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Influence of Defects, Surface Roughness and HIP on the Fatigue Strength of Ti-6Al-4V Manufactured by Additive Manufacturing

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Abstract

The additive manufacturing (AM) is expected to be a promising manufacturing process for high strength or hard steels such as Ti-6Al-4V for the aerospace industry components having complex shapes. However, disadvantage or challenge of AM is presence of defects which are inevitably contained in the manufacturing process. This paper focuses on the effects of defects, surface roughness and Hot Isostatic Pressing (HIP) process on the fatigue strength of a Ti-6Al-4V manufactured by AM. Defects were mostly gas pores and those made by lack of fusion. Many defects which were formed at subsurface were eliminated by HIP and eventually HIP improved fatigue strength drastically to the level of the ideal fatigue limit to be expected from the hardness. Surface roughness had strong detrimental influence on fatigue strength. The method for estimating the effective size $\sqrt{area}_{\mathrm{effmax}}$ of irregularly shaped defects and interacting adjacent defects was proposed from the viewpoint of fracture mechanics.

Keywords: Additive manufacturing (AM), Fatigue strength, Ti-6Al-4V, Defects, The $\sqrt{area}$ parameter model, Pores, Lack of fusion, HIP, Surface effect, Statistics of extremes

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1. Introduction

The additive manufacturing (AM) is expected to be a promising new manufacturing process for components having complex geometry; for example see Fig. 1 [1]. High strength alloys such as Ti-6Al-4V and also light metals such as Al alloys are expected to be used for the aerospace