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AFM surface investigation of Inconel 825 with multi wall carbon nano tube in electrical discharge machining process using Taguchi analysis

S. PRABHU
Assistant professor (Sr.G), School of Mechanical Engineering, SRM University, Chennai-603203, India, prabhume@yahoo.co.in

B.K. VINAYAGAM
Professor & Head, Department of Mechatronics Engineering, SRM University, Chennai-603203, India, bkvei23@yahoo.com

Demand for better surface finish has been increasing recently for super alloys. Carbon nano tube (CNT) is mixed with dielectric fluid in EDM process because of high thermal conductivity. The analysis of surface characteristics like surface roughness, micro cracks of Inconel-825 is carried out and an excellent machined nano finish can be obtained by setting the machining parameters at optimum level. The Taguchi design of experimental technique is used to optimize the machining parameters and an L9 orthogonal array is selected. The predicted surface roughness was estimated using S/N ratio and compared with actual values. ANOVA analysis is used for finding the significant factors affecting the machining process in order to improve the surface characteristics of Inconel-825 material. Taguchi design of experiments were used to identify the best experiment which optimize the surface roughness to nano level and meet the demand of high surface finish and accuracy to great extent. AFM analysis using CNT improves the surface characteristics like surface morphology, surface roughness and micro cracks from micro level to nano level. The regression analysis are used to predict the error between actual and regression values of surface roughness using carbon nano tube as dielectric fluid in EDM process.

Keywords: *multi wall carbon nano tube, electric discharge machining process, surface roughness, Taguchi method, ANOVA analysis, atomic force microscope, regression analysis*.

1. Introduction

Nano level surface finish has become an important parameter in several industries like semiconductor, optical, electrical and mechanical industries. Most of the materials used in these industries are either super alloys or some other difficult to machine materials like ceramics, glass and silicon wafers. Manufacturing processes such as micro moulds, micro holes etc on these materials would be almost impossible owing to high tool wear rate and expenses involved. Hence certain Non Traditional Machining techniques are involved in order to meet the present demand for high accuracy. Electrical Discharge Machining is one of the most widely accepted methods involved in production of complicated shapes and apertures of high accuracy. Hard and brittle materials can be easily machined using the EDM process. The tool and work piece are separated by a very small gap and submerged in dielectric fluid. During the discharge temperature as high as 40 000 K can be produced, this melts and vaporizes the required region while the top surface re solidifies and cools at a very fast rate. This is how we can do the otherwise very cumbersome machining quite easily.

1.1. Literature review

Y.H. Guu et al. [1] proposed the electrical discharge machining (EDM) of AISI D2 tool steel was investigated. The surface characteristics and machining damage caused by EDM were studied in terms of machining parameters. Based on the experimental data, an empirical model of the tool steel was also proposed. Surface roughness was determined with a surface profilometer. S. Prabhu et al. [2] proposed the nano surface finish of AISI D2 tool steel material using multi wall carbon nano tube (MWCNT) in electrical discharge machining process (EDM). The surface morphology, surface roughness and micro cracks are determined using an atomic force microscope (AFM). I. Puertas et al. [3] carried out on the influence of the factors of intensity (I), pulse time (ti) and duty cycle (η) over the listed technological characteristics. The ceramic used in this study was a cemented carbide or hard metal such as 94WC–6Co. Y.H. Guu et al. [4] presents the effects of titanium nitride (TiN) coating by physical vapor deposition (PVD) on the fatigue life of AISID2 tool steel, which was electrical discharge machined (EDM) at various machining parameters, such as pulse current and pulse-on duration. Surface hardness, surface roughness, residual stress and fatigue strength were measured. Y.H. Guu [5] proposed the surface morphology, surface roughness and micro-crack of AISI D2 tool steel machined by the electrical discharge machining (EDM) process were analyzed by means of the atomic force microscopy (AFM) technique. K.R. Mahajan et al. [6] presents the basic principles of designing a knowledge based system for automated EDM electrode design. Electric discharge machining (EDM) electrode design has always been an important activity in the die and mould making sector. A.G. Mamalis et al. [7] written to give a consolidated view of the synthesis, the properties and applications of carbon nanotubes, with the aim of drawing attention to useful available information and to enhancing interest in this new highly advanced technological field for the researcher and the manufacturing engineer. P. Pecas et al. [8] presented electrical discharge machining using simple and powder-mixed dielectric: The effect of the electrode area in the surface roughness and topography. (PMD-EDM) EDM technology with powder mixed dielectric and to compare its performance to the conventional EDM when dealing with the generation of high-quality surfaces. Y.S. Wong et al. [9] presented Near-mirror-finish phenomenon in EDM using powder-mixed dielectric. A study of the near-mirror-finish phenomenon in electrical discharge machining (EDM) when fine powder is introduced into the dielectric fluid as a suspension at the tool–work piece or inter-electrode gap during machining.