

Mechanistic study of residual stresses and damage induced by shot peening

Shot peening is a surface treatment known for increasing the fatigue life of mechanical parts. The peening process induces plastic strain at the surface of the material, generating a residual stress gradient. The compressive stress state is opposed to service tensile stresses, thus delaying the onset of cracks. The enhancement of fatigue life is a competition between the compressive stress state and the induced damage from plastic strain, microcracks or grain failure [1].

During service, fatigue cracks will be formed at the weakest point of the microstructure with respect to the load. This study deals with the understanding of the damage mechanisms at the structural and microstructural levels.

A single phased model material will be analysed for this study where plastic strain prevails compared to other deformation mechanisms. Aluminum alloys will therefore be tested.

After industrial shot peening of specimens, average values of mechanical fields (stress, plastic strain) will be determined and compared to numerical models [2]. The evolution of those fields will be observed during few tension-compression cycles using an in-situ tensile machine. Microstructural observations in the depth of specimens will be carried out to determine the change in the microstructure.

In order to determine the sources of damage after impact, single shot experiments will be performed on a laboratory test bench. The effect of the interactions between few shots on the microstructure will be addressed (microhardness, cracks) and subsequent in-situ tensile cyclic tests will be performed where the mechanical fields and damage mechanisms are determined.

Research and Work plan

The work plan will be twofold: the study of damage induced by the industrial shot peening and a study on individual shots

1. Material behavior:
 - Cyclic behavior
 - Dynamic high speed behavior
2. Industrial shot peening :
 - Microstructural characterization before and after shot peening, hardness profile
 - Stress analysis and measurements of X-ray diffraction peak broadening within the depth
 - In situ low cycle fatigue tensile tests on a X ray diffraction goniometer to study the relaxation mechanisms (stress level and peak width)
3. Individual shot peening and damage analysis:
 - Controlled single (velocity and diameter) and multiple (coverage rate) impacts on a polycrystal. Micro hardness measurement in the vicinity of impacts.
 - Post mortem characterization of the impacted microstructure to understand the deformation mechanisms of a single shot and the interaction between several shots.

[1] G.W. König, "Life Enhancement of Aero Engine Components by Shot Peening: Opportunities and Risks" in , 2006, in Shot Peening (ed L. Wagner).

[2] P. Renaud, "Modélisation numérique du grenaillage des pièces initialement cémentées ou carbonitrurées", PhD Thesis Arts et Métiers ParisTech, 2011.

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Research field: Mechanics of Materials, Material Science, Process

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