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A study on Wire Breakage in Electrical Discharge Machining of Polyurethane Foam

Azmir Azhari, Zamzuri Hamedon and Mebrahitom Asmelash Gebremariam

Faculty of Manufacturing Engineering, Universiti Malaysia Pahang, 26600 Pekan, Malaysia

Abstract

The present work discusses the feasibility of cutting polyurethane foam using wire electrical discharge machining (WEDM) process. The foam consists of nickel copper coated polyester (PET) fabric. Three different thicknesses of foam constitute to different surface and volume resistivity were chosen as work material. The effect of various processing parameters on machining length was investigated. The process experiences a high-energy loss which leads to frequent wire breakages due to the low electrical conductivity of polyurethane foam. In case of increasing the pulse-on time, the length of cut became shorter since the wire breakage was provoked by a decrease in the discharge frequency. The length of cut increases with increase in pulse-off time as a result of sufficient time to remove the debris. At a higher peak current, the length of cut increases due to an increase in current intensity. The length of cut also decreases at lower servo voltage since machining at lower voltages was unstable with frequent wire breakages. It is important to have a special care while machining these foams.

Keywords:Wire electrical discharge machining, Polyurethane foam, Wire breakage

1. Introduction

Electrical discharge machining (WEDM) is one of the most extensively used non-conventional material removal processes. It is a well-established machining option for producing geometrically complex or hard material parts that are extremely difficult-to-machine by conventional machining processes. The unique feature of using thermal energy to machine electrically conductive parts regardless of hardness has been EDM's unique advantage in the manufacture of moulds, dies, and automotive, aerospace and surgical components. In addition.

Emai id: azmir@ump.edu.my

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EDM does not make direct contact between the electrode and the work piece thus eliminating mechanical stresses, chatter and vibration problems during machining.A certain electrical conductivity is required for electrical discharge machining of a material. Based on previous researches, EDM can be successfully applied to machine ceramics if the electrical resistivity is below 100 Ω / cm [1, 2]. Attempts have also been reported of increasing the electrical conductivity of ceramics to make it more suitable for EDM operation [3, 4]. One of the ways to increase the electrical conductivity of ceramics is by covering the ceramic surfaces with conductive materials. The surface of the non-conductive work piece can be covered with a conductive substance through physical vapour deposition (PVD) process [4]. This conductive layer on the ceramic will act as an assisting electrode. In recent years, EDM can be applied to insulating ceramics using assisting electrode method where an electrical conductive layer is formed on the work piece surface by generating long pulse discharge [5].

However, all researchers realized that the quality of cuts in terms of material removal rate (MRR) and surface roughness are very low as compared to the cutting of metals which are more conductive than ceramics. Dauw et al. [6] explained that the MRR and surface roughness are not only dependent on the machining parameters but also on the properties of material of the part. For polymer based composite materials which are generally have low level of electrical conductivity, some studies have been made in wire EDM processing of carbon fibre and reinforced liquid crystal polymer composites [7-9]. These studies show that wire EDM yields better cutting edge quality and has better control of the process parameters with fewer work piece surface damages. However, it has a slower MRR for all the tested composite materials. A highly stable control system was developed to improve EDM performances using adaptive control system by minimum-variance control law [10]. The adaptive control system is able to control electrode discharging cycle not only to follow a specified gap state for fast machining but also to track the dynamical response of a reference model for stabilizing EDM process.

Many factors contributed to wire breakage such as a decrease in flushing pressure, inefficient removal of erosion debris, low conductivity of work materials and as well as other types of stochastic phenomena that appear during the cutting process. If that happened, the machining process is stopped and the wire has to be threaded again which leads to an undesired waste of time. However, the symptoms related to wire breakage are still not completely identified and understood.

In the present research, an attempt to cut polyurethane foam using EDM process was conducted. The effect of various processing parameters namely pulse-on time (μs), pulse-off time (μs), peak current (A) and servo voltage (V) on machining length was investigated.

2. Methodology

In this investigation, the experiments were conducted on wire electrical discharge machine, Sodick AQ535L. CuZn37 Brass wire with diameter 0.20 mm was chosen as electrode in machining polyurethane foam.

The machining parameters and their levels were selected based on preliminary investigations and literature reviews [7-9]. A total of four machining parameters were selected namely pulse on-time (μs), pulse-off time (μs), peak current (A) and servo voltage (V). The rest of the parameters were kept constant. Servo feed was set at 150 mm/min. Dielectric fluid used was deionized water which flushing pressure was set at 1.2 MPa. The machining parameters and their levels are shown in Table 1. A total of 20 experiments were conducted.

Table 1
WEDM parameters and their levels

Parameters	Pulse on time (μs)	Pulse off time (μs)	Peak current (A)	Servo Voltage (V)
Level 1	0.2	10	8	10
Level 2	0.5	12	10	20
Level 3	0.8	14	12	40
Level 4	1.1	16	14	50
Level 5	1.4	18	15	60