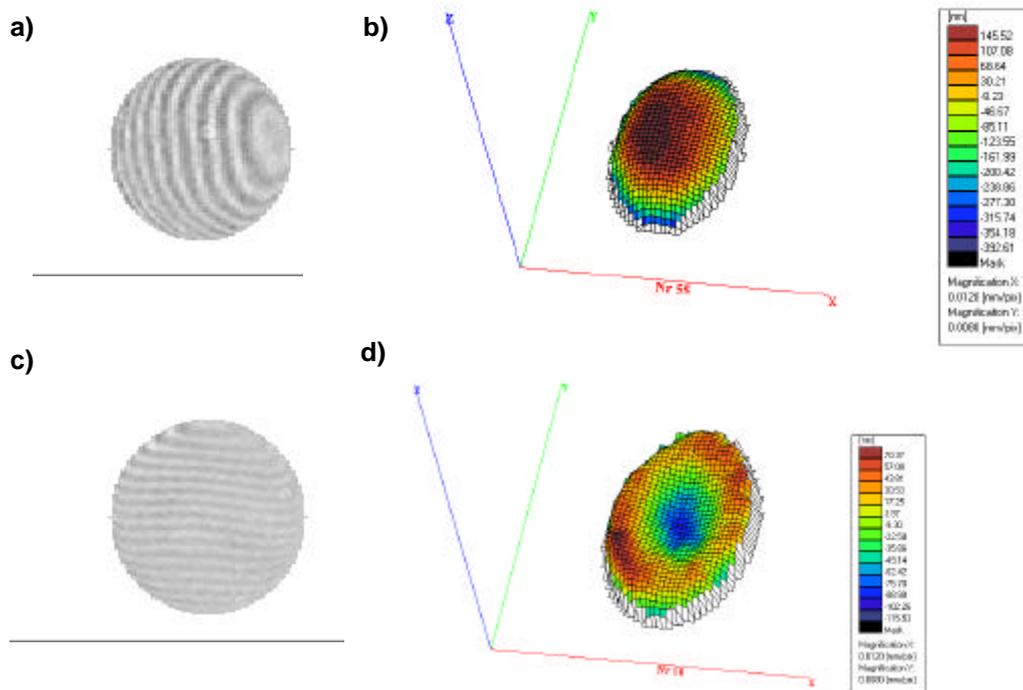


Figure 7. Shapes of samples after lapping on different tools: fringe pattern (a) and data 3-D plot of measured shape (b) obtained on a concave tool presented on Fig. 6b; fringe pattern (c) and data 3-D plot of measured shape (d) obtained on a convex tool presented

4 CONCLUDING REMARKS

Flatness of an active surface of the lap has an essential influence on the shape accuracy of lapped surfaces. Profile wear of the tool is not uniform along the radius because of the kinematics of lapping process. Appropriate kinematic conditions can be chosen in order to correct the flatness error of the lap – e.g. by changing the position of the conditioning rings. Determination of the acceptable range of the flatness error of the tool as well as obtaining the required shape of lapped surfaces – convex or concave, will be the next step of a study into the influence of the working surface state on the quality of the lapped surface. Vickers impressions obtained along the reference line can be used as the bases for profile wear measurement.

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