Investigation of Ti-6Al-4V alloy Acoustic Softening

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Investigation of Ti-6Al-4V alloy Acoustic Softening

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Abstract

High power ultrasonic vibration is widely used for improving manufacturing processes such as machining and metal forming. High frequency mechanical vibration affects material properties and friction forces in contacting surfaces. Flow stress reduction under superimposed ultrasonic vibration is called as acoustic softening. The amount of this parameter should be determined for ultrasonic assisted metal forming processes. For determination of this parameter for workhorse Ti-6Al-4V alloy, experimental setup was designed and fabricated. Then tensile test under longitudinal ultrasonic vibration was performed for different ultrasonic powers. Results show that ultrasonic vibration has considerable effect on plastic behavior of the alloy and decreases flow stress. Also, increasing ultrasonic power leads to higher acoustic softening. Yield stress reduction up to 9.52%, ultimate stress reduction up to 4.55% and elongation up to 13% were obtained at 340W ultrasonic power. After applying ultrasonic vibrations and its termination, hardness of specimens were measured in which increase up to 9% was observed.

Keywords: Ultrasonic vibration, Acoustic Softening, Ti-6Al-4V Alloy, Mechanical Property, Longitudinal vibration.

1.Introduction

Firstly, Blaha and Langenecker in 1955 introduced the using of superimposed ultrasonic vibration during metal forming. They investigated the ultrasonic vibration effect on Zinc crystal behavior. Then, many researchers have been investigated the influence of ultrasonic vibration as high frequency low amplitude mechanical wave on different manufacturing processes such as wire drawing [1], grinding [2], forming [3-6], casting [7,8], machining [9] and impact treatment [10,11]. Results show helpful effects such as reduction in forming force, reduction in flow stress, interface friction reduction, improvement in the surface quality and processing efficiency. These effects attributed to the following mechanisms: acoustic softening [12,13], acoustic hardening [14], thermal softening [15], friction reduction [16,18] and stress superposition [19-21]. Two former mechanisms declare changes in material properties while third term relates to change in interface friction and the last mechanism states change in loading condition. Acoustic softening is described as reduction of flow stress during superimposing ultrasonic vibration while acoustic hardening refers to increasing flow stress beyond normal condition after ultrasonic vibration stoppage. Also, these acoustic effects depend on ultrasonic parameters and material property and different material shows different behavior. The thermal softening is due to frictional heating.

On the other hand, Ti-6Al-4V is the most widely used titanium alloys and it has wide application in the fields of aerospace, chemical industries, medical prostheses, automotive, marine, jewelry industries and sport equipment [22]. This alloy possess a number of advantageous properties, such

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