Experimental evaluation of laser cut quality of glass fibre reinforced plastic composite

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ABSTRACT

Fibre reinforced plastic is a high strength and low weight material and is often used in aerospace industry, or even as our everyday products. The traditional machining of this material is difficult as the tool will continuously encounter alternate matrix and fibre materials, whose response to machining can vary greatly. Because of this, a noncontact material removal process like laser machining offers an attractive alternative. The objective of this study is to assess the quality of cut surface of glass fibre reinforced plastic by single-pass and double-pass laser beam. A first-order orthogonal design has been adopted to conduct experiments where the nozzle diameter, material thickness, and cutting speed were the input laser variables and the roughness of the cut surface and kerf width at the irradiation and exit sides were the output. The results show that the quality of cut surface produced by double-pass beam appeared to be much better than that produced by a single-pass laser beam. The model equations developed indicate that the effects of input variables on the output are different in single-pass and double-pass beam. The double-pass beam produced lower kerf width compared to single-pass beam and kerf width was smaller at the exit side. While the single-pass beam produced better surface finish than the double-pass beam. Moreover, the effect of nozzle diameter on both the surface roughness and kerf width was found to be significant. The surface finish and kerf width were better when the nozzle diameter was smaller.

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1. Introduction

Glass, aramid and carbon are the three main fibers used to reinforce plastic materials. Glass is the most widely used reinforcement fiber and is the lowest in cost. Glass fiber reinforced plastic (GFRP) has high strength-to-weight ratio; good dimensional stability; good heat resistance to heat and cold, and is moisture and corrosion resistant; good insulation; ease of fabrication and relatively low cost [1]. Conna and Mathew [2] in their review article has mentioned that the texture and behavior of the material are different in case of the fibre reinforced plastic (FRP) as it has uncommon fibre and matrix properties and the fibre orientation and relative volume of the matrix and the fibre also influence its behavior. Conventional machining of this material will be difficult as the tool will continuously encounter alternate matrix and fibre materials, whose response to machining can vary greatly. This is because the tool encounters a low temperature soft epoxy matrix and brittle glass fibres in the case of glass-epoxy composite. Due to this variation in the property of the constituent materials, composites, in general, are difficult to machine. In view of this, a noncontact material removal process like laser machining offers an attractive alternative.

Iorio et al. [3] have observed that there are two commonly used lasers in the industry namely the carbon dioxide (CO2) laser and neodymium-doped yttrium aluminum garnet (Nd:YAG) laser with the former being a gas laser and the latter a solid state laser for cutting a variety of materials. Besides these two lasers, fibre and disk lasers are also suitable for cutting composite materials.

The absorptivity of the material has the largest influence on laser power requirements. The material absorptivity determines the fraction of the impinging radiation energy that is actually absorbed by the material. The remainder of the beam energy is reflected back into the environment. The absorptivity value can vary much depend on the wavelength of the beam, surface roughness of the material and temperature, phase of the material and the use of surface coating. The wavelength of the YAG laser (1.06 µm) is transparent or has low absorptivity to glass. Thus, it is not an ideal candidate for the cutting of glass-fibre reinforced materials. While for CO2 laser, it is feasible due to the high surface absorption of glass at 10.6 µm. The laser beam has a certain power, and thus, has a heat input into the material. However, because of the different properties of the fibre and matrix, the two