ABSTRACT

In the past, researchers thought that the introduction of ultrasonic-assisted vibration in tapping processes could generate smaller tapping torque than nonultrasonic-assisted vibration process. However, since the ultrasonic vibrator’s temperature increases with processing time, the temperature of the workpiece may get too high. As a result, the ultrasonic vibrator may generate an unstable resonant frequency and amplitude, which can cause poor quality in the workpiece. This research used ultrasonic-assisted vibration and LabVIEW software to develop an ultrasonic-assisted vibration automatic tracing frequency system (UAVATFS). With this orthogonal array experiment, UAVATFS and the appropriate processing parameters (vibration amplitude, vibration frequency) were used to perform tapping on a titanium alloy workpiece. The effect of using this system on internal thread processing was investigated.

Keywords: Automatic Tracing Frequency System, Tapping, Thrust Force, Titanium Alloys, Torque, Ultrasonic-Assisted Vibration

INTRODUCTION

Titanium alloys have excellent mechanical properties and higher specific strengths (tensile strength/weight) than aluminum, magnesium and nickel alloys. Thus, titanium alloys have been widely used in the aerospace, automotive, communications electronics and medical industries. Nevertheless, there are increasing needs for high quality, high precision and a large number of internal threads. For example, the US F-22 raptor fighter jet uses titanium alloy parts for 41% of the total airplane weight. On the other hand, titanium alloy has low thermal diffusivity (16%-25% of steel’s). Since cutting heat dissipation is difficult and the titanium al-

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loy has good metal compatibility, the tapping process is prone to cause the built-up edge (BUE) phenomenon (Lei & Liu, 2002; Ribeiro, Moreira & Ferreira, 2003; Che-Haron & Jawaid, 2005; Singh & Khamba, 2006; Sun, Brandt & Dargusch, 2009). Moreover, due to the low elastic modulus of titanium alloy, large elastic rebound occurs on the processing surface and the tap relief face is prone to produce severe frictional torque, which can cause small taps to get stuck and break in an internal threaded hole. To solve this breakage problem in the tapping process, many researchers suggest assistance with a constant frequency vibration. However, in tapping processes, due to material removal and temperature increases, vibration assistance may become unstable and seriously affect the quality of the product. Therefore, ultrasonic-assisted vibration and LabVIEW software were used to develop ultrasonic-assisted vibration automatic tracing frequency system (UAVATFS). With this orthogonal array experiment, UAVATFS and the appropriate processing parameters (vibration amplitude, vibration frequency) were used to perform tapping on a titanium alloy workpiece. The effect of UAVATFS on internal thread processing was thus investigated.

THEORIES ON ULTRASONIC-ASSISTED TAPPING PROCESS

Ultrasonic Processing System

The ultrasonic-assisted vibration processing system mainly comprises of an oscillating circuit generator, a signal amplifying circuit, a vibrator, an amplitude amplifier (horn) and tool. According to the principle of ultrasonic vibration, the oscillating circuit generates oscillating power, and then the oscillating power, through piezoelectric material, converts alternating voltage into vibration across the thickness and amplifies the amplitude using a set of horns. This vibration is then transmitted to the tool or the target workpiece to produce vibrations to augment the traditional processing, as shown in Figure 1. A general oscillating circuit is an

Figure 1. Vibrator vibration mode
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