SURFACE ENHANCEMENT OF TI-6AL-4V USING CONVENTIONAL AND ULTRASONIC DEEP COLD ROLLING PROCESSES

A. Tolga BOZDANA

PhD *in School of Mechanical, Materials and Manufacturing Engineering, University of Nottingham*

Supervised by: Prof. Dr. Nabil N.Z. GINDY

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This research aims to enhance the surface characteristics of Ti-6Al-4V through the use of conventional and Ultrasonic Deep Cold Rolling (namely CDCR and UDCR) processes. The CDCR process incorporates high plastic deformation through the application of high static pressure on the part surface, resulting in a smooth, hardened surface with compressive residual stresses induced in the near-surface. The UDCR process is achieved by introducing ultrasonic vibrations into the CDCR process so that the part surface is exposed to dynamic loads due to high-frequency ultrasonic vibrations in addition to static load, enabling easier plastic deformation. The static loads applied in the UDCR process are considerably less than those in the CDCR process. Therefore, UDCR can be an appropriate technique for treatment of thin-walled, hard metal components in order to enhance surface characteristics without adversely affecting the part geometry.

A number of indentation tests were performed at static pressures, varying from 300 to 600 bar for CDCR and from 3.4 to 27.6 bar (i.e. from 50 to 400 psi) for UDCR, to measure the area of deformations, which were in good agreement with the values predicted by elastic-plastic contact models proposed in this study. The surface treatments were also conducted at different treatment speeds (6000 - 12000 mm/min). Both processes decreased the surface roughness (from 0.38 μm down to 0.06 μm by CDCR and 0.13 μm by UDCR at certain parameters). UDCR caused considerable increase in surface micro-hardness as compared to CDCR (from 388.25 HV to 412.4 HV after CDCR and 488.0 HV after UDCR). The compressive residual stresses of about 1000 MPa at a depth of 0.2 mm from treated surfaces were achieved by both processes, which were validated using finite element models developed in this study.