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A Review Paper on Effects of Drilling on Glass Fiber Reinforced Plastic

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Abstract

Drilling is an important process for making and assembling components made from Glass Fiber Reinforced Plastic (GFRP). Various processes like conventional drilling, vibration assisted drilling and ultrasonic assisted drilling have been attempted in order to maintain the integrity of the material and obtain the necessary accuracy in drilling of GFRP. This paper attempts to review the influence of machining parameter on the delamination damage of GFRP during drilling. In conventional machining feed rate, tool material and cutting speed are the most influential factor on the delamination hence machining at higher speed, harder tool material and lower feed rate have lesser delamination of the GFRP. Vibration assisted drilling and Ultrasonic assisted drilling have lesser thrust and hence lesser delamination compared to conventional drilling, which indicates that both vibration assisted drilling and Ultrasonic assisted drilling are more appropriate for drilling of GFRP.

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Keywords: GFRP; Drilling; Feed Rate; Thrust Force; Cutting Speed; Tool Material; Delamination;

1. Introduction

Glass fiber reinforced plastic (GFRP) composites have been widely used in engineering application such as automotive, aircraft and manufacture of spaceships and sea vehicles' industries due to their significant advantages

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over other materials. They provide high specific strength/stiffness, superior corrosion resistance, light weight construction, low thermal conductivity, high fatigue strength, ability to char and resistance to chemical and microbiological attacks. As a consequence of the widening range of applications of GFRP, the machining of these materials has become a very important subject for research [1, 2]. Machining composite materials is a rather complex task owing to their heterogeneity, anisotropy, and high abrasiveness of fibers, and it exhibits considerable problems in drilling process such as delamination, fiber pull-out, hole shrinkage, spalling, fuzzing and thermal degradation [3]. Several non-traditional machining processes such as laser cutting, water-jet cutting, ultrasonic cutting, electro discharge machining, etc., have been developed for application on FRPs for machining holes. Due to the anisotropic and inhomogeneous structure of FRPs, drilling FRPs causes some problems, which do not occur in other materials. Among the defects caused by drilling, delamination around the drill hole site appears to be the most critical, which can result in a lowering of bearing strength and can be detrimental to durability by reducing the in-service life under fatigue loads [4]. Delamination can often become a limiting factor in the use of FRPs for structural applications [4–7]. Therefore, addressing how to improve the quality of holes in drilling of FRPs is imperative.

Thrust force has been considered as the cause of delamination by several researchers and it is believed that there is a 'critical thrust force' below which no damage occurs. Vibration drilling is a branch of vibration cutting, which is fundamentally different from conventional drilling. The vibration drilling technique has attracted extensive interest in recent years. Both the theoretical investigations and experimental results have indicated that the machining quality of the drilled holes can be improved, as well as the thrust force being reduced by means of vibration drilling metals [8–11]. Some researchers, on the other hand, have conducted experiments to recognize the effect of vibration-assisted drilling on thrust force and delamination [12-14]. These studies showed that applying vibration may reduce the amount of thrust force, delamination and wear of tool. As well as applying ultrasonic assisted drilling reduces the thrust force and therefore the drilling induced delamination dramatically [15]. This review paper shows effect of different machining process on delamination of GFRP and this will help to choose better machining process to reduce delamination while drilling of GFRP.

2. Conventional Drilling

Drilling is an essential operation in the assembly of the structural frames of automobiles and aircrafts. The life of the joint can be critically affected by the quality of the drilled holes [16].

2.1 Delamination mechanisms

Damages associated with drilling FRP composites were observed, both at the entrance as well as at the exit of the drilled hole, in the form of peel-up and push-out delamination, respectively [17].

2.1.1 Peel-up at entrance

Peel-up delamination occurs as the drill enters the laminate and is shown schematically in Figure 1(a). After the cutting edge of the drill makes contact with the laminate, the cutting force acting in the peripheral direction is the driving force for peel-up delamination. It generates a peeling force in the axial direction through the slope of the drill flute. The flute tends to pull away the upper laminas and the material spirals up before it is machined completely. This action results in separating the upper laminas from the uncut portion held by the downward acting thrust force and forming a peel-up delamination zone at the top surface of the laminate. The peeling force is a function of tool geometry and friction between the tool and work piece [18].

2.1.2 Push-out at exit

Push-out delamination occurs as the drill reaches the exit side of the material and is shown schematically in Figure 1(b). As the drill approaches the end, the uncut thickness gets smaller and the resistance to deformation decreases. At some point, the thrust force exceeds the interlaminar bond strength causing an exit delamination zone as the tool