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Variation characteristic of drilling force and influence of cutting parameter of SiCp/Al composite thin-walled workpiece

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Abstract In this paper, the variation characteristic of the drilling force, and the influences of cutting speed, feed rate, and workpiece thickness on the drilling force, were evaluated when drilling a silicon carbide particle reinforced aluminum matrix (SiCp/Al) composite thin-walled workpiece with a high volume fraction. Under the condition that the workpiece thickness was less than the drill tip height, three characteristic stages of drilling force variation were proposed. The results indicate that there is a significant difference between the variations in the drilling force when drilling a thin-walled workpiece compared to thick-walled workpiece. When the chisel edge drills out the lower surface of the workpiece, there is an abrupt decrease in the thrust forces of the thin-walled and thick-walled workpieces. In addition, there is an abrupt decrease in the torque of the thick-walled workpiece, whereas that of the thin-walled workpiece increases. According to the thickness of the thin-walled workpiece, the instant of the abrupt decrease in the thrust force may lead or lag behind the theoretical instant at which the chisel edge reaches the lower surface of the workpiece without deformation. When drilling a thin-walled hole, the cutting speed has a slight influence on the thrust force, and there is a slight increase in the torque in accordance with an increase in the cutting speed. The thrust force and torque increase in accordance with an increase in the feed rate. When drilling a thin-walled workpiece with a thickness of 1 mm, the critical thickness of workpiece cracking decreases in accordance with an increase in the cutting speed, and increases in accordance with an increase in the feed rate. When drilling a thin-walled workpiece with a thickness of 0.5 mm, the concave deformation of the workpiece and the critical thickness of the workpiece cracking increase in accordance with an increase in the feed rate. However, the increment in the critical thickness of the workpiece cracking is less than that in the concave deformation of the workpiece.

Keywords SiCp/Al composites · Thin-walled workpiece · Drilling · Drilling force

1 Introduction

Silicon carbide particle reinforced aluminum matrix (SiCp/Al) composites have received significant research attention in recent years due to their excellent mechanical physical properties [1–4], which offer major economic benefits. They have numerous possible applications in aviation, aerospace, electronic devices, nuclear energy, and the automobile industry, among others [5–7]. Due to the requirement for lightweight components, thin-walled monolithic components have been increasingly employed in the aerospace industry. Moreover, thin-walled drilling is critical to several industries. However, SiCp/Al composites contain a large number of SiC ceramic particles which have a high hardness and good wear resistance [8], thus, increasing the difficulty of the cutting process of SiCp/Al composites [9, 10]. This is especially true for SiCp/Al composites with high volume fraction of micron-sized SiC

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