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A Fuzzy Logic based Model to predict the improvement in surface roughness in Magnetic Field Assisted Abrasive Finishing

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Abstract

In this paper the effect of process parameters during Magnetic Field Assisted Abrasive Micro Finishing (MFAAF) of SS316L material is reported. Based on the experimental results obtained, S/N ratio and ANOVA analyses were made to identify the significant process parameters to improve the percentage improvement of surface roughness (%ΔRa). From the results it is observed that the process parameters like voltage applied to the electromagnet, machining gap, rotational speed of electromagnet followed by abrasive size are significant to improve the %ΔRa. Based on the process parameters selected from the S/N ratio analysis and ANOVA analysis, a fuzzy logic model has been developed to predict the %ΔRa. To develop the fuzzy model, four membership functions based on the four process parameters are assigned to be connected with each input of the model. The developed fuzzy model is tested using three different set of process parameters values that are not used in already existing experimental data set. It is found that the developed fuzzy model has a close relation with the experimental values with the maximum deviations of 7.16%.

1. Introduction

Traditional finishing processes like grinding, lapping and honing employ a rigid tool that subjects the workpiece to substantial normal stresses which may cause micro-cracks resulting in reduced strength and reliability of the machined part[1]. So, Traditional finishing processes alone are incapable of producing required surface finish[2]. This led to the development of newer non traditional finishing process like Magnetic Field Assisted Abrasive Finishing (MFAAF). This process employs the magnetic force and magnetic abrasives for finishing a variety of engineering materials. The MFAAF process removes tiny amount of material by indentation and rotation of magnetic abrasive particles (MAPs)[3]. The MAPs are consisting of iron particles and abrasive powder which is

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filled in the gap between the workpiece and the electromagnet. The MAPs join with each other along the lines of magnetic force and form a Magnetic Abrasive Flexible Brush (MAFB) between the workpiece and the electro magnet. Magnetic force plays a dominant role in the formation of MAFB and developing abrasion pressure. This MAFB behaves like a multi-point cutting tool while rotating the magnet [4]. The basic principle of the MFAAF process for finishing of flat surfaces were studied by Shinmura et al. [5,6] on difficult-to-machine materials. Further many researchers have investigated to improve the MFAAF process by investigating characteristics of abrasive behavior[7], forces acting during MFAAF[8] and surface texture generated for finishing of flat surfaces[9]. Jain et. al[10] studied the effect of working gap and circumferential speed on the performance of magnetic abrasive finishing process. Singh et al. [11] investigated the parametric study of Magnetic Abrasive finishing process to improve change in surface roughness. Mori et al. [12] clarified the mechanism of abrasive finishing for the non magnetic material. Kremen et al. [13] investigated the machining time required to achieve specified accuracy of the workpiece. Yang et al. [14] demonstrated the magnetic abrasive finishing of stainless steel work material using a permanent magnet. On the other hand, many researchers started to develop the mathematical modeling of MFAAF process [1,15]. Mulik and Pandey[16] developed a Response Surface Methodology (RSM) along with second order polynomial model to predict ΔRa based on variation of voltage, mesh number, rotary speed and weight percentage of abrasive particle. Recently, Lee et al. [17] developed sensor based approaches coupled with artificial neural network to correlate relationship between data obtained by force and acoustic emission signal to surface roughness. Teimouri et al. [18] developed a Feed Forward Back-Propagation Neural Network (FFBP-NN) and Adaptive Neuro-Fuzzy Inference System (ANFIS) to predict the performance of magnetic abrasive finishing process.

From the literature survey, it is observed that most of the researchers used to predict the change in surface roughness by using linear models[11], RSM based models[16], artificial evolutionary approaches[18] like Artificial Neural network models and neuro-fuzzy inference system to produce smoother surface in MFAAF process. From the literature, it is found that very few researches are carried out in MFAAF process using fuzzy inference system. So, in this study a fuzzy logic model has been developed to predict the percentage improvement in surface finish. The developed fuzzy logic model is used for analyzing the effect of process parameters and it is explained using the three dimensional surface plots. The S/N ratio and ANOVA analyses were made to find the significant process parameters. These analyses are also used to validate the experimental results before developing the fuzzy logic model.

2. Experimentation

In the present work, an experimental set-up was developed for carrying out the MFAAF process in a precision CNC vertical milling machine. The experimental setup consists of an electro magnet, mandrel, sleeve, lock-nut and power supply for electromagnet. Fig.1 shows the schematic view of experimental setup.

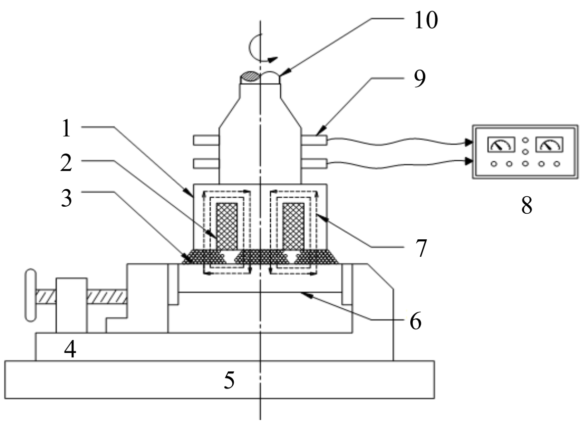

Fig. 1 Schematic view of MFAAF setup

Item No	Item Name
1	Electro Magnet
2	Coil
3	MFAB
4	Machine Vice
5	Machining Table
6	Workpiece
7	Magnetic Flux(Φ)
8	Power Supply
9	Slip Rings
10	Machine spindle