Evolution of loading surface for ultrasound-assisted deformation

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Abstract: This study discusses the evaluation of loading surface associated with the phenomena of ultrasonic temporary softening and ultrasonic residual hardening and residual softening registered in the experiments for plastic deformation of aluminum and titanium in ultrasonic field. The aim was to model these phenomena in terms of the synthetic theory of irrecoverable deformation. We extend the flow rule relationships by two terms constructed on the base of microstructural processes occurring in ultrasound assisted deformation. The model results show good agreement with experimental data.

Introduction and Results

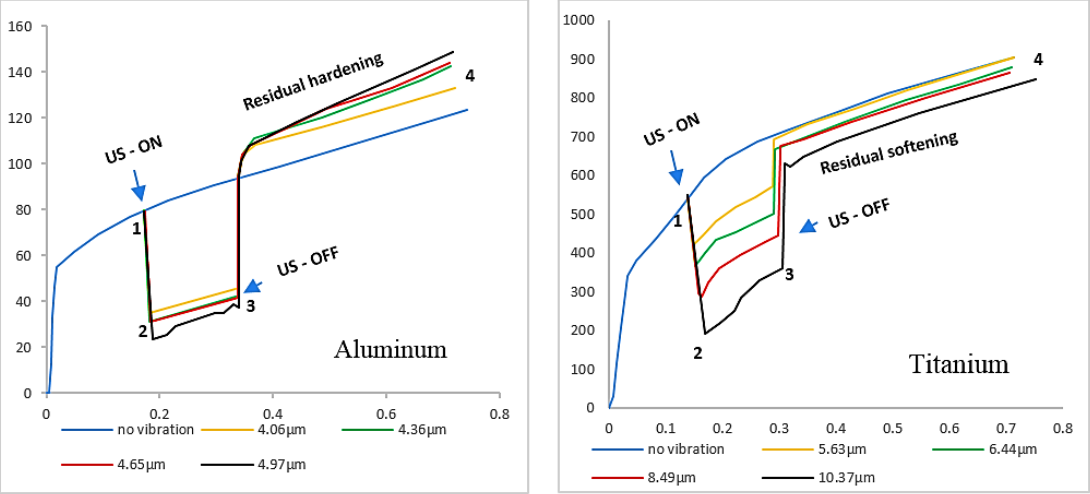
A number of studies relating the effect of ultrasound upon the deformation properties of metals can be resumed by Zhou et al. results shown in Figs.1.

Two portions can be identified:

Ultrasound assisted deformation (acoustoplasticity). The plastic flow of both aluminum and titanium takes place at stresses less compared to the ordinary loading (Figs.1, US-on). This phenomenon is referred to as ultrasonic temporary softening.

Deformation in post-sonicated period (Figs.1, US-off). The high frequency vibration can permanently change the mechanical properties of metals, which results in so called ultrasonic residual effects.

The deformation for both aluminum and titanium specimen is calculated in term of the synthetic theory. The inner surface in Fig. 3b, which corresponds to the end of sonication, clearly demonstrates that the loading point A is reached by the common action of static ($\vec{S}$) and acoustic ($\vec{u}$) vector-portions. It is obvious that $\varphi_{Nr} < \varphi_N$, i.e. the stress~strain curve runs above that corresponding to ordinary loading. Therefore, formula (14) models the phenomenon of ultrasonic residual hardening, which is observed **for aluminum**, Fig (3b) portion a-b. **With titanium**, it is clear from that $\varphi_{Nr} > \varphi_N$, i.e. the stress~strain curve locates beneath that where unidirectional load acts alone. Here, we obtain the case of ultrasonic residual softening. Fig (3b) portion a-c.



a)

b)