EFFECT OF ROUGHNESS ON RESIDUAL STRESSES MEASURED BY X-RAY DIFFRACTION USING CONVENTIONAL $\psi / \Omega$ GEOMETRIES

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ABSTRACT
This work investigates the behavior of the residual stress field produced by shot peening process in the samples of AISI 1070 steel as a function of subsequent mechanical polishing of the sample surface. Different depths of the near surface zone were probed by X-ray measurements and respective residual stresses values were confronted with the surface roughness parameter, Ra, varied by mechanical polishing. Three regimes of the sample’s thickness variation as a function of surface roughness are identified.

Keywords: Residual stress, X-ray diffraction, roughness.

INTRODUCTION
Shot peening is a widely used method of surface treatment for fatigue strength enhancement of metallic components. It is generally accepted that the creation of compressive residual stress field on the surface is beneficial for work-piece lifetime due to increased tensile strength on the surface (Löhe, 2002). The change of surface roughness is another typical consequence of shot peening processes which has to be taken into consideration, because the surface roughness is the additional parameter influencing fatigue strength of components. Valleys of rough surfaces act as stress concentrators, making fatigue strength decrease with increasing surface roughness (Arola, 2002). A straightforward solution for improving the fatigue strength performance of components is to improve the surface finish after shot peening, performed with the help of mechanical, chemical or electrochemical polishing.

Although the effect of the residual stress and the roughness on the fatigue-life has being extensively studied for many decades, the investigation of the alterations in the residual stress field induced by changes in the surface roughness, as well as the eventual interference of the roughness on the residual stress measurements by conventional X-ray diffraction methods, received much less attention. The surface roughening produced by shot peening can induce a large variation of a local residual stress field across the metal surface within thicknesses comparable with the mean height value of the peak-to-valley of the surface (Ra). A systematics of such a variation (higher compressive stresses under valleys and lower compressive stresses under peaks) can produce systematic deviations in residual stress...
measurements by X-ray diffraction method. In this study, we investigated the effect of the surface roughness modification by mechanical polishing on residual stress measurements in conventional \( \Psi/\Omega \) X-ray diffraction geometries of strain measurements. The shot peening process was used to produce a high level of residual stresses on the surface of AISI 1070 steel samples.

RESULTS AND CONCLUSIONS

Three sets of the residual stress values obtained from the strain versus \( \sin^2 \psi \) plots are shown in Fig. 1 as a function of the mean roughness \( Ra \). Each set of data corresponds to a different average penetration depth of X-rays, \( \tau \), in the sample, which in turn is defined by the intervals of \( \psi \) angles considered in the analyses. Relation between \( Ra \) and the total thickness of the removed sample layer estimated by mass loss measurements is shown in Fig. 2.

![Fig. 1 - Residual stress versus Ra parameter for three average effective thickness of surface](image1)

![Fig. 2 - Relation between Ra and the average thickness of the removed surface layer](image2)

Three distinct regimes (shown by symbols with different colors) of \( Ra \) behavior as a function of the surface polishing process can be identified in Fig. 2. The alterations in the residual stress values correlate perfectly with these three modes of the surface modification in case of small thicknesses of probed surface layers (Figure1).

REFERENCES
