Impact of Shot Peening Forming on Surface Integrity of Aluminum Alloys

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Shot peen forming is a dieless process performed at room temperature which has been widely used to form various aircraft components. Shot peening usually produces spherically-shaped dents (Figure 1) on the peened component after small, round steel shots impact the surface of the work piece, resulting in stretching of the material in the near-surface region and local plastic deformation that result in residual compressive stress. The compressive stress induces a convex curvature on the peened side. In order to achieve weight reduction and improved service life, integrated construction panels are employed as mainly load-bearing components in wings or the fuselage of large aircraft. Due to the overall size and the complex curves of the large panels, large size shots are used to improve the efficiency of shot peen forming.

In the present study, the microstructure evolution in the near-surface layer induced by a shot peen forming process is investigated. Due to the use of large shots, deep dents are generated on the surface of the alloy and defects, such as microcracks, may develop around the dents. The fatigue life of the formed panels may be influenced by such defects. Thus, it is essential to determine the defect distribution around the dents. The objective of the investigation is to understand the effect of processing parameters on the microstructure in the near-surface layer and, therefore, to optimize shot peen forming for improvement of the mechanical properties of the components.

It was revealed that severe plastic deformation and, consequently, a modified microstructure, including ultrafine grains, microcracks and redistribution of intermetallic particles, were introduced to the near-surface layer (Figure 2). The coarse intermetallic particles in the near-surface layer beneath the dents were broken up into finer ones and redistributed during shot peen forming, which retards the propagation of cracks and, hence, improves the fatigue properties of the alloy. Further, an ultrafine grained structure was produced in the near-surface layer of the dent region on the aluminium alloy subjected to shot peen forming (Figure 3). The co-action of dislocation activities and dynamic recrystallization was considered to be the main mechanism responsible for grain refinement. The thicknesses of the refined grain layers increased with the increasing air pressure.

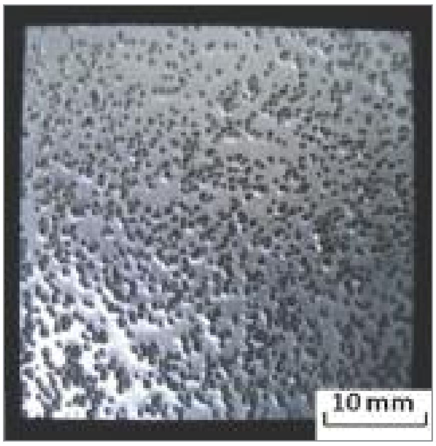

Fig. 1 Optical image of the alloy surface after shot peen forming.

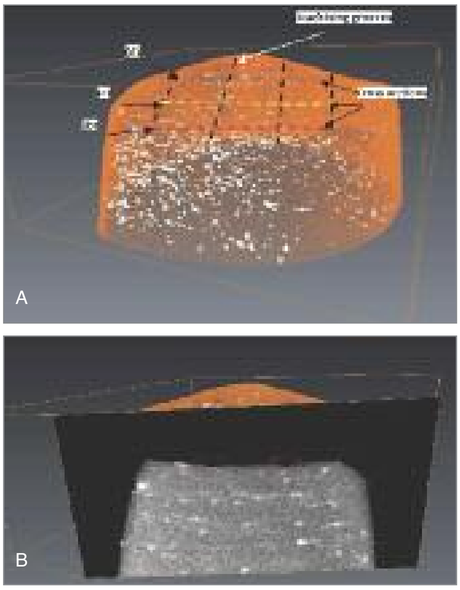

Fig. 2 3D X-ray volume reconstruction of a dent on the surface of the alloy peened at 0.5 MPa.

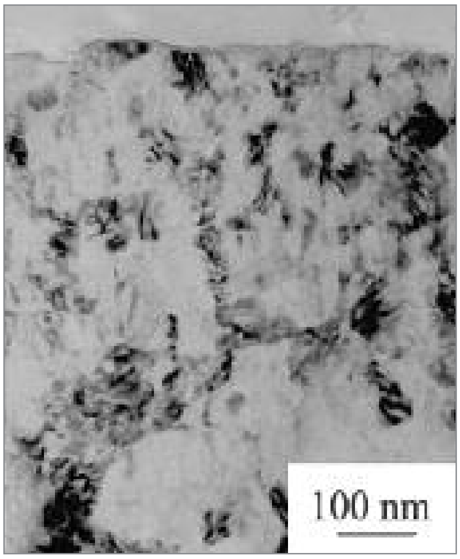

Fig. 3 Transmission electron micrograph of a cross section of the near-surface region at the centre of a dent, revealing an altered microstructure characterized by ultrafine grains.

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Publications: P. Gai, Y. Zeng, X. Zhou, G. E. Thompson. Microstructure Evolution in the Near-Surface Layer of AA2024 Aluminum Alloy during Shot Peen Forming, submitted to Acta Materialia.