

Surface Characterization of Ultrasonic Shot Peening Surface

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1. Introduction

Ultrasonic shot peening (USP) is known to generate compressive residual stresses which improve life fatigue resistance. This paper is dedicated to the study of surface roughness induced by USP. Through the modification of USP conditions, a multiscale roughness analysis, [1] is carried out to seek the most relevant roughness parameters.

2. Material and treatment conditions

The material used in this study is 316L stainless steel. It was treated using different conditions. For the USP treatment, four parameters were varied: the ball material (304L and 100C6) and diameter (1 and 2 mm), the coverage rate (100%, 1000% and 10000%) and the sonotrode amplitude vibration (30, 60 or 80 μm). From the combination of these parameters, eight samples were studied. This limitation is due to a poor covering of the surface.

3. Method

The surface roughness was measured using a white-light interferometer.

It is well known that the surface roughness parameters are influenced by the evaluation length. Thus, approximately fifty surface parameters were calculated for about twenty evaluation lengths. Then, for each type of condition (*i.e.* change of ball material, change of diameter, ball materials and ultrasonic amplitude), the surface parameter enabling to distinguish the condition variation was sought.

4. Results

The effect of the diameter of the balls and the coverage rate were best depicted by the mean density of furrows but for different length scales and filters. The influence of the ball material was best described by the density of summits on the surface. The effect of the vibration amplitude depended on the ball material. Indeed, its effect was identified using the peak extreme height for the 100C6 balls (Fig. 1) whereas the density of summits was the relevant parameter for the 304L balls.

Then, a linear function was sought to link a certain roughness parameter with the tested treatment conditions. The following function including the **Mean Depth of Furrows (MDF)** was identified with a coefficient of determination equal to 0.97 (Fig. 2):

$$\text{MDF} = 0.755 + 0.213D + 0.005C + 0.074B + 0.014R$$

where D, C, B and R are respectively: the ball diameter, the vibration amplitude, the ball material (0=100C6 and 1=314L) and the coverage rate.

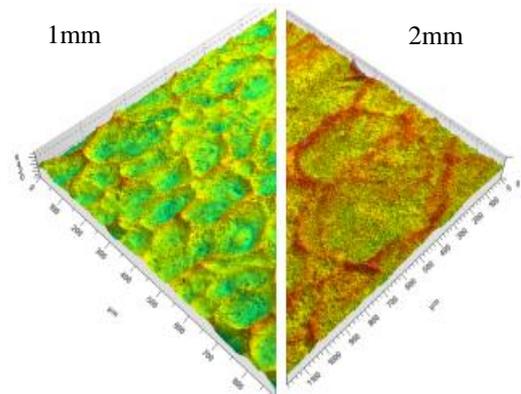


Fig.1 Diameter effect for the 100C6 balls (High pass filter, Evaluation length = 9).

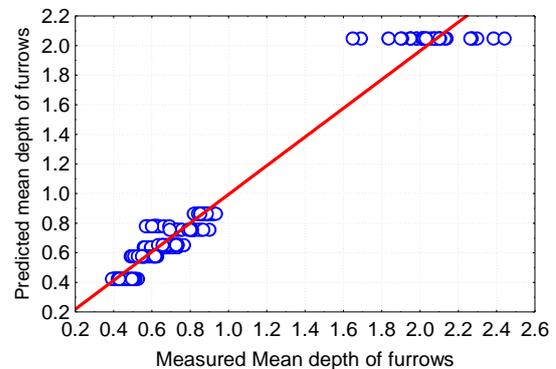


Fig.2 Predicted MDF roughness of the linear model as a function of the measured MDF roughness.

5. Conclusion

For each type of variation of the treatment conditions, a relevant roughness parameter and its corresponding length scale was identified. A linear relationship was found between the four previous types of treatment conditions and the mean density of furrows.

6. References

- [1] Bigerelle, M., Mathia, T., Bouvier, S., "The multiscale roughness analyses and modeling of abrasion with the grit size effect on ground surfaces", *Wear*, 286-287, 2012, 124-135.