Shot Peening Induced Residual Stress Profile and Thermal Stability within a 7xxx Series Aluminum Powder Metallurgy Alloy

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Aluminum powder metallurgy (PM) is an emerging low-cost metal forming technology that is now the preferred means of fabricating a host of automotive components. Unfortunately, market penetration has been dampened by the small amount of residual porosity that is inevitably inherent in PM processed components. This feature imparts reduced mechanical properties when compared to wrought systems and this gap becomes particularly pronounced when considering dynamic properties such as fatigue. To mitigate this issue, a study was launched to quantify the fatigue gains that could be realized through shot peening of aluminum PM products. Shot peening has long been used to combat fatigue failures in conventional (cast, wrought, etc.) materials by the introduction of compressive residual stresses in the surface of treated components. Quantitative analyses of the residual stresses that can be achieved by shot peening of aluminum PM alloys are critical to the development of optimized fatigue properties yet such data are not available in the open literature. Hence, the central objective of this study at Chalk River was to conduct pioneering studies in this area.

A peening intensity of 0.4 mmN was chosen from a previous study [1] for further analysis by quantitatively measuring the induced residual stress profile by neutron scattering at CNBC. As this work is intended as a baseline for implication in under the hood automotive applications, the effects of thermal exposure on the residual stress profile was also of concern. Samples were produced by press-and-sinter PM processing, followed by heat treatment to the T6 condition and peened to 0.4 mmN intensity. Select samples were also exposed for 1000 hrs to elevated temperatures (80^{o}C, 120^{o}C and 160^{o}C) so as to study the thermal stability of the peening-induced residual stresses. In order to determine an unstressed lattice spacing of the system, filings were taken from the samples and x-ray diffraction (XRD) was utilized. The residual stress profile devised from our initial studies at CNBC within the peened component can be seen in Figure 1. Upon comparing to literature of a 7075-T651 sample peened in a similar manner [2], our results show a considerably thinner compressive layer. Upon further study it was found that in the press-and-sinter samples, there is a significant chemical gradient at the surface (Figure 2). This is a result of Zn vaporizing off the free surface during sintering. It is believed that this reduced Zn content could be having an effect on the lattice spacing of the system. Work is ongoing to determine if this chemical gradient is affecting the lattice parameter, which is used as the unstressed condition in calculating strain. Once this is determined, the thermally exposed samples will be studied to show the stability of the residual stress profile following elevated temperature exposure.

References

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[2] M. Benedetti, V. Fontanari, P. Scardi, C.L.A. Ricardo, M, Bandini. 2009. Reverse bending fatigue of shot peened 7075-T651 aluminum alloy: The role of residual stress relaxation. International Journal of Fatigue 31 (2009) 1225-1236.

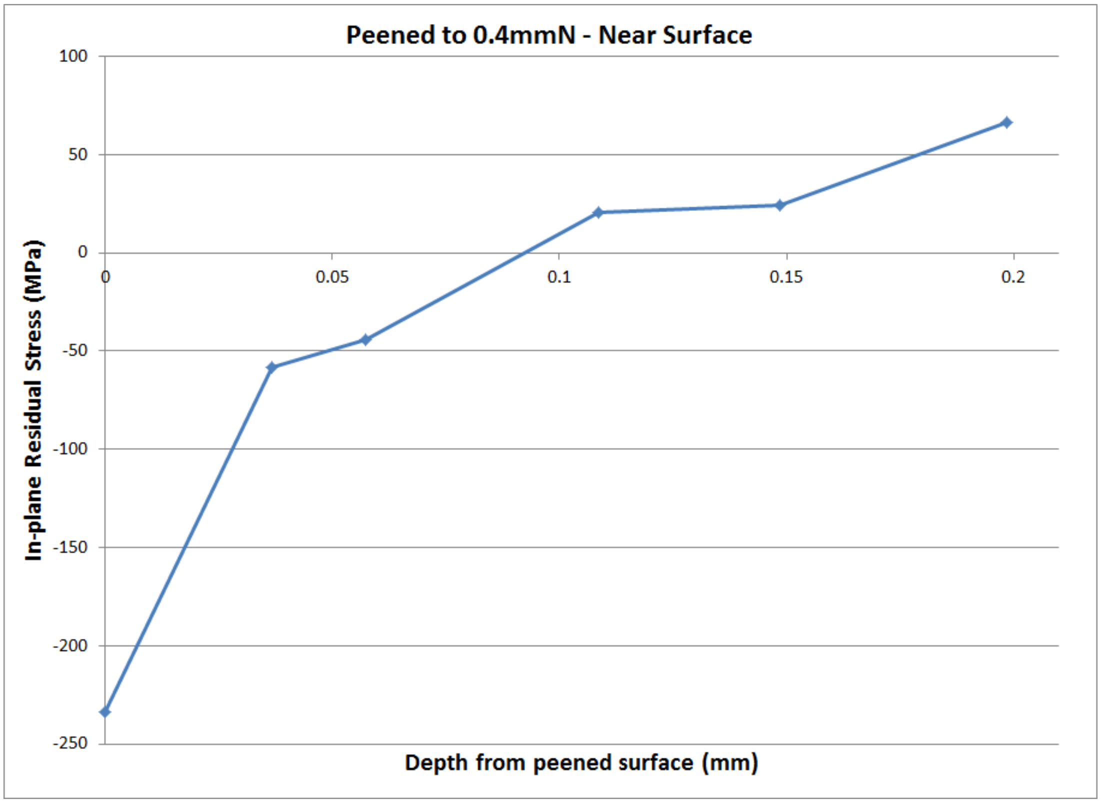

Figure 1 Residual stress profile measured at CNBC in a peened specimen of a 7xxx series aluminum PM alloy.

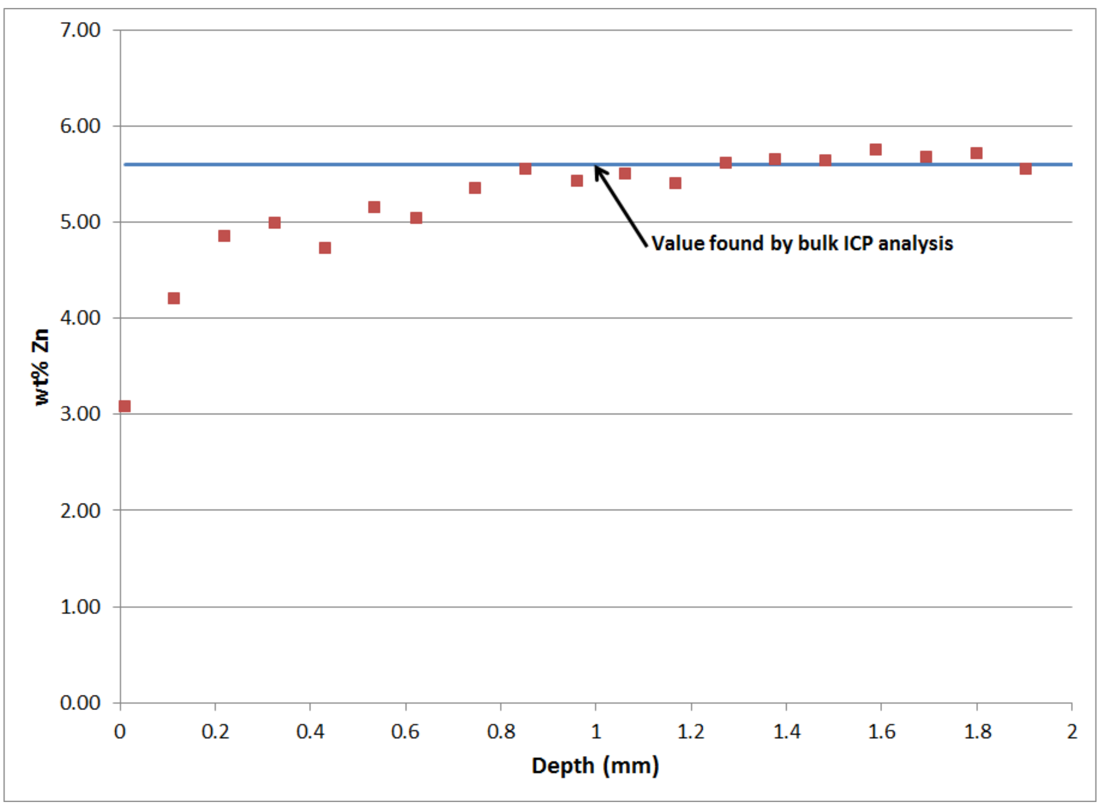

Figure 2 Quantitative analysis of the sub-surface Zn depletion profile caused by evaporative losses during sintering. Data were acquired through electron probe micro-analyses using a wavelength dispersive detector.