Rapid assessment of surface topography via non-destructive acoustic testing

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1. Overview

We have developed a **rapid and non-destructive method** for assessing the surface topography of engineered materials. A low kinetic energy impact between two solid bodies generates an acoustic output, the characteristics of which depend on the geometry of the bodies, the material properties, and the nature of the contact.

Parameters including density, modulus, and surface topography influence the acoustic output produced from an impact, and therefore can be used for the evaluation of material and surface properties. The sound generated from the impact of a **nylon sphere** onto a series of **aluminium plates** was recorded. The plates were polished to different grades and exhibited surface roughness in the range 500 – 3,000 nm.

Analysis of the sound generated revealed that surface topography was discernible, post-processing requiring only a few seconds of computation. **The acoustic output following this low kinetic energy impact correlates with the specimen surface topography.**

The prospects for using this methodology for identifying changes in surface topography will be discussed, along with the opportunities for automated data acquisition and processing. It is envisaged that this method could be suitable for in situ monitoring of the extent of wear progression.

2. Method

Analysis of the impact sound generated by a nylon sphere rebounding from a surface.

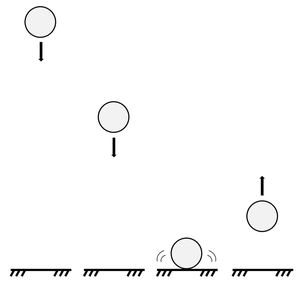

Fig 1. Sphere impact sound

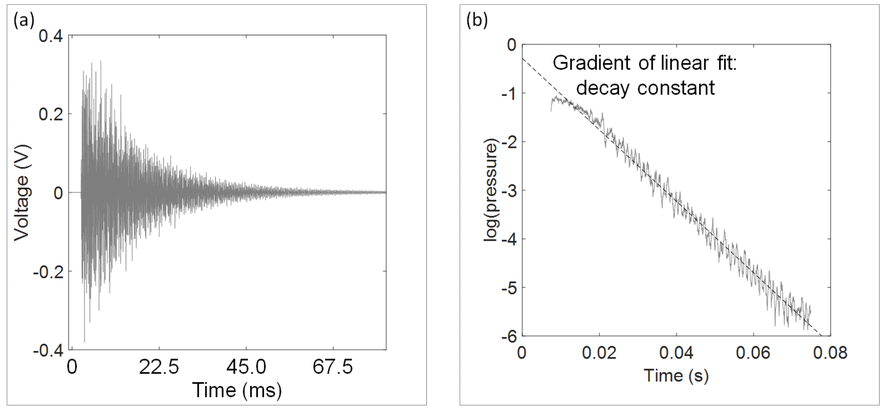

Fig 2. Sound analysis: (a) amplitude in time domain; (b) sound pressure decay

3. Results

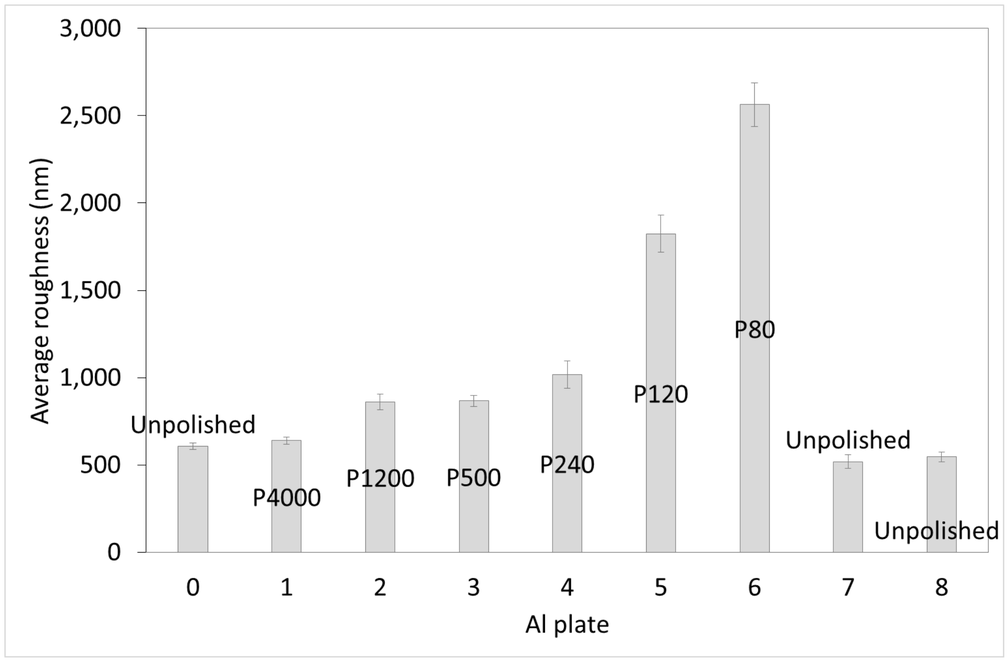

Fig 3. Average roughness of unpolished and roughened aluminium plates

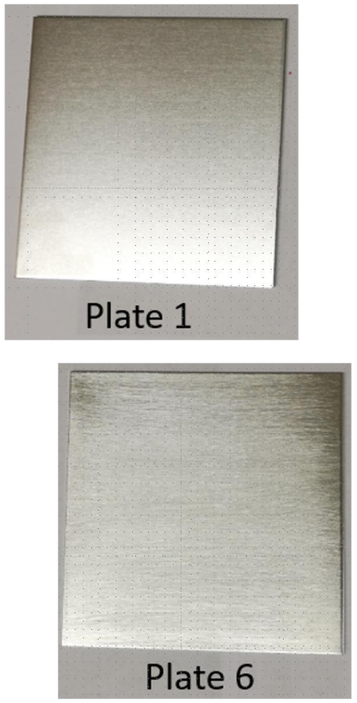

Fig 4. Al plate surfaces

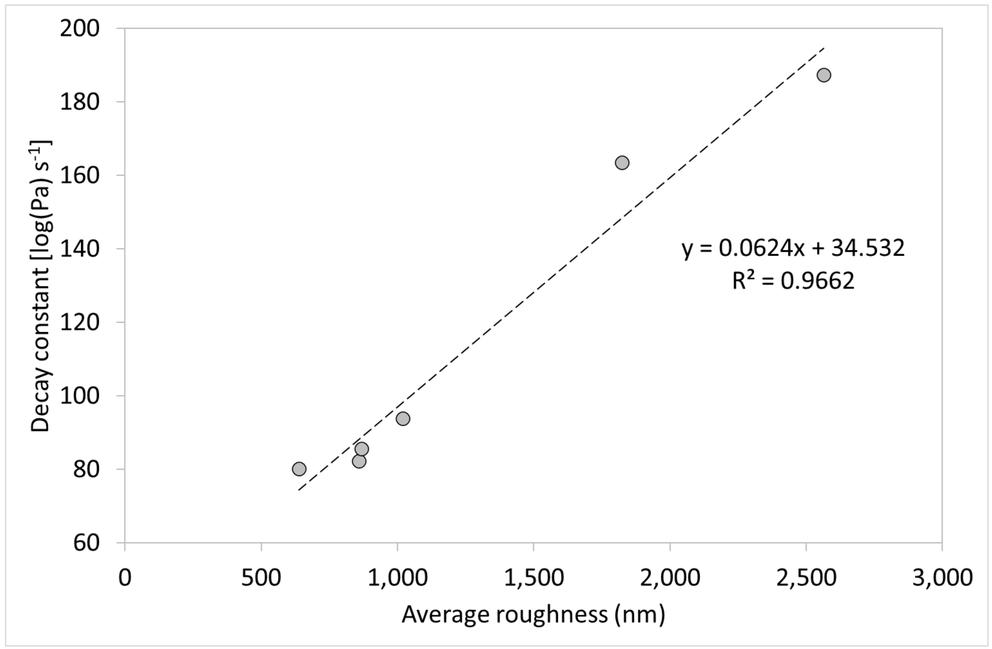

Fig 5. Effect of surface roughness on decay constant

4. Summary

The duration of the solid/solid contact during the impact is around 1.1 ms, with a 9 N maximum normal load. The maximum contact diameter between a 13 mm diameter sphere and the substrate is 0.54 mm.

The measurement takes < 5 s to perform while acoustic analysis takes < 10 s. The experimental setup is low cost, requiring only a tripod, microphone, and PC/laptop.

Substrate modulus, substrate thickness, and sphere modulus have also been determined using this method.

5. Future Work and Applications

We are currently working towards automation of the impact event, acoustic recording, and data processing. Our ambition is to develop a scalable, rapid, affordable method applicable to surface engineering.

These preliminary studies have generated highly encouraging results. We are actively seeking opportunities for collaboration and innovation with materials characterisation researchers and the tribology community.

Acknowledgements: Materials Workshop staff at the Open University School of Engineering and Innovation.