Relation between roughness and surface hardening after ultrasonic shot peening

J. Marteau[1*] and M. Bigerelle[2]

[1)] Laboratoire Roberval, UMR 7337, UTC/CNRS, Centre de Recherches de Royallieu, BP20529, 60205 Compiègne, France
[2)] Matériaux, surfaces et mise en forme, LAMIH, Université de Valenciennes, 59313 Valenciennes, France.

[*]Corresponding author for tribo-lyon2013@sciencesconf.org

1. Introduction

Tribological behavior is directly linked with the material hardness, roughness or the presence of a gradient of mechanical properties at the surface. Dealing with all the previous phenomena is difficult. This work presents a method that dissociates the hardness from surface effects. The identified hardness is then used to find a relation between surface hardening and surface roughness obtained with ultrasonic shot peening.

2. Material and processing parameters

An AISI 316L stainless steel was ultrasonically shot peened using several processing parameters. The variation of the shot diameter, the shot material, the coverage and the sonotrode vibration amplitude enabled to get eight samples having different hardness.

3. Hardness calculation

Using the method developed in [1], the hardness of all the specimens (reference + treated) and the corresponding intervals of confidence were determined.

4. Multiscale roughness analysis

Using a white-light interferometer, the surface topography was measured. As the value of a roughness parameter is directly linked with the chosen evaluation length, the surfaces of the specimens were described using approximately 50 roughness parameters, about 20 evaluation lengths and two types of filters (High-pass and Low-pass).

5. Results

Using the method presented in [1], it was confirmed that the Root-Mean-Square roughness and the standard deviation values of zero-point corrections show a clear linear relation at the scale of the indenter (15 µm). It was also shown that the indentation size effect is the same, irrespective of the processing parameters.

Then the best relation linking the true hardness and the different multiscale roughness parameters was searched. It was found that the 5-point valley height S_{5V} roughness parameter (local depth of roughness) gave the best relation with a coefficient of determination equal to 0.73, as indicated in Fig. 1. A power law was identified at a scale equal to 100 µm: this critical length corresponds to the size of the shot impacts.

This power law, characterizing the stochastic ball indentations, predicts an average hardness equal to 3.7 GPa for the reference specimen (Fig. 2) with a standard deviation of 0.25 GPa. As the experimental hardness for this specimen is equal to 3.48 ± 0.02 GPa, it validates the relation found between the 5-point valley height S_{5V} roughness and the hardness.

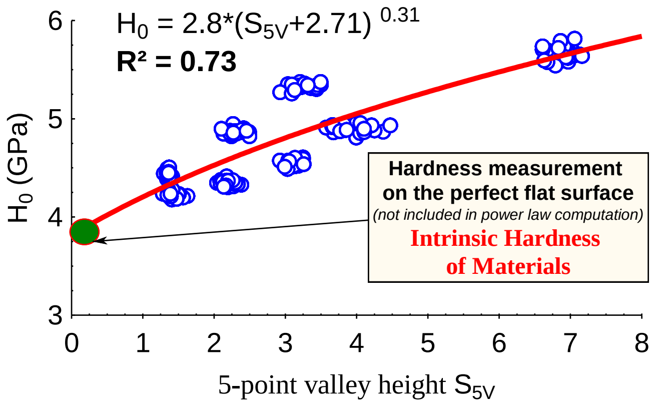

Fig.1 Experimental hardness H_0 as a function of the 5-point valley height S_{5V}.

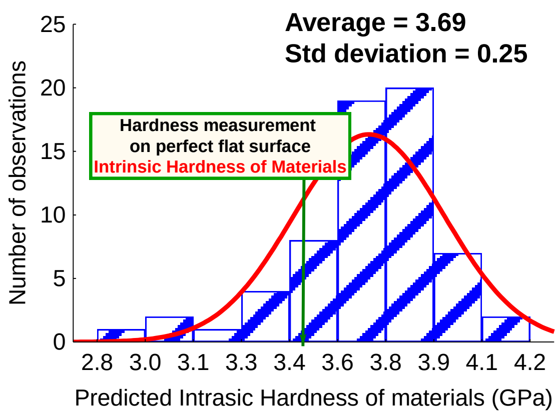

Fig.2 Predicted Intrinsic Hardness H_0 from power law $H_0 = 2.8*(S_{5V}+2.71)^{0.31}$ with $S_{5V}=0$.

6. Conclusion

The method describes in this work enables to find a relation between the material hardness and the roughness induced by the ultrasonic shot peening treatment.

7. References

[1] Marteau, J., Bigerelle, M., Xia, Y., Mazeran, P.-E. and Bouvier, S., "Quantification of first contact detection errors on hardness and indentation size effect measurements", Trib. Int., 59, 2013, 154-162.