Correlations for roughness, slope and peak height for bead blasted surfaces

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ABSTRACT – This work reports the results of measurements of the topography of 79 rough surfaces. The materials were stainless steel, mild steel, aluminium and copper. The surfaces of the specimens were blasted with particles of different materials at a range of pressures. It was found that profile heights were generally Gaussian. Simple correlations between measured parameters were developed. Analysis was also conducted of the effect of different cut off lengths. It was confirmed that roughness parameters are not intrinsic properties of the surface, but depend on the cut-off length.

1. INTRODUCTION

In many applications information about surface characteristics in addition to Ra (Average roughness) and Rq (RMS Roughness)) are needed. In a majority of experimental investigations, however, only the surface roughness is reported. In tribological applications, contact between two surfaces generally occur at or near the peaks of contacting surfaces. Song et al [1], as well as Wahid and Madhusudana [2] showed that for interfacial heat transfer especially across the gas-gap, peak height plays a vital role. The main objective of the present study is to develop correlations between surface parameters such as roughness, slope and peak-height.

2. SURFACE PREPARATION OF TEST SPECIMENS

The test specimens of AISI 304 Stainless Steel, C 15 mild steel, Copper 211 and Aluminium 2011 were cut from cylindrical rods. The surfaces were blasted randomly from a nozzle at an angle of to the top of the exposed surfaces from a distance of approximately 100 mm. A range of blasting pressures ranging from 250 kPa to 690 kPa and blasting materials, for example, Al oxide, Garnet and Steel Grits were employed to get different surface topographies for the test specimens. For each surface, typically around 3 to 7 traces were randomly selected.

3. MEASURING SYSTEM

Surface texture was quantified using Federal Surf Analyzer 5000 precision measuring instrument at the University of New South Wales.

4. ANALYSIS OF SURFACE TEXTURE AND DISCUSSION

For the analyses materials Roughness cut off was specified as 0.8mm, thus roughness trace of the part surface will include only those irregularities that have a wavelength of 0.8mm or less. All longer wavelengths will be filtered out. The measurement filter used was ANSI 2-RC.

Developed correlation given below fits all of the 79 surfaces consisting AISI 304 stainless steel, mild steel, aluminium and copper.

The following correlations are deduced from Figures 1, 2 and 3 for 0.75 < Rq < 10.

$$Ra = 0.8087Rq - 0.0412 \quad (1)$$

$$\Delta q = 0.0969\ln(Rq) + 0.1112 \quad (2)$$

$$Rp = 3.3619Rq^{0.8997} \quad (3)$$

It can be easily proved that, for Gaussian surfaces, $Ra \cong 0.8\,Rq$. An examination of Eq (1) indicates that, for bead blasting of surfaces, the distribution of surface heights was invariably Gaussian.

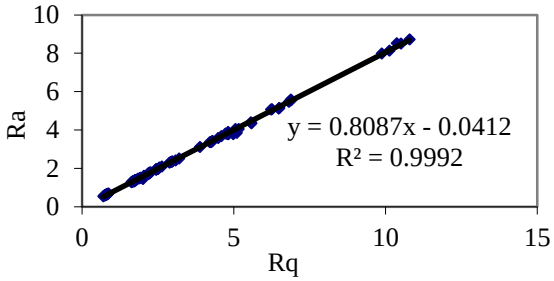

Figure 1 Average roughness vs RMS roughness.

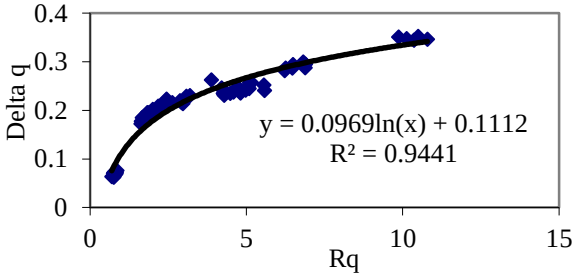

Figure 2 RMS slope vs RMS roughness.

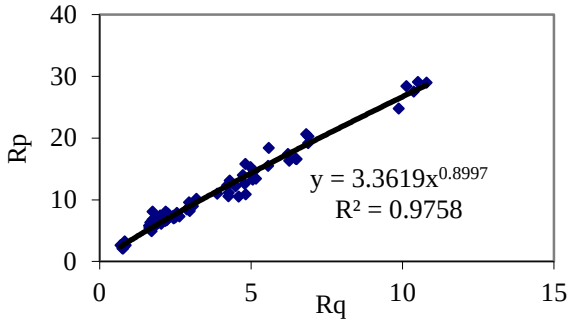

Figure 3 Peak height vs RMS roughness.

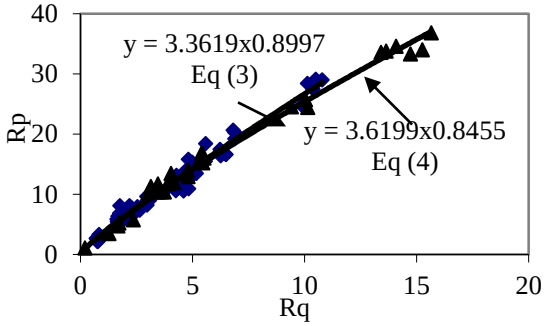

Figure 4 Comparison of results for Rp.

4.1 Variation of Slope

It is also seen that the relationship between the roughness and the slope is non-linear.

4.2 Variation of Peak Height

Equation (4) correlates the peak-height with the rms roughness. It is instructive to compare the present data with a second set of thirty surface measurements of AISI 304 stainless steel with different surface finishes that had been prepared by the authors in connection with evaluating gap conductance in contact heat transfer. The specimens were all machined from a single rod. This ensured that they all had the same mechanical and thermal properties. In this case, the measurements were made with a Talysurf 4 Surface Analyser, the correlation between the peak-height and the rms roughness was deduced Figure 4.

$$Rp = 3.6199 \times Rq^{0.8455} \quad (4)$$

The simplicity between correlation (3) and (4) is indeed remarkable when we see that (a) the specimens were made of different material and, (b) the measuring equipment were different. This confirms the repeatability of Rq and Rp measurements for surface produced by similar processes.

4.3 Effect of Cut off Length

Seven specimens were randomly selected, consisting of stainless steel, mild steel, aluminium and copper, and each of them having different surface preparations were scanned using different cut-off lengths and are listed in It was found that rms slope is nearly constant whereas RMS roughness height has increased for higher cut-off length. For fine surfaces, the effect of increasing the cut-off length is not significant. For example for ss67 Rq increases from 0.81 to 0.85μm, an increase of just 5%, when the cut-off length was changed from 0.8mm to 2.5 mm. However, for a rougher surface, such as ss26, Rq has increased from 10.6 to 12.52 μm, representing an increase of 18%. This emphasizes that rougher surfaces are sensitive to cut-off lengths. This could be attributed to the fact that roughness is dependent on high-pass cut-off, whereas slope is independent of it.

5. CONCLUSIONS

Surface characteristics of 79 surfaces of four different materials were studied experimentally. The surfaces had been produced by a number of different blasting methods to give a wide range of surface roughness (0.69 to 10.79 μm). Three to seven traces were made on each specimen at various positions of the specimen. It was found that profile height distributions were Gaussian. Simple correlations for CLA roughness, the slope and the peak height as function of rms roughness were also developed. The results agreed with the published results of previous workers [3], [4]. Measurements on specimens made from different materials and using different measuring equipment indicated that the results are repeatable reasonably accurately. Analysis was also carried out to find the effect of cut-off length on roughness parameters. It was confirmed that surface roughness parameters are not intrinsic properties of the surface, but depend on the cut-off length.

6. REFERENCES

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