4-25-2020

Specimen Preparation and Surface Analysis

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April 24, 2020

Background:

Upon analysis of the boiling chamber experimental data that was conducted in the fall of 2019, two sets of unpredicted data were found. The first was a consistent negative spike in the critical heat flux curves that occurred around the same point in several experiments, while the second was the profilometry data that showed that the samples with lubricant-infused surfaces contained more deposition compared to plain aluminum. In order to verify these results, further testing must be conducted, and the samples must be reprepared using methods that remove all traces of contamination. Sandpaper of varying grit was initially used to remove this contamination. However, a plane of scratches was visibly apparent for each of the samples. Because these scratches can potentially affect the heat flux of the samples, further methods were required for restoring the samples to their original states. This method consisted of a rotating buffing wheel. Buffers are instruments used to polish a specimen of metal. The buffing process involves the application of the specimen to a rotating wheel. The repeated buffing of a specimen eventually results in a level and bright finish. These conditions can then be viewed with a high degree of precision using a stylus profilometer, which measures the miniscule imperfections on a sample's surface. This experiment investigates the effectiveness of a buffing wheel on creating a smooth finish for various aluminum discs to be used in future research.

Objective:

The object of this experiment is to use a buffing wheel to restore previously used aluminum discs to their original condition. After the buffing process, the samples will be analyzed under a stylus profilometer in order to inspect their progress of obtaining level surfaces.

Experimental Setup:

For the setup of this experiment, an electric buffer was mounted to a platform and a buffing wheel was attached. Eight disk shaped aluminum samples with a diameter of 25.4 mm and a thickness of 2.032 mm were used for this experiment. Using pliers, the samples were applied to the rotating wheel, maintaining consistent pressure and even application throughout the surface. The samples were buffed with three buffing wheels of the following grit in sequential order: 120, 180, and 240. Each wheel contained a diameter of 6 inches. Figure 1 below illustrates the experimental setup for this part of the experiment.

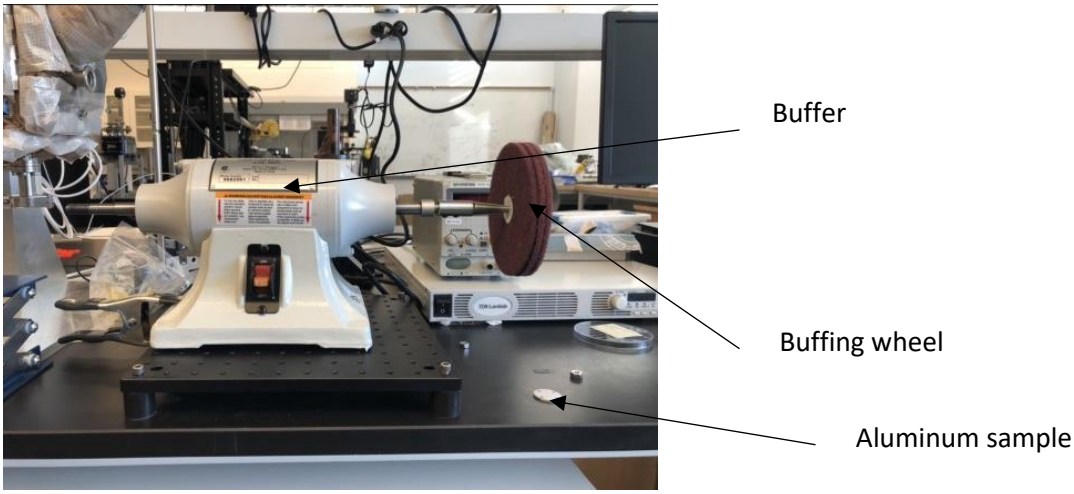

Fig. 1 Buffering experimental setup

For the profilometry experiment, the samples were scanned with a KLA-Tencor Alpha-Step D-100 profilometer using a scan length of 16 mm and a stylus force of 0.5 mg. Each sample was scanned two times in perpendicular directions (noted A and B), using the 0.5 mm hole as a reference. A diagram of a sample and the paths of its scans can be found below in Fig. 2.

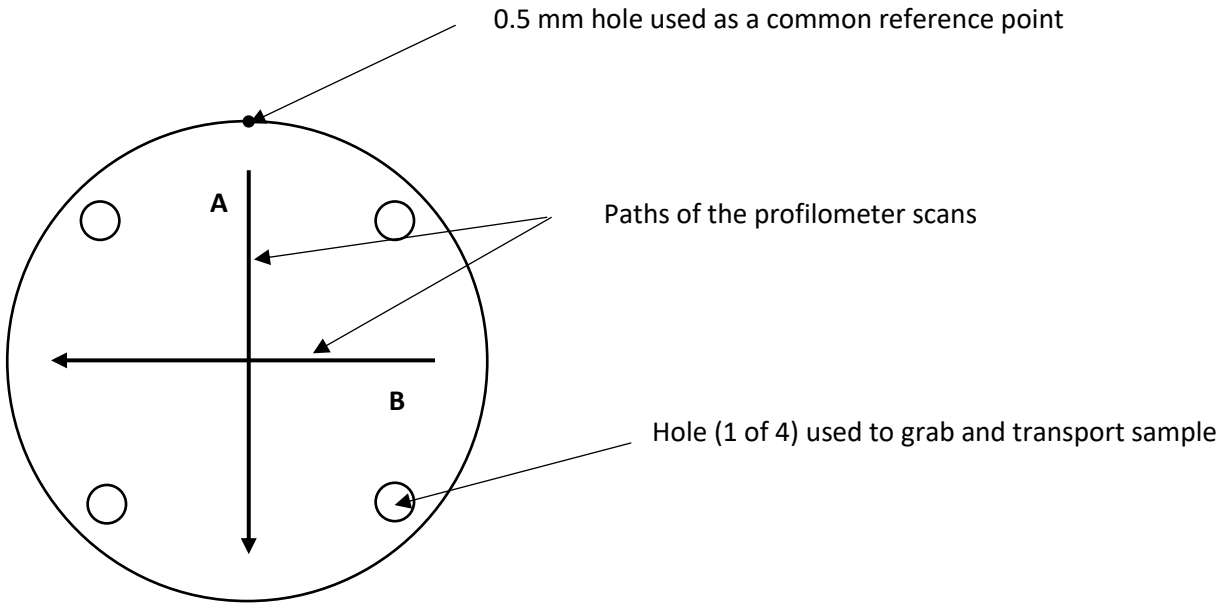

Fig. 2 Samples Diagram with Profilometry Scanning

Experimental Results:

From the profilometry data, 16 graphs were obtained in total. Each graph was plotted with the surface profile [μm] as a function of position [mm]. A selection of graphs is displayed below in Fig. 3. The title of each graph displays the sample number along with the directional path of the profilometer stylus.

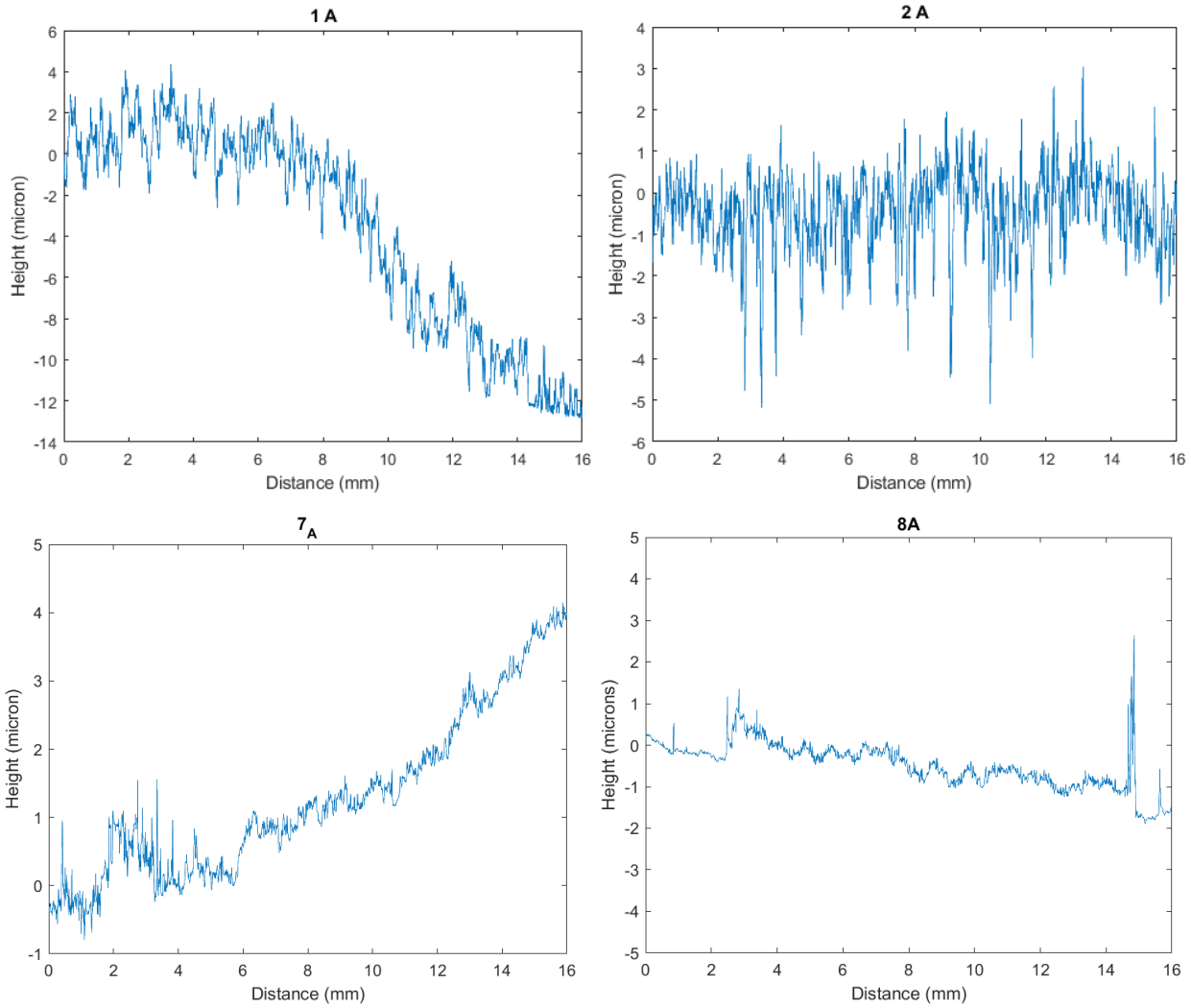

Fig. 3 Examples of Profilometry Curves from Selected Samples

Analysis:

The results of the data display varying degrees of success for creating a microscopically smooth surface. It is important to note that there are two ways in which the surface can be analyzed. The first is the roughness of the surface, as indicated by the magnitude of the dense fluctuations in each graph. Graphs 1A and 2A (top) exhibit surfaces of a relatively high roughness, while Graphs 7A and 8A (bottom) exhibits a surface roughness that is relatively low. The second feature that can be analyzed is the gradient of the curves, or the overall change in the surface height as the stylus moves across the sample. For instance, Graphs 1A and 7A (left) display a large gradient in their respective surfaces, while Graphs 2A and 8A (right) exhibit a relatively low gradient. The remaining graphs displayed a variety of combinations between these two factors. These inconsistencies are likely due to the fact that the buffing process is very user-dependent, and slight varieties in pressure applied to the buffing wheel can drastically alter the surface structures at the microscopic level.

The experiments that these samples will be used for require them to have both a minimal roughness and gradient. This concept is most ideally seen in Graph 8A, which corresponds to Sample 8. However, an estimated tolerance can be made for deciding which samples can be used. Previous experiments have shown layers of copper sulfate deposition range from 10 microns to 50 microns in thickness on the samples. Therefore, a desired surface roughness and gradient of less than one micron should be achieved for each sample used in future experiments.

Future Experiments:

Due to many of the samples not fulfilling the experimental requirements for surface roughness, plans were sought to use an alternate method for polisher with an aluminum oxide solution in order to achieve the desired surface structure. Additionally, profilometry data would be gathered to confirm the roughness and gradient of the surfaces. However, the recent COVID-19 pandemic has brought research to a pause and these plans were unable to be accomplished this semester.