Modeling of Electrical Discharge Machining of CFRP Material through Artificial Neural Network Technique

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***Abstract*- In the present research, electrical discharge machining (EDM) of carbon fiber reinforced plastic (CFRP) material was studied. The selection of optimum electrical discharge machining parameters combinations for the purpose of obtaining higher cutting efficiency and accuracy is a challenge task due to the presence of a large number of process variables. This paper presents an attempt to develop an appropriate machining strategy for a maximum process criteria yield. A feed-forward back-propagation neural network was developed to model the machining process. The three most important parameters-material removal rate, tool electrode wear rate and surface roughness-were considered as measures of the process performance. A large number of experiments were carried out over a wide range of machining conditions to study the effect of input parameters on the machining performance. The experimental data was used for the training and verification of the model. Testing results demonstrated that the model is suitable for predicting the response parameters accurately as a function of most effective control parameters, i.e. pulse duration, peak current and tool electrode rotational speed.**

Keywords- Electrical Discharge Machining (EDM); CFRP; Neural Network Technique; Metal Removal Rate; Tool Electrode Wear Rate; Surface Roughness

I. INTRODUCTION

Carbon fiber reinforced plastic (CFRP), is a very strong and light composite material or fiber reinforced polymer. It consists of a polymer (usually duroplastics, thermoplastics or epoxy) employed as a matrix material in which carbon fibers with diameters of a few micrometers are embedded. CFRPs exhibit considerably greater rigidity, sharply enhanced electrical and thermal conductivity and a lower density. Their positive characteristics (relative to the weight) enable them to be typically used for many applications in aerospace engineering, automotive industry, motor racing, sport equipment subject to high levels of stress as well as in sailboats and high-strength and high-rigidity parts in industrial applications, such as robot arms, reinforcement and sleeves in turbo molecular pumps or drive shafts.

However, machining CFRP is difficult, because it is inhomogeneous substances consisting of electrical conductive high-tensile fibre materials and an electrical non-conductive matrix material that is usually made of a plastic or epoxy resin. The use of traditional machinery to machine hard composite materials such as turning, sawing, drilling, etc. generally results in serious tool wear due to the high strength, delaminating, splintering, burrs of machined surface and shorting the life of the tool used [1, 2]. Although other non-conventional machining techniques such as ultrasonic machining, water jet machining and laser beam machining have been increasingly used [3], the machine equipment itself is very expensive and the height of the workpiece is constrained to be small.

Electrical discharge machining (EDM) is an effective alternative for machining difficult-to-cut materials. Machining with EDM is achieved by a series of accurately controlled micro sparks produced by the breakdown of a liquid dielectric in a narrow gap subjected to high voltage for the purpose of eroding (vaporizing) metals. Therefore, electrical discharge machining process is capable of machining any electrically conducting material regardless of its hardness. The scope of the EDM processes ranges from the drilling of micro-holes to machining very large automotive dies [4, 5].

At present, the selection of machining parameters in EDM process is important for achieving optimal machining performance. Usually, the desired machining parameters are determined based on experience or handbook values. However, this does not ensure that the selected machining parameters result in optimal or near optimal machining performance for that particular electrical discharge machine. In some cases, selected parameters are conservative and far from the optimum, and at the same time selecting optimization parameters requires many costly and time consuming experiments [6, 7]. Many researchers tried to optimize the machining performance by adapting different optimization techniques. Several attempts have also been made to model and control the electrical discharge machining processes such as mathematical modeling, response surface methodology, artificial neural networks, genetic algorithms, expert and fuzzy systems [8-11].

Artificial neural networks (ANN) are highly flexible modeling tools with an ability to learn the mapping between input variables and output feature spaces. The superiority of using ANN in modeling machining processes make easier to model the EDM process. ANN models usually assume that computation is distributed over several simple units called neurons, which are