Quantitative approach to determine the mechanical properties of sandblasted materials by nanoindentation

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1. Introduction

The tribological process occurs as a relative motion of the two contact surfaces. The characterization of mechanical properties of the involving surfaces is important for the tribological study. Nanoindentation is a common way to measure the near-surface mechanical properties. But the inaccuracy in determining the initial contact point between the indenter and the specimen is a big problem for the estimation of material properties. One of the inevitable reasons is the effect of surface roughness.

2. Material and Method

In the present work, a more accurate approach is proposed for extracting mechanical properties from nanoindentation data. Thanks to this method, the surface roughness effect on the first contact point detection can be eliminated effectively. The most significant feature of this model is the simultaneous statistical treatment for a set of the nanoindentation loading curves I, whose locations are set by a specific definition of the first contact error $\Delta h_{ci,i\in I}$ as a gap between the individual experimental loading curve i and the simulated one with Bernhardt law. This method is applied to four AlCu4MgSi specimens sandblasted with different parameters (see Table 1).

Table 1 Sandblasting parameters for 4 specimens

Name	Distance(cm)	Pressure(bar)	Angle
S1	15	1	90
S2	30	1	90
S3	30	0.5	90
S4	30	0.5	60

3. Results and discussions

The estimated macro-hardness for four specimens are in the range of 1.65-1.95 GPa with the small deviation around 0.02 GPa (see Fig.1), which is more accurate than the one given by the Nanoindentation MTS™ system using average (around 2 ± 0.3 GPa). The average of macro-hardness globally decreases with the surface roughness from S1 to S4. It is logical because a shorter distance, a stronger pressure or the vertical angle in sandblasting experiment means a higher external stress. They produce a rougher surface and create a thicker strain hardening layer in the subsurface region, which could enhance the surface mechanical properties.

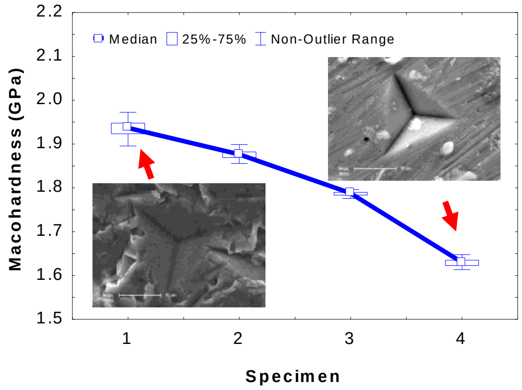

Fig.1 Macro-hardness for each sandblasted specimen

A multi-scale analysis of the roughness is applied to find the most accurate scale for the evaluation of each roughness parameter. The basic idea is that: the best scale for roughness identification is given when the best linear relation is found between the standard deviation of the zero position and the roughness parameter R_q calculated using the chosen evaluation length. This relation is found when the evaluation length is around 15 μm (Fig.2), which is in the same order of indenter. It means that the proposed model allows predicting the mechanical properties based on nanoindentation test on rough surface without bias link to the roughness itself.

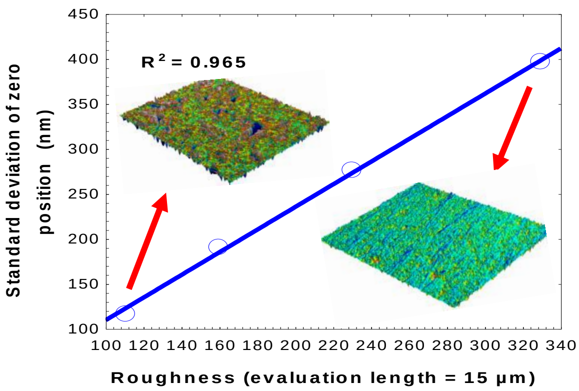

Fig.2 Linear relation between the standard deviation of zero position and the roughness parameter R_q

4. References

[1] Bigerelle M, Mazeran PE and Rachik M, "The first indenter-sample contact and the indentation size effect in nano-hardness measurement," Mat. Sci. Eng. C, 27, 2007, 1448-1451.