A Comparative Review of Effect of Ultrasonic Shot Peening on LCF Behavior of the Alloys

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Abstract: The low cycle fatigue (LCF) behaviour of AA7075, AA2014, and austenitic stainless steel was studied in relation to ultrasonic shot peening (USSP) treatment, with all three materials sharing nearly identical parameters for ultrasonic shot peening treatments of varying durations. Ultrasonic shot peening is a recent method for causing high plastic deformation on the surface of materials. Nanosized grains develop on the surface of the materials as a result of the procedure. If performed correctly, ultrasonic shot peening can be observed in some tests to increase the surface hardness and fatigue resistance of the material to which it is applied. In this research, the effects of USSP on various materials are compared. The LCF life of AA7075 has enhanced by 54 percent thanks to the low strain amplitude. Both AA2014 and austenitic stainless steel have demonstrated that, when subjected to low strain amplitude, there is an improvement in LCF life as well as a delay in fatigue fracture on the material.

1. Introduction

Deformation by purpose a component's surface by hitting it with a hammer is known as peening in the cold working world [1], [2]. In most cases, the quality index of cast alloy will be rather low [3]. The elastic subsurface bulk material stops the top layer from expanding during peening. The top layer's compressive residual stresses are countered by tensile residual stresses elsewhere in the structure, resulting in a favourable compressive residual stress distribution. Shot peening is a low-cost, straightforward, and dependable method of enhancing wear resistance. Many researchers have investigated shot peening as a means to protect components from wear and fatigue [4]–[6]. This approach bombards a surface with microscopic hard particles with dimensions in the order of millimetres, which are comprised of cast iron, steel, or glass [7]–[9]. The surface deforms significantly as a result of the impact forces created by the hard particles. As long as hard particles impact the surface, the deformed zones will continue to grow in size [10], [11].

Recently, the sub-micrometre or nanoscale grain refining processes of a wide range of metals and alloys have been widely explored, both in bulk [12], [13] and at the surface, over many decades. In metals and alloys, a variety of methods, such as equal channel angular pressing (ECAP), friction sliding, surface mechanical grinding treatment, and the conventional shot peening (CSP) [14], [15], have resulted in considerably polished grains.

Using the most recent study, researchers have verified that USSP can be used to produce nanostructure grains on metals [16], [17] and alloys, which has already piqued the interest of scientists all over the globe. According to the USSP technique, the USSP approach provides the promise of considerable improvement in metal treated with ultra-fined grains on a nanoscale scale via the USSP method [1], [18].

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2. USSP Treatment

2.1 LCF Behaviour

In the last year, there is several number of studies have reported analysing how LCF behaviour on various materials affects the results of USSP treatment on the selected materials. Due to the fact that different materials have a different outcome on the treated specimen, the present study focuses more on the full details on the low cycle fatigue behaviour of the treated USSP specimen depending on the parameter and material has up to current information until 2022. New studies on USSP treatment in a variety of conditions are compiled and displayed in Table [1].

Table [1]: Report work on USSP treatment on varying materials

Material	Parameter	Ref.
AA7075	• 3mm hard steel ball • 80μm amplitude • 0.5, 1, 3 and 5 min	[19]
Ti-6Al-4V	• 3mm 100C6 grade steel hard ball • 80μm amplitude • 45, 60, 90min	[20]
Austenitic Stainless steel	• 3mm hard steel ball • 80μm amplitude • 3, 6, 10, 14, and 18min	[21]
AA2014	• 3mm hard steel ball • 80μm amplitude • 10min, 15min and 20min	[22]
Ti-13Nb-13Zn	• 3 diameter chrome steel • 2,4,6 min	[23]
AA7075	• 1.4 – 3mm cast steel ball • 32 - 40μm amplitude	[24]