DETERMINING THE CONDITIONS FOR TEMPERATURE MEASUREMENTS DURING FLAT LAPPING

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Abstract

Lapping is used in the production of components of the highest quality in terms of form finish accuracy and surface integrity. A number of precision manufacturing applications use lapping process as a critical technology to achieve thickness tolerance and surface quality specification. Because of required parts accuracy tool flatness is the key to the successful machining. To avoid its excessive thermal expansion, plate temperature research was taken.

This work presents a part of results concerning temperature measurements conditions. Experiments were being conducted during flat lapping with use of ABRALAP 380 lapping machine and infrared camera V-20 II produced by VIGO System SA. Firstly the influence of conditioning rings number on wheel temperature rise was investigated. It was proved that number of rings had a significant impact on temperature rise value and the highest were during machine working with all three rings.

Then another test was made, to simulate the work during real 8-hours shift. The aim was to determine time of machine working after which temperature would stop rising. Temperature was measure during Al_2O_3 (95%) elements lapping with use of silicon carbide grains. Tests results showed that after five hours temperature fluctuated around a certain value. In future analysis temperature after five hours lapping will be taken into account.

Keywords: *lapping, thermal measurement, lapping plate temperature, lapping parameters*

1. Introduction

Modern-day products are characterised by high-precision components. A wide range of materials, including metals and their alloys, ceramics, glasses and semiconductors, are finished to a given geometry, finish, accuracy and surface integrity to meet the service requirements. To satisfy those high requirements several machining techniques can be applied, among them is lapping.

Lapping is widely used in manufacturing of optical mirrors and lenses, ceramics, hard disc drive, semiconductor wafers, valve seats, ball bearings and many more parts. This type of machining is capable of providing high finish and accuracy of form without complex setup. It is carried out by applying loose abrasive grains between two surfaces and causing a relative motion between them resulting in a finish of multi-directional lay. In general one of the two surfaces is the surface to be machined which is called the work surface or workpiece and the other is the lap or plate surface (Fig. 1).

The most extensively used type of lapping process is flat lapping. Its goal is to achieve extremely high flatness of the workpiece and/or close parallelism of double-lapped faces. The other applications include removal of damaged surface and sub-surface layers and, enhancement of the surface finish on workpieces [1, 2, 4, 7].

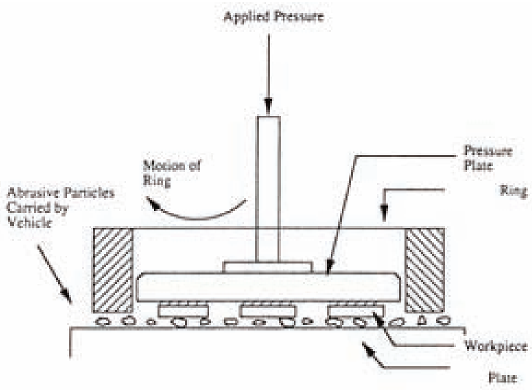

Fig. 1. Schematic diagram of free abrasive machining

2. Temperature importance in lapping process

The grains, workpiece, and lap are the three materials that take part in abrasion process, which occurs as a result of the relatively motion of the affecting partners. Among all grains supplied to the working gap, only a particular part is active (can roll or slide), which means it takes part in material removal process.

As the result of such grains work, the temperature of executory system elements increases. Many observations pertaining to the mechanical state of lapped surfaces have shown that the temperature rise at the interface between an abrasive particle and the work surface is small during lapping. Therefore, lapping is said to be a low temperature process.

Despite the temperature rise is quite low during lapping, it influences on plate flatness due to uneven heating over its surface and thus non uniform thermal expansion. Since lapped parts will take a mirror image of the wheel surface, the flatness of free-abrasive machining wheel is the key to the operation of FAM and therefore a temperature-resistant tool is an essential requirement.

Hence, today produced lapping machines have devices to carry away the heat generated during the process or to control lap plate temperature. It could be water-cooled system build in the plate (Fig. 2) or temperature control system or both. Older machines, still operated, haven't such equipment, so there is a need to find other solution to the problem of uneven plate thermal expansion [2, 6, 8-13].

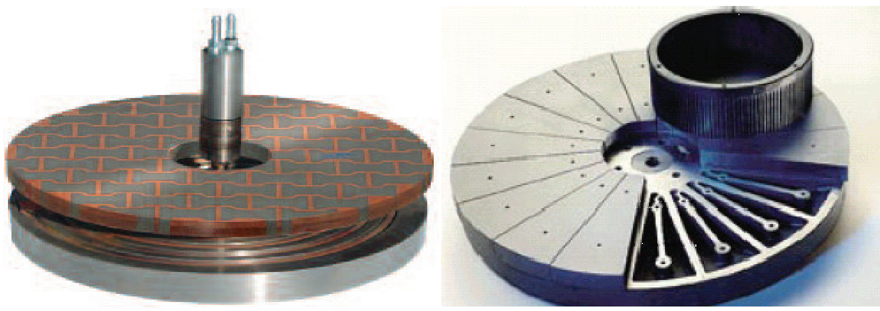

Fig. 2. Water cooled wheel; a) manufactured by LAMPLAN, b) manufactured by PETER WOLTERS [11, 12]

3. Lapping plate temperature measurement

To control thermal deformation of the lapping plate, the influence of basic lapping parameters on wheel temperature should be known. In the published literature there are very few works about lapping temperature. Hence, this is the goal of the research being conducted [2, 5, 6].

At the beginning measurements conditions should be determined. In order to do that, test apparatus showed in Fig. 3. was setup.

a) b)

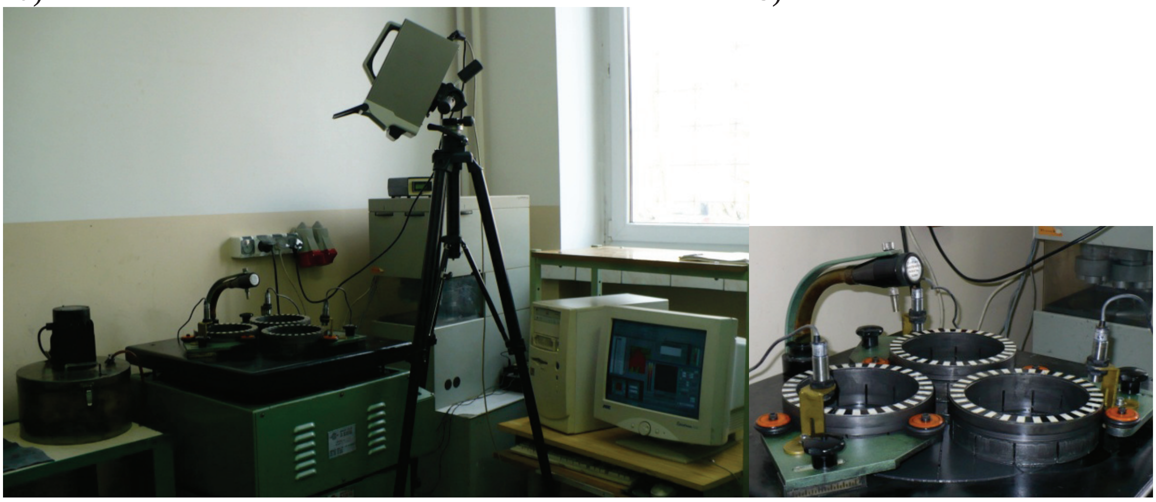

Fig. 3. Experimental setup; a) general view, b) executory system

The experiments were carried out on a plate-lapping machine ABRALAP 380 with a grooved cast-iron lapping plate and three conditioning rings (Fig. 3b). The machine kinematics allows for direct adjusting wheel velocity in range up to 64 rev/min. It is also equipped with a four-channel tachometer built with optical reflectance sensors SCOO-1002P, and a programmable tachometer 7760 Trumeter Company, which enables to read the value of rings and plate rotational speed.

Temperature was measured by thermographic camera V-20 II produced by VIGO System S.A. The camera serves for contact-less, remote temperature measurement and visualization of its distribution. It cooperates with three types of computers, traditional PC, laptop or PALMTOP. In the camera, two measuring ranges are defined: 10-80 and 10-350 0C. As a result of a measurement it is obtained a data set that is presented in a form of a colour map: a thermogram (Fig. 4a). The thermogram consists of 57600 measuring points (240 points in 240 lines).

a) b)

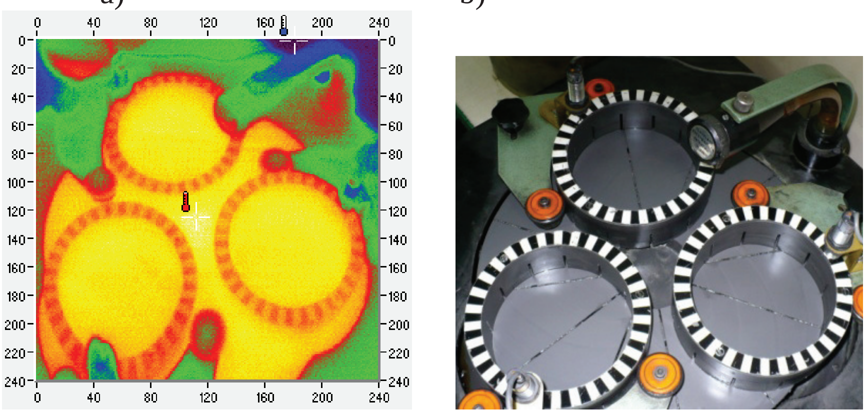

Fig. 4. ABRALAP 380 executory system: a) the thermographic camera view, b) photo camera view

4. Test procedure and results

In the first step the goal was to confirm the dependence of lapping plate temperature rise on conditioning rings number. It was realised during four experiments conducted with different number of rings (i = 0, 1, 2, 3). For each test lap wheel temperature was measured with help of thermographical camera (Fig. 5). Then the results were statistically analyzed with hypotheses testing use and with help of F-test. The analysis showed (Tab. 1) that the number of rings had a significant impact on plate temperature, which was expected [3, 6].

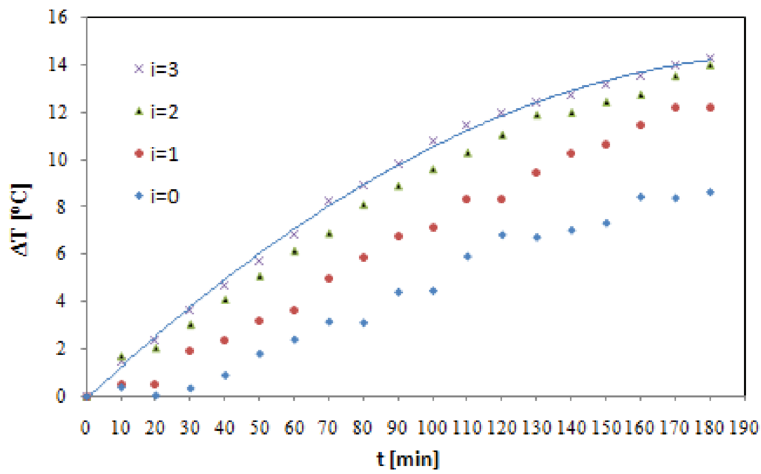

Fig. 5. Dependence of lapping plate temperature rise on conditioning rings number [6]

Tab. 1.Statistical analysis results [6]

Numerator degrees of freedom	υ_1	3
Denominator degrees of freedom	$\upsilon 2$	8
Significance level	α	0,05
Upper critical value of the F distribution	$F_{,05(\upsilon 1,\upsilon 2)}$	4.07
Test statistic	F	96.98

The next tests were carried out to simulate real machine working during 8-hour shift. It was realized when Al_2O_3 (95%) ceramic elements were being lapped. The lapping slurry was composed of silicon carbide grains F400/17 mixed with kerosene and machine oil in the ratio of one part of abrasive to six part of fluid (53% kerosene and 47% oil) by weight. A constant supply of the slurry was maintained using the abrasive feed mechanism to provide a fresh supply of abrasive grains into the work zone. The supply of abrasive slurry was maintained at 20 cm3/min. The lapping pressure p = 0.06 MPa was provided by dead weights. The wheel velocity had maximum value i.e. 64 rev/min.

This research aim was investigating the change in time of lapping plate temperature rise to determine time after which the rise would stabilize. The results are presented in the graph (Fig. 6).

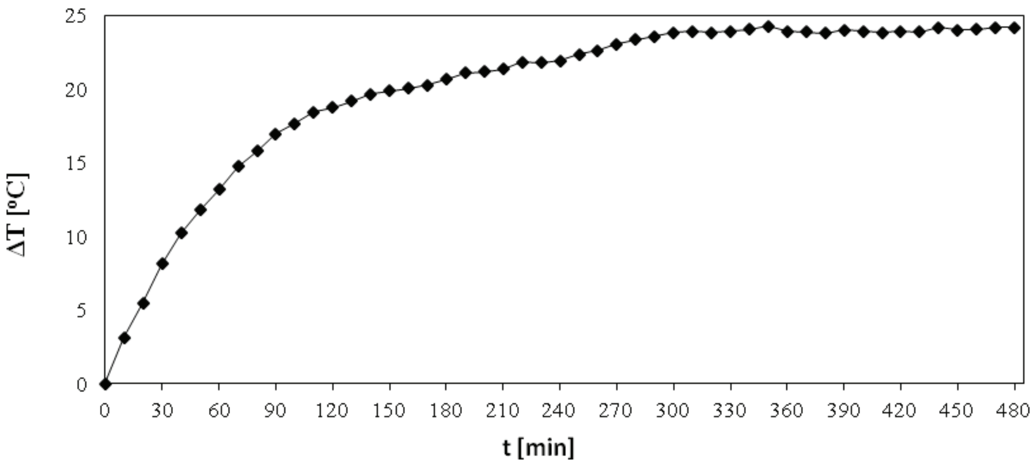

Fig. 6. Dependence of lapping plate temperature rise on machine working time

Shape of the curve is similar to curves shapes received from other, earlier experiments [5, 6]. The results indicates that temperature rise after five hours of machine working fluctuates around a certain value, hence that value will be taken in the further analysis as a maximum plate temperature rise under specified conditions. Such assumption will highly simplify future analysis.

5. Conclusions

This and earlier authors works focus on determining the conditions for subsequent research of lapping plate temperature rise. Firstly the influence of the rings number on tool temperature rise was investigated. According to expectations, experiments proved the significant impact of working rings number on wheel temperature. In industrial environments, due to processing efficiency and cost-effectiveness, machines should be working with all, fully loaded rings. Therefore, in future tests the number of rings will be constant and specimens will be loaded to all three rings.

As follows from previous studies plate warming up with machine working time. To simplify determining the equation describing influence of lapping parameters on lapping plate temperature rise, it is necessary to find such value which will be representative and appropriate for further analysis. This was the goal of next experiments. It was shown that temperature was almost constant after five hours of lapping machine working. Temperature value after that time will be taken into consideration in future analysis.

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