

MEASUREMENTS OF SIZE ABRASIVE GRAIN IN LAPPING

A. Barylski

Department of Manufacturing Engineering and Automation
Faculty of Mechanical Engineering
Technical University of Gdansk, PL 80-952 Gdansk, Poland

Abstract: In this paper there are presented the results of studies of lapping. One of the main disadvantages of lapping is the contamination of machined surfaces with micrograins of the grinding material. This phenomenon is detrimental from the tribological point of view. The micrograins which are embedded into the machined surface during coarse lapping, penetrate during the fine lapping into the abrasive slurry and interfere with the reduction of surface roughness. The abrasion wear of sliding elements is considerably increased during the operation of contaminated parts.

Keywords: lapping, micrograins, surface contamination, measurements

1 INTRODUCTION

The high demands required today by design engineers for machine parts and tools necessitates very precise machining. The lapping process leads to a surface with low roughness and high precision. The topographical structure of the surface after lapping is very advantageous for sliding joints because of the high lubricant retention ability, as well as in non-sliding joints because of the high load - carrying ability.

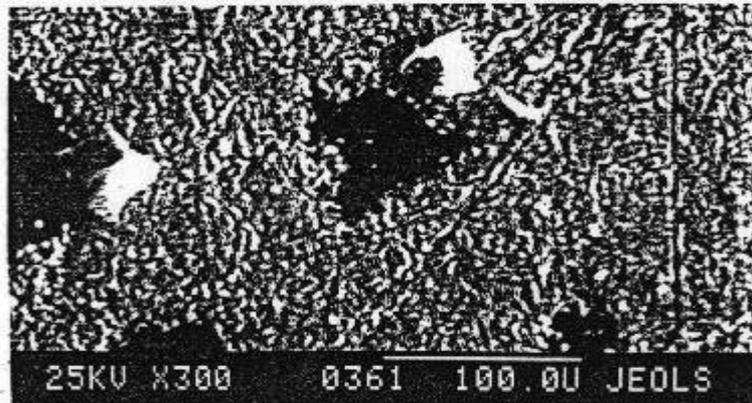


Figure 1. Microphotograph of Zs55003 cast iron (SEM) after lapping; JSM-35C microscope

One of the main disadvantages of lapping is the contamination of machined surfaces by micrograins of the abrasive material (Fig. 1). The micrograins embedded into the machine surface during coarse lapping (Fig. 2) enter the „machining” zone during fine lapping. During service, contaminated surfaces are objected to excessive wear [3].

Since surface contamination is harmful and the methods of removal of the embedded micrograins are ineffective, the intensity of the contamination should be reduced as much as possible during the lapping process. The indentation of abrasive material into a machined surface should be considered as an element of general behaviour of abrasive micrograins including position of the micrograins, their size, shape as well as the physical and mechanical properties of the machined material and the lapping tool. The pressure and the lapping speed are also important.

In the present investigation, surfaces contaminated by abrasive micrograins have been studied with an electron microscope and a microanalyzer. The combination of microscopy with X-ray analysis

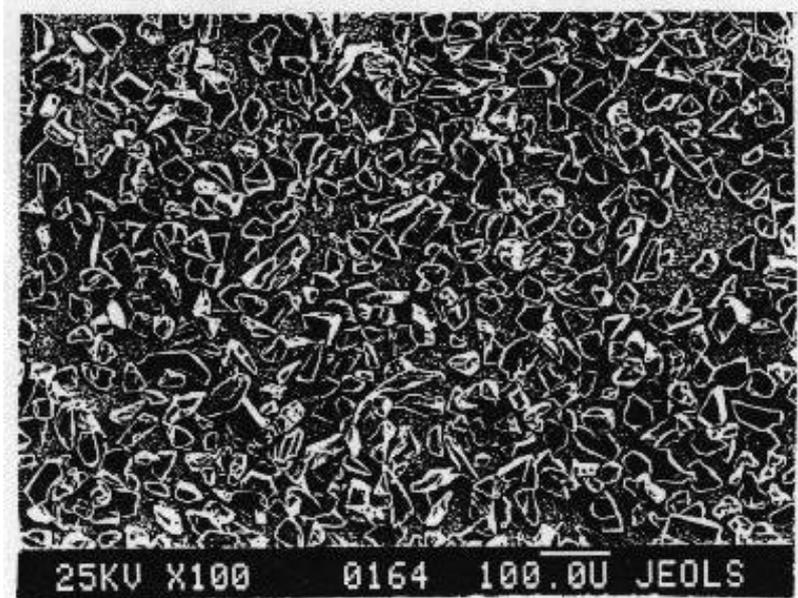


Figure 2. Scanning electron microphotograph of the abrasive materials (silicon carbide F320/29); JSM-35C microscope

permits the study of secondary electron images and the X-ray images of the same spot on the sample. The statistical size of abrasive slurry micrograins was estimated by means of an automatic image analysis (TV image analysis) [2].

2 RESULTS

Tests were done in stages. In the first stage, the X-ray and spot analyses were carried out for the evaluation of indented micrograins with respect to the structural components of cast iron. In the second stage, the influence of lapping parameters such as pressure p , speed v and time t , on the contamination intensity were found. Complementary tests included the evaluation of the influence of micrograins size and concentration in the abrasive slurry as well as the method of cleaning the surface following lapping. Changes of radiation line intensity of specific elements in the X-ray analysis are equivalent to the changes of their concentration (Fig. 3).

Due to the fact that in the spot method the relative error depends on the number of analysed spots, the subsequent tests were based on the surface distribution analysis of the elements. Statistical test have proved that the distribution of number of indented abrasive micrograins observed in particular fields of analysis follows a Poisson distribution [1]. After estimating surface distribution for silicon it has been found that the concentration of indented abrasive micrograins is smaller for longer machining times.

Tests of indented micrograins have shown log-normal distribution for the micrograin size. Depending on the tested factors the mean value $E(d)$ of the indented micrograins size with respect to expected values of abrasive slurry micrograins amount to 30-60%. As well as surface analysis for the distribution of elements, secondary electron images have also been made. These observations show that surface contamination with micrograins of size $E(d) > 30 \mu\text{m}$. is very rare. The fragments of micrograins, a result of their cracking and chipping, penetrate into pearlite and ferrite as well. An increase in penetration or micrograins into the graphite border and into the ferrite envelope has been observed. The influence of the packing factor B of the micrograin in the machining zone (Fig. 4) and the micrograin size of cast iron contamination intensity have also been analysed [1].

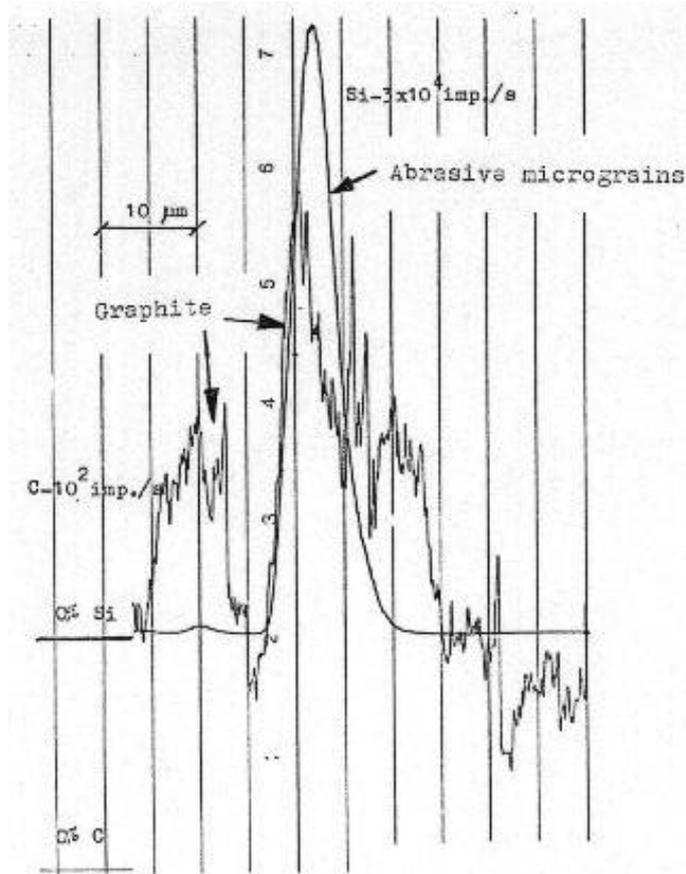


Figure 3. The linear distribution of C and Si on the surface of Zs55003 cast iron

3 CONCLUSION

The following conclusions can be formulated on the basis of the test that have been carried out:

- The effects of surface contamination with abrasive material can be reduced by prolonged time of lapping and by decreasing the micrograin packing in the machining zone in the beginning, or by reduction of unit pressure and lapping speed. During the lapping process the dispersion of abrasive micrograins increases where as the load by a single micrograin and its penetration dept into the machined material is reduced.
- The distribution of size for silicon carbide micrograins indented into the machined surface is log-normal (Fig. 5). The same type of distribution is typical for the characteristic radiation value $SiK\alpha$ defined in the cast iron surface after lapping.
- For greater micrograin number in the abrasive slurry, the concentration of cast iron contamination micrograins is reduced.
- There are no significant differences in intensity of surface contamination by silicon carbide micrograins after lapping and cleaning (manual or ultrasonic).
- The number of micrograins indented into cast iron surface per individual microscopic field of view has a Poisson distribution with relatively great variance, where as the number of micrograins of defined size are characterises by a Poisson distribution of relatively small variance (Fig. 6).
- Contamination of any particular structural components of the cast iron is relatively uniform [1].

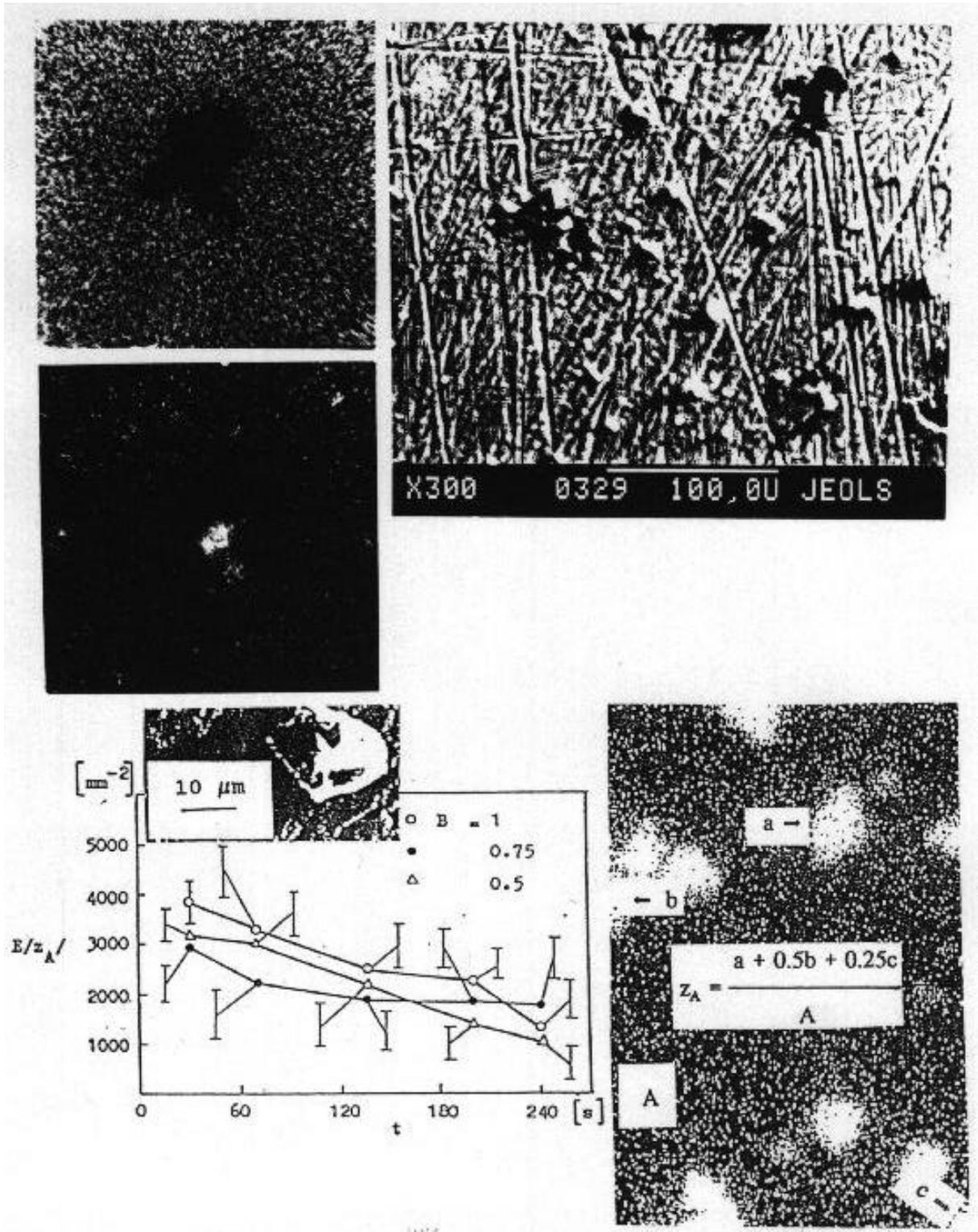


Figure 4. The effect of abrasive material packing factor B and the lapping time t on the concentration of micrograins contamination the surface of Zs55003 cast iron (silicon carbide 800, $p=0.19$ MPa, $v=0.46$ m/s)

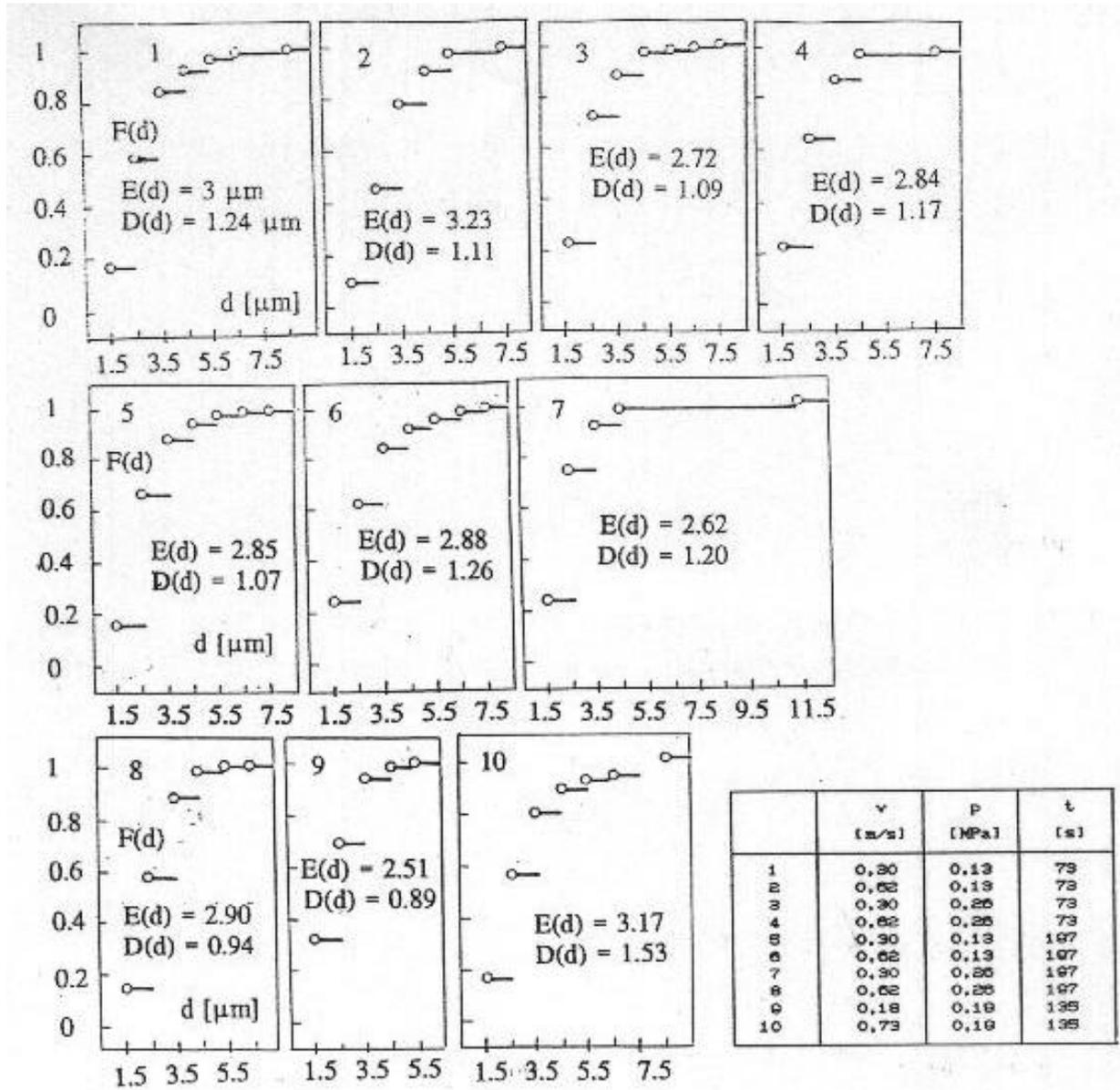


Figure 5. Empirical distribution function $F(d)$

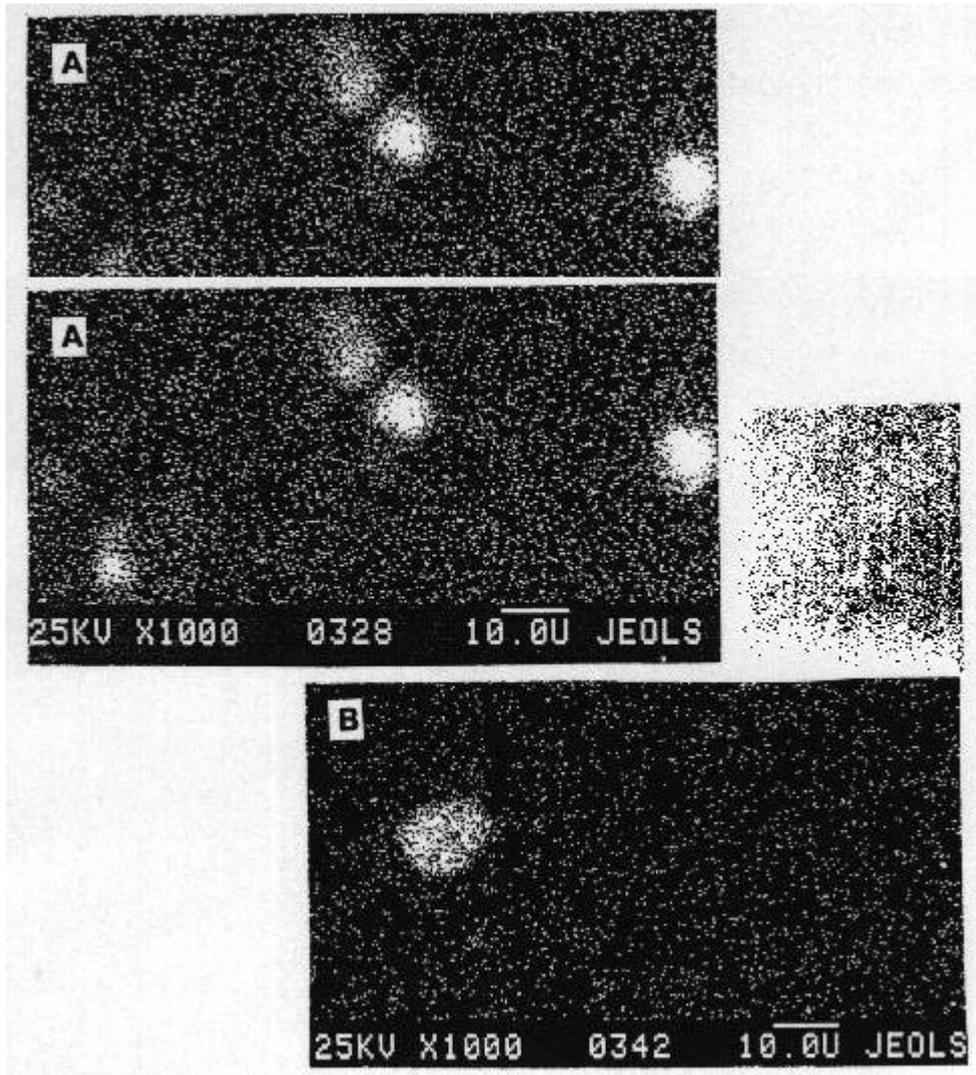


Figure 6. The X-ray images of Si distribution made random selected spots (A , B) on the surface of Zs55003 cast iron lapped with silicon carbide micrograins

REFERENCES

- [1] A. Barylski, Fundamentals of flat surface lapping with single-disk. *Sc. Bull. of TU Gdansk*, 491 (1992), 3-196.
- [2] A. Barylski, Application of electron microscopy and X-ray analysis for examination of lapped surfaces contamination by grinding materials. *Pract. Metallogr.*, 25 (1988), 349-355.
- [3] A. Misra, I. Finnie, On the size effect in abrasive and erosive wear, *Wear*, 65 (1981), 359-373.

AUTHOR: A. BARYLSKI, Faculty of Mechanical Engineering, TU Gdansk, G. Narutowicza 11/12
PL 80-952 Gdansk, Poland, Phone Int. ++048 58 3471982, Fax Int. ++048 58 3471025
E-mail: abarylsk@pg.gda.pl