IS-662

INVESTIGATION OF VIBRATORY POLISHING VARIABLES

By
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June 1963

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UNITED STATES ATOMIC ENERGY COMMISSION • DIVISION OF TECHNICAL INFORMATION

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USAEC Division of Technical Information Extension, Oak Ridge, Tennessee

IS-662

Metals, Ceramics, and Materials (UC-25)
TID-4500, April 1, 1963

UNITED STATES ATOMIC ENERGY COMMISSION

Research and Development Report

INVESTIGATION OF VIBRATORY POLISHING VARIABLES

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E. N. Hopkins and D. T. Peterson

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Ames Laboratory
at
Iowa State University of Science and Technology
F. H. Spedding, Director
Contract W-7405 eng-82

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INVESTIGATION OF VIBRATORY POLISHING VARIABLES

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ABSTRACT

The vibratory polisher has become a useful tool in the polishing of metallographic samples. This investigation established some of the effects of the lap material, weight of sample, number of samples, types of abrasives, and vibrational amplitude on the rate of metal removal and the quality of the polished surface.

INTRODUCTION

Vibratory polishing since its introduction to the field of metallography in 1956[1] has shown considerable merit. The principal advantages with respect to rotating wheel methods of polishing have been the ease of operation, the saving of skilled operators' time and the reduction in relief polishing. This report is concerned with the influence of some of the many variables in vibratory polishing and an attempt to measure the effect of these variables on the rate of metal removal. The variables under consideration in this report are the effect on the rate of metal removal of the lap material, vibrational amplitude, specimen and holder weight, number of samples in the bowl, type of abrasive and the hardness of the material to be polished.

PROCEDURE

The test specimens were mounted in bakelite and ground through 600 grit silicon carbide paper. Most of the investigation was done with annealed specimens of 1020 steel. Diamond pyramid hardness impressions were made using a 1000-g load and the diagonal lengths measured. The specimens were then polished for a measured length of time and the diagonals were remeasured. The rate of metal removal was calculated from the difference in the diagonal measurements and the known geometry of the diamond indenter. Photographs were taken of representative areas to show the quality of the polish.

A standard vibratory polisher[2] was used for all tests. The lap or cloth used for polishing was secured with a standard retaining ring. When necessary, cloths and laps were glued to the surface of the bowl with Pliobond cement. The amount of abrasive used was 20 g and the abrasive was suspended in 500 ml water and 10 ml liquid Vel detergent. The rheostat used with the vibratory polisher was the Model LPC-01 Separate Controller purchased with the vibratory unit.

RESULTS AND DISCUSSION

Very early in the investigation, an unexpected result became apparent. The amount of metal removed was not directly proportional to the vibrational amplitude. Figure 1 shows typical examples of the variation in the rate of metal removal as the rheostat setting is varied. It is apparent that small differences in the rheostat setting can produce considerable

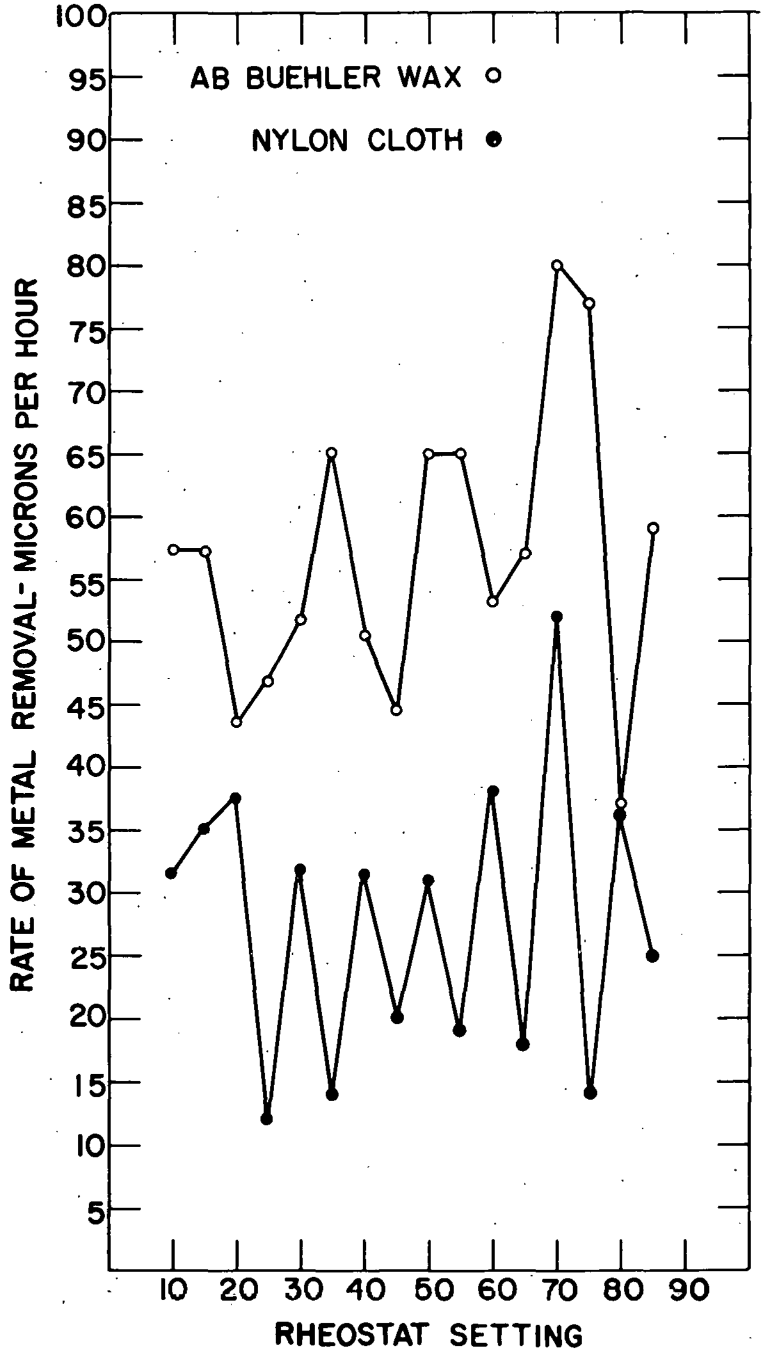

Fig. 1. The rate of metal removal as a function of the rheostat setting.

differences in the rate of metal removal. The rate of metal removal could be reproduced at a given rheostat setting if the setting were not changed but the rheostat setting could not be reproduced. The setting at which maximum polishing occurred also varied with the type of material being polished. For example, a zinc specimen did not reach the maximum rate of metal removal at the same rheostat setting as a steel specimen even when both were polished simultaneously. This sensitivity of the polishing rate to the rheostat setting required that a number of tests be made at varous rheostat settings as other variables were changed.

The maximum, minimum and average rates of metal removal by different cloths and laps are shown in Table I. From this table it is seen that a wax lap has the highest rate of metal removal followed quite closely by Pellon discs and nylon cloth. It should be noted that the maximum rate of metal removal did not occur at the same rheostat setting for the different lap media. The Pellon cloth, epoxy resin, and wax gave the maximum metal removal at rheostat settings between 70 and 80 whereas the other cloths and laps gave maximum removal at rheostat settings below 30. Figure 2 shows the quality of polish obtained with various lap materials. With the exception of the epoxy resin lap and Microcloth, the quality of the polished surfaces are comparable. Plastic laps when used with Linde A abrasive leave the surface with scratches comparable in depth to the original 600 grit

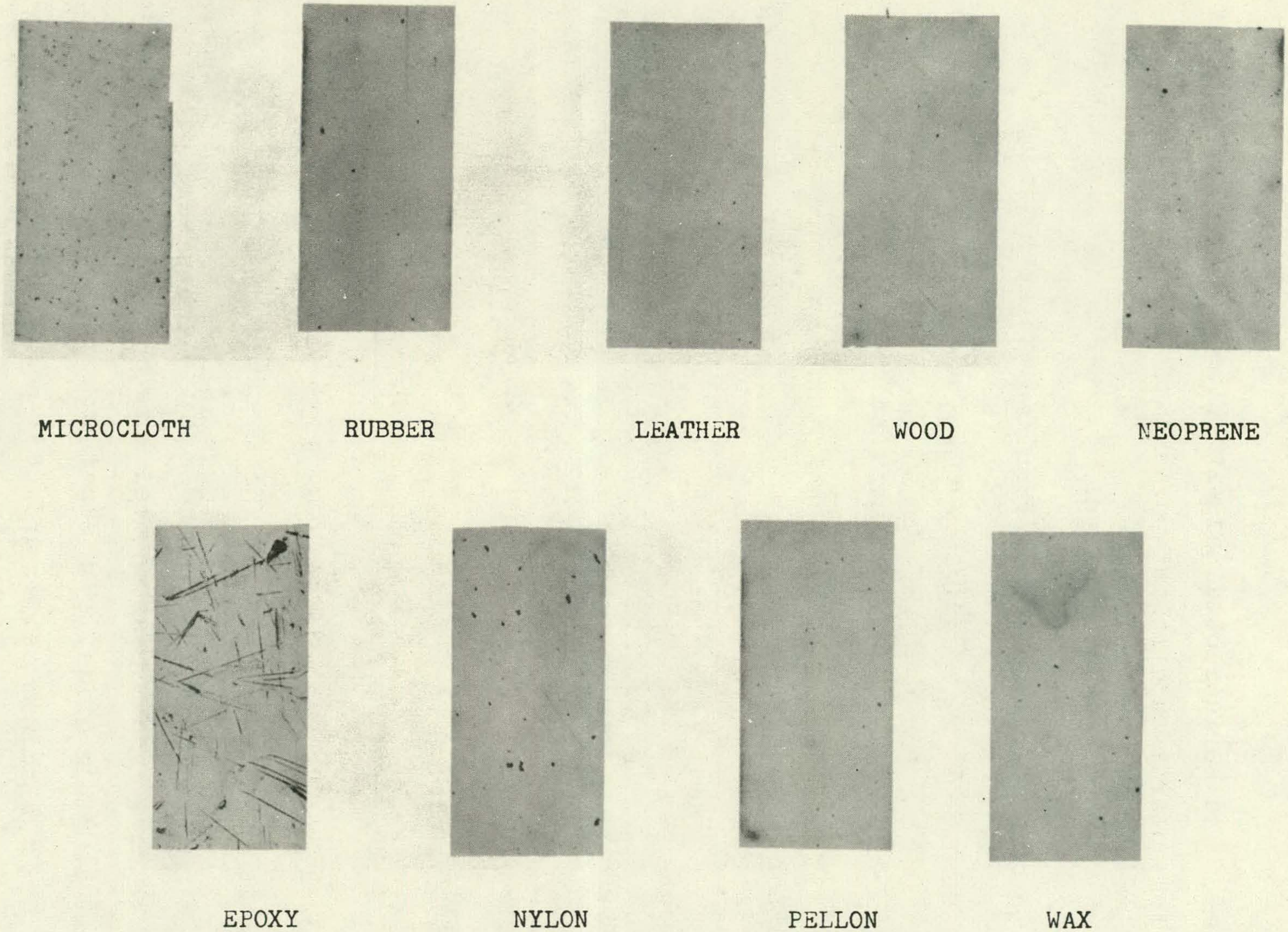

Fig. 2. Comparison of various cloths and laps unetched. X 100.

scratches. The surface obtained with Microcloth showed considerable irregularity and relief polishing.

Table I

Rate of Metal Removal as a Function of Lap Material

	Rate of metal removal--μ/h		
Lap material	Minimum	Average	Maximum
microcloth	2	7	13
rubber	1	5	19
leather	2	9	22
wood	2	14	34
neoprene	5	14	35
epoxy resin	24	36	45
nylon cloth	12	28	52
pellon disc	21	43	59
wax	37	59	80

The effect of the abrasive as a factor in the rate of metal removal is shown in Table II. The specimens were polished on wax laps under identical conditions except for the use of different abrasives. The abrasives used were 600 grit silicon carbide, 600 grit aluminum oxide, 15 μ aluminum oxide, 1 μ magnesium oxide, 0.3 μ aluminum oxide, and .05 μ aluminum oxide. The 600 grit abrasives were not as effective in removing metal as the smaller 15 μ abrasive and produced fewer but deeper scratches.

This condition is probably the result of poor sizing in the larger abrasive materials. It is possible that the sample was not in contact with the entire abrasive bed but was supported by the small number of large particles, thus not removing as much material as would be expected from a coarse abrasive. The magnesium oxide abrasive did not remove as much metal as the much finer 0.3 μ aluminum oxide. Aluminum oxide appears superior to magnesium oxide in the rate of metal removal. Figure 3 shows the quality of polish obtained with the various abrasives.

Table II

Rate of Metal Removal as a Function of Abrasive

	Rate of metal removal-- μ/h		
Abrasive	Minimum	Average	Maximum
0.3 aluminum oxide	37	57	80
1.0 magnesium oxide	4	16	29
15.0 aluminum oxide	70	115	239
600 grit aluminum oxide	36	106	177
600 grit silicon carbide	7	66	141

The fourth variable studied was the specimen weight. A comparison of the rate of metal removal as a function of specimen weight is shown in Table III. The standard holder and specimen weighed 375 g. Increasing the weight increased the rate of polishing up to 600 g but decreased the polishing rate after this

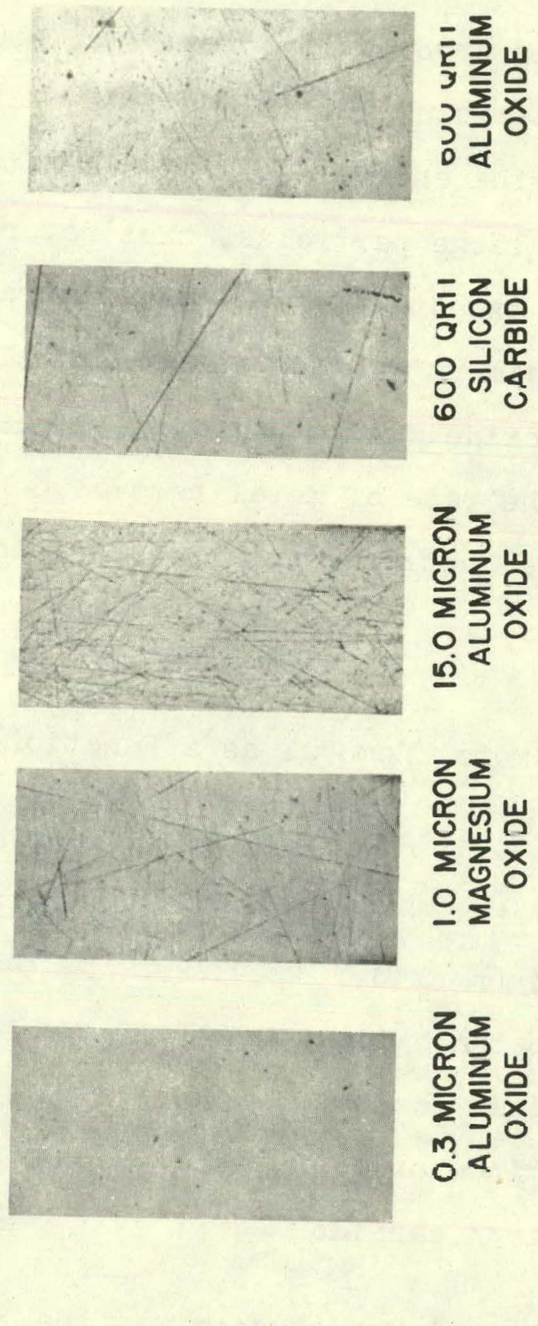

Fig. 3. Comparison of various abrasives unetched. X 100.

point. The standard specimen holder did not give the maximum rate of metal removal but the difference is not great enough to warrant a change in the weight of the standard specimen holder.

Table III

The Rate of Metal Removal as a Function of the Sample and Holder Weight

Weight of sample in grams	Rate of metal removal--μ/h
100	16
200	4
375	53
600	60
800	45

It was observed that the maximum, minimum and average rates of metal removal decrease with an increasing number of specimens in the bowl. The maximum rate does not decrease rapidly or to any great extent but the minimum rate decreases rapidly and is much less with 14 specimens than with one specimen. The polishing rates for various numbers of specimens in the bowl are given in Table IV.

Table IV

The Rate of Metal Removal as a Function of the Number of Samples Polished

Number of samples simultaneously polished	Rate of metal removal-- μ/h Minimum	Average	Maximum
1	37	57	80
5	11	45	65
9	4	39	65
14	4	25	51

Table V illustrates the effect of differences in hardness on the rate of metal removal. The hardness of material is

Table V

The Rate of Metal Removal as a Function of Sample Hardness

Sample material	Diamond pyramid hardness 1000 g load	Rate of metal removal-- μ/h
zinc	90	41
steel	170	33
steel	200	46
steel	350	24
steel	510	33
steel	600	32
steel	790	32
vanadium carbide	875	41

certainly not the only contributing factor in the polishing characteristics. As is seen from this table, a harder material can polish faster than softer material. Some of the reasons for this may be the amount of surface-worked metal and the ductility or the brittleness of the sample as well as the hardness.

CONCLUSIONS

The vibratory polisher is easy to operate and gives an excellent quality of polish. However, the large variations in the rates of metal removal with changes in vibrational amplitude and other factors are undesirable. These differences are believed to be due in part to the vertical component of vibratory movement. An increase in the horizontal motion and a decrease in the vertical motion might cause much of the erratic behavior of the vibratory polisher to disappear. A polisher which would still be easy to operate but would be considerably more effective and reproducible might be developed by modification of present types or the evolution of new types of vibratory polishers.

The desirability of an intermediate polishing step using a 15μ aluminum oxide abrasive between the 600 grit abrasive papers and the 0.3 ι Al_2O_3 is clearly indicated. With the use of the 15μ Al_2O_3 abrasive, the time of polishing would be considerably decreased. The use of the 600 grit powder abrasives is of no advantage.

The weight of the standard specimen holder is in the correct range for most efficient polishing.

Increasing the number of specimens in the bowl decreases the rate of polishing, particularly the minimum rate of metal removal. With a more effective polisher this would not be a problem since polishing would be done in the region of maximum rate of metal removal.

The hardness of the metal to be polished is not the only factor to be considered in the rate of polishing, and no quantitative prediction can be made to fit all metals at the present time.

The vibratory polisher is a step forward in the field of metallography. With the further improvement of this type of metallographic polishing, sample polishing will some day be relegated a minor role in metallography.

ACKNOWLEDGMENT

The authors would like to acknowledge Mr. H. Baker, who helped with a considerable portion of the experimental work covered in this paper.

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