EDM Characteristics of Carbon Fiber Reinforced Plastic

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Abstract

Carbon fiber reinforced plastic (CFRP) is a very strong and light composite material, and it has many applications in aerospace and automotive fields. However conventional mechanical machining methods, such as cutting and grinding have some problems; delaminating, splintering, burrs of machined surface and short tool life. Electrical discharge machining (EDM) is an effective alternative for machining difficult-to-cut materials. In this paper, the EDM characteristics, such as material removal rate, electrode wear rate and surface roughness for CFRP were experimentally investigated with varying discharge peak current and pulse duration.

Keywords

Electrical discharge machining (EDM), Carbon fiber reinforced plastic (CFRP), Material removal rate, Electrode wear, Surface roughness

1 INTRODUCTION

Carbon fiber reinforced plastics (CFRP) are distinguished by their extremely high strength, high rigidity, high resistance to impact, high corrosion resistance and light weight. Their positive characteristics mean that CFRP materials can be typically used for applications in aerospace engineering, in the automotive industry, sport equipment subjecting to high levels of stress.

Manufacturing process is one of the most important factor controlling the successful use of CFRP material. Conventional mechanical techniques such as drilling, turning, milling and etc. for machining CFRP, have many problems such as delamination, splintering, the presence of burrs and short tool life due to their high specific strength, and high specific modulus, and composite structure [1－4]. Also, nontraditional machining techniques such as laser, water jet and ultrasonic can be used to cut CFRP but with some difficulties [5－8].

Electrical discharge machining (EDM) is one of the non-traditional machining processes which can be widely used for machining difficult-to-machine materials. It is an effective alternative for generating very complicated shapes with high accuracy in advanced materials like metal matrix composite and hard materials [9, 10]. Lau et al. [1] made an investigation about the machining of carbon fiber composite materials by EDM process. They found that copper electrodes performed better than graphite electrodes in terms of electrode wear and that the electrode with positive polarity gave higher material removal rate and lower tool wear ratio. Tandon et al [8] made investigations into the machining of composites by using electrochemical spark machining process. They developed mathematical models between material removal rate, electrode wear rate and the working gap distance with machine setting parameters.

In this study, the EDM experiments for CFRP are conducted with varying machining parameters, such as discharge peak current and pulse duration using copper and graphite electrodes. And the influences of machining parameters on material removal rate, electrode wear and surface roughness are investigated, comparing those for steels.

2 EXPERIMENTAL PROCEDURES

The experiments are carried out using NC die sinking EDM (Sodick AQ35LR). Kerosene type working fluid (Sodick hightech VITOL2) was used. Cylindrical copper and graphite (Ibiden ED－3) of 8 mm in diameter were used as electrode. The workpiece material was carbon fiber reinforced plastics (CFRP) sheet (Sakai Industries F63438－05) with two perpendicular orientations of carbon laminates formed by autoclave method. Mechanical properties of CFRP used in this study are shown in Table 1. In this molding method, layered sheets comprising reinforcing fibers and high-ductility epoxy resin were pressed and heated in an autoclave for curing to produce carbon fiber reinforced plastics. SKD11 was also machined for comparison.

Fiber type	T300
Fiber content ratio (vol. %)	60
Tensile strength (kgf/mm^2)	360
Elasticity10^3 (kgf/mm^2)	23. 5
Elongation (%)	1. 5
Breaking expansion (%)	1. 3
Density (g/cm^3)	1. 76
Plastic	Epoxy
Plastic density (g/cm^3)	1. 19

Table 1: Properties value of CFRP.

Due to the lack of known EDM conditions and no EDM maker recommended conditions to machine CFRP material, a series of EDM experiments with varying discharge conditions were firstly carried out.

Various electrical conditions such as pulse durations, peak current were selected for the purpose of obtaining optimum EDM conditions for CFRP material. The EDM conditions are shown in Table 2. EDM characteristics such as material removal rate, electrode wear rate, and surface roughness were evaluated when cylindrical cavity of