LAPPING OF FLAT SURFACES WITH TWO-METALLIC TOOLS

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1. Introduction

Lapping is one of the most common finishing operation used on flat or cylindrical surfaces. 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, as well as in stationary joints because of the high bearing ratio. Elements of this machining system are characterised be the set of many structural, material and surface properties connected with the workpiece, lap, abrasive particles and the lapping machine. The lap – a tool used in lapping – has an essential influence on the dimensional and shape accuracy [6,7,13].

Lapping and polishing using loose abrasive are classified as the basic finishing operations. These technologies can be used on metallic parts, as well as on non-metallic machine elements, mainly on engineering ceramics which have found use in many engineering applications. There is no limitation on material which can be lapped or polished [1,4,5]. Metallographic sections belong to the wide range of their use. Multi-directional lay, low temperature of the process, relatively low unit pressure and lapping speed help to obtain high dimensional accuracy and fine surface finish. The quality and efficiency of lapping depends on many factors connected with the lap, lapping machine and test conditions. Free charging with abrasive [8] (the abrasive particles become embedded in the lap during lapping - conventional lapping), as well as machine forced charging before lapping [9] can be done on an active surface of the tool.

2. Lapping with tools of cast iron freely charged with abrasive

This method of machining, apart from many advantages, has an essential disadvantage related to the abrasive contamination mainly of the soft materials or soft structural constituent The abrasive contamination of the surface layer is damaging during the operating period and causes increasing abrasive wear of elements in sliding joints [2,3]. When the abrasive compound is dosed periodically, the material removal rate decreases quite rapidly. Introducing abrasive grains of different numbers (size) intensifies the material removal but it also affects the quality of the lapped surface.

The probability of breaking the grains up increases with the increase in the micrograin size, under the constant load and abrasive particles concentration. In order to ensure the one-layer distribution of the large number micrograins it is necessary to reduce the abrasive particles concentration on the active surface of the lap and in turn abrasive particles crushed under the higher unit pressure and the material removal rate decreases. When the abrasive is supplied from the paste of abrasive compound periodically, the removal rate and the surface roughness decrease due to the crushing of micrograins and the charging of the active surface of the lap with abrasive stabilises in the final phase of lapping.

3. Lapping with two-metallic tools

Good abrasive properties of two-metallic laps could be explained by the fact that the micrograins supplied on an active surface get an adequate angular acceleration what makes the machining more intensive, then they penetrate the tool surface and eventually become embedded in the softer material. Material can be removed by particles embedded in the lapping plate as well as by rolling grains [10]. Two-metallic tools of cast iron-copper and cast iron-steel were used in lapping experiments and a monometallic lap of cast iron was used for comparison experiments. The main frame of tools made of Z_s50007 cast iron (183 HB) and metallic inserts of 45 steel (387 HB) and MOOB copper (80 HB) were joined together with glue. Surface area of metallic inserts took 50% of an active surface of the tool (Fig.1 and 2). The highest removal rate was observed for cast iron-steel lap and the lowest for monometallic lap. The results of testing on two-metallic tools show that material removal increases considerably with the increase in unit pressure and lapping speed (Fig.3). This is the results of deeper penetration of the workpiece surface by abrasive particles and the results of the change in the dynamic interaction of abrasive. Also the higher the relative speed in the lap-workpiece system is, in the period of time, the longer the cutting trajectories are. The higher material removal rate was also recorded during experiments performed on samples of NC6 steel using cast iron-steel lap. The same is true for experiments performed on samples of Z_s55003 cast iron, however the use of cast iron-copper lap for relatively hard samples of NC6 steel is not as effective. The lowest surface roughness was obtained for cast iron-copper tool and the highest roughness for cast iron-steel lap.

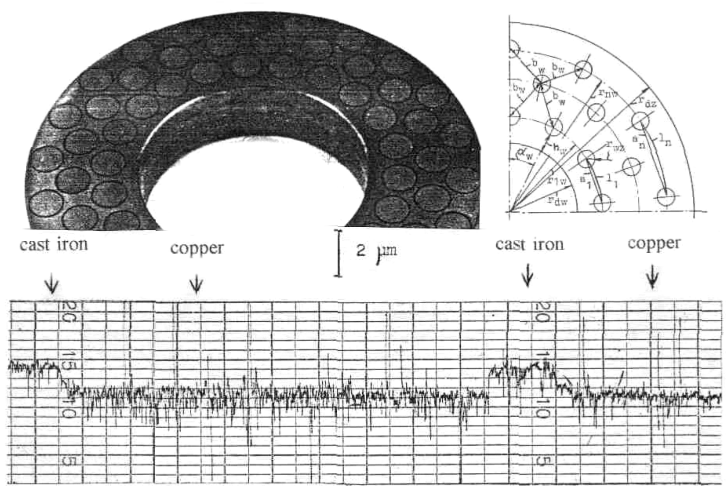

Fig.1. Construction of two-metallic lapping tools

4. Lapping with abrasive-metallic toools

Abrasive particles are introduced into the contact region between the workpiece and the lapping tool drop by drop or periodically when monometallic and two-metallic laps are used. Some of micrograins are removed from the active surface of the lap by moving workpieces and separators and they do not take part in machining. Particles are usually dosed excessively in practice. Taking into accounts conditions of conventional lapping, promising approach to lapping is to utilise non-conventional constructional solutions of lapping tools [11,12].

An abrasive-metallic lapping plate is one of the examples. Only cutting fluid (based on machine oil and kerosene) is dosed on the tool during lapping. The main frame of the tool is

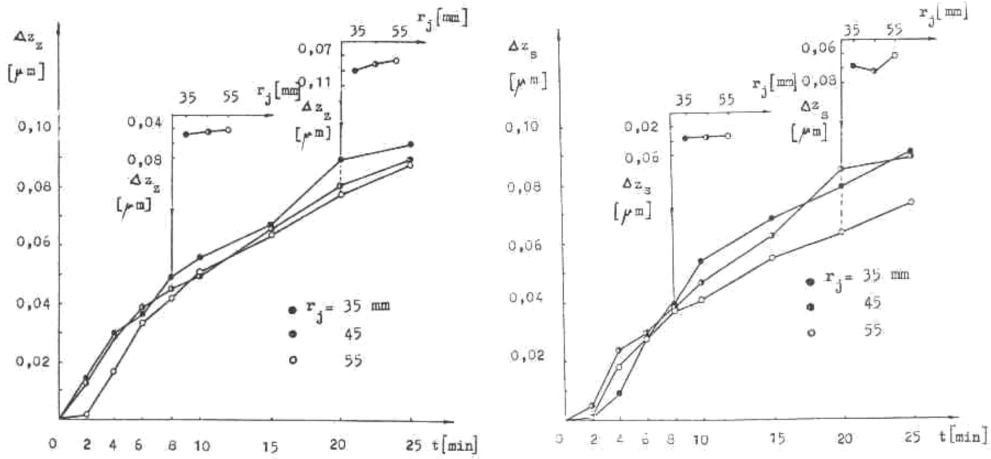

Fig.2. Wear (for r_j diameter) of two-metallic lapping tools (_z_Z – Z_S50007 cast iron, _z_S – 45 steel) at machining of cast iron Z_S55003 (99C F400/17, p=0.23 MPa., v=0.15 m/s)

made of Zl250 cast iron (191 HB) with ferritic-perlite matrix. In the first version of the tool, abrasive inserts consists of silicon carbide or aloxite grits and are located on the active surface symmetrically. Their contours can be rectangular or circular. In the second version, circular abrasive inserts consist of BC 400 micrograins mixed with electrographite or copper micrograins and epoxy resins. The effect of using abrasive-metallic laps based on the 99C F320/29 abrasive (hardness J) is shown in Fig.4. The material removal rate is twice as high as in conventional lapping but the quality of lapping decreases – surface roughness is lower. Designed abrasive-metallic tools are characterised by the possibility of using cutting ability of particles from the worn inserts. The active surface of the cast iron frame can be charged with these micrograins. The proper selection of inserts characteristic can make easier the optimisation of lapping what is very important especially when superhard grits are used due to the high cost.

5. Conclusion

The results of testing enable formulation of the following conclusions:

- higher material removal was recorded for conventional lapping but machine forced charging of laps with abrasive makes possible obtaining the surface roughness lower
- using two-metallic laps, the highest removal rate was observed for cast iron-steel tool, and the lowest surface roughness was obtained for cast iron-cooper lap,
- the high rate of material removal was achieved when metallic tools with abrasive inserts were used but the quality of lapping decreased as compared to surface roughness obtained in conventional lapping.

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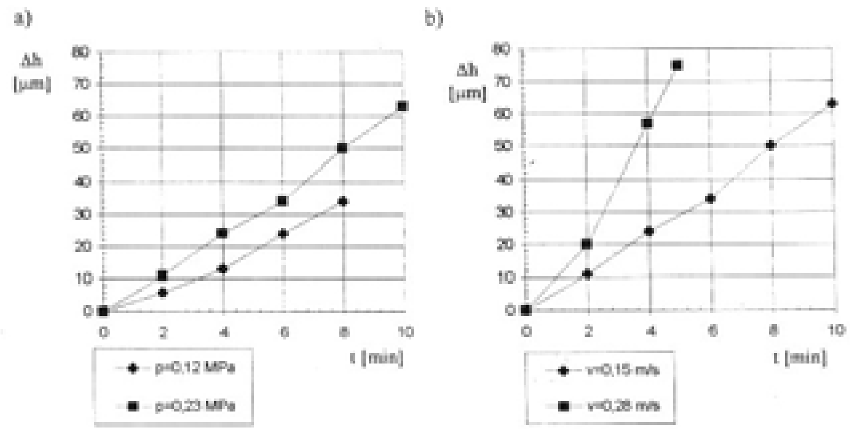

Fig.3. Material removal rate as a function of time for lapping of: a) cast iron Z_s55003, v=0.15 m/s, b) steel NC6, p=0.23 MPa; test conditions: forced charging with abrasive of 99C F400/17, charging conditions: p=777 N/m, t=180 s, v=0.059 m/s

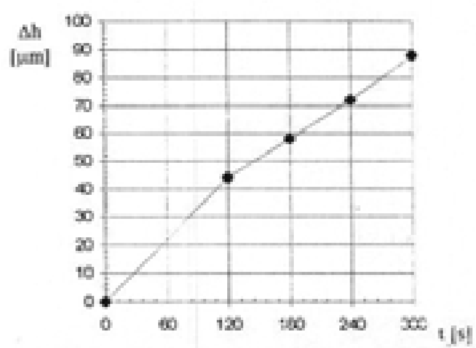

Fig.4. Material removal rate in lapping of NC6 steel using abrasive-metallic tools; test conditions: v=1m/s, p=0.169 MPa

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