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Study of surface integrity and recast surface machined by Wire electrical discharge machining

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Abstract

The surface quality of wire electric discharge machining is determined by formation of recast layer and its roughness profile. These characteristics has a great relationship with the process parameters. To attain an intense knowledge of the surface roughness and recast layers of a surface machined by WEDM on stainless steel 316, the inputs and outputs correlation has been constructed using artificial neural network model. Particle swarm optimization algorithm is used to extract the optimal set of process parameters for multi responses. Thick white layers (13–16 μm) and rough surface (3.5-4 μm) was found at high pulse on time while very thine white layer (3-5 μm) and finish surface (1.5-2 μm) can be observed at low pulse on time.

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Keywords: WEDM; AISI SS316; Roughness; Recast layer; PSO

1. Introduction

Wire electric discharge machining (WEDM) is an advance machining process useful to machine any metallic materials irrespective of their mechanical properties, because there is no physical interaction between the tool electrode and the workpiece during the process [1]. In WEDM removal of material occur by a thermo-electric process where a series of sparks occur between two electrodes with in a second [2]. With the advantages of high-performance price ratio, good cooling effect, and material removal ability, WEDM play a significant role in

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different manufacturing industries mainly automotive, aerospace, and molding to machine electrically conductive difficult-to-machine materials with accurate, intricate, and irregular shapes [3]. Due to generation of high temperature and pulse discharge rate, this process faces some difficulties including formation of recast layer, crack, defects, and high surface roughness which can damage the surface integrity. Therefore, to reduce surface defects it is essential to study the effect of process parameters on surface characteristics that can control machining performance. For its complex behavior, it is necessary to evaluate an optimal parametric setting to increases machinability of WEDM process. Many literatures have already narrated on machinability and optimization of EDM/WEDM. Sidhom et al [4] reported the effect of electro discharge machining on white layer formation and corrosion resistance of AISI316L SS. Surface defects like pores, craters and the cracks were observed using Scanning electron microscopy (SEM), energy dispersive microanalysis (EDX) analysis Punturat et al [5] studied the surface characteristics and defects of monocrystalline silicon machined by wire-EDM. The EDX analysis revealed that low spark density and low flushing rate of dielectric fluid were increased the deposition of electrode materials such as copper, zinc, silicon on the machined surface. Ekmekci et al [6] examine the electro discharge machinability of mold steel and micro cracks found on white layer due to residual stress. Sharma et al [7] found that pulse on time and servo voltage play as a significant role in the formation of recast layer. Due to high discharge energy, larger craters might be formed on the machined surface. Dewangan et al [8] reported that low flushing rate of dielectric fluid unflushed molten material gets re-solidified and formed very hard and grained layer on the machined surface which is called recast layer that leads to generation of cracks and other surface defects.

Modeling of machining process is necessary to interpret, predict and optimize the results, which are otherwise hard to understand [9]. Optimization of the WEDM process parameters is also essential because identify optimal machine settings plays a vital role in obtaining high productivity along with better surface quality. Several research has been reported on modeling and optimizing WEDM using well known methods. Dewangan et al [10] made an approach using fuzzy-TOPSIS to optimize performance characteristic such as recast layer thickness, surface roughness, surface crack density, and over cut after machining AISI P20 tool steel in EDM. Maher et al [11] introduced ANFIS for modeling the process parameters and performance characteristics. Kuriachen et al [12] discuss fuzzy based particle swarm optimization technique for prediction and optimization of MRR, surface roughness in micro-wire EDM of Ti-6Al-4V. In present investigation, artificial neural network (ANN) is used to map the input/output relationships to reduce error prediction of the WEDMed surface and then model is hybridized with particle swarm optimization (PSO) to search the best combination of WEDM parameters. Present study also highlighted the surface topography, elemental dispersion and inclusion in WEDM.

2. Experimentation and measurements

Austenite standard chromium nickel steel AISI 316 of 12 mm thickness plate was used to machine using WEDM (ELECTRONICA SPRINTCUT). The uncoated soft brass (CuZn36) (250 m in diameter) is used as tool electrode deionized water as dielectric fluid. The specification of work material is shown in Table 1 and Table2. Wire feed rate, servo voltage and flushing pressure are kept constant as 4.0 m/min, 1020 machine unit and 10.0 L/min respectively during machining process.

Table 1. Chemical composition of AISI 316 stainless steel.

ELEMENTS	C	Cr	Mn	Mo	Ni	P	S	Si	Fe
%	0.03	17	2	2.5	12	0.045	0.012	1	Balance

Table 2. Basic physical properties of AISI 316 stainless steel.

Density	Melting Point	Thermal Conductivity	Electrical Resistivity	Specific Heat Capacity	Hardness
8.1 G/M3	1371ºC-1399ºC	16.2 W/M/K	0.74 Ohm-mm2/m	450 J/Kg-K	15-20 HRC