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Optimization of Circularity in Wire EDM Process for Different Diameters

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Abstract:

Electrical discharge machining is a thermal erosion process which is based on thermoelectric energy between the work piece and electrode. Its capability of machining in hard and difficult to cut materials has made it most popular. materials EN24,H13,SS316 are taken into wire EDM machining process. In the present study, the performance parameters i.e. cutting speed and surface roughness and circularity were investigated. The experiments were conducted under the constant cutting parameters of TON, TOFF, WP, WF, WT, SV. In the present study, copper wire having diameter 0.25mm was used as wire electrode. It has been observed that the surface roughness and roundness error of the WEDT components are influenced by the occurrence of arc regions, width of arc and normal discharge regions and average ignition delay time.

Keywords — WEDM, circularity.

I. INTRODUCTION

The electrical discharge machining (EDM) is a thermoelectric process that erodes work piece material by a series of discrete electrical sparks between the work piece and electrode. Unlike traditional cutting and grinding processes which rely on a much harder tool or abrasive material to remove the softer work material, the EDM process utilizes electrical sparks or thermal energy to erode the unwanted work material and generate the desired shape. WEDM is a technology, which provides high rate of cutting and high-precision operation to realize enhance productivity and improved accuracy. In WEDM, dielectric is used in working space i.e gap space between wire electrode and work piece to allow cooling action. It also allows flushing out of debris or the resolidified eroded particles from the gap. Effective flushing is required; otherwise eroded particle in the gap will cause undesirable craters in the wire and work piece material.

Principle of EDM:

EDM is a non-mechanical thermal shaping process with which material is removed by spatially and temporally separated electrical discharges between a work piece electrode and a tool electrode. The high frequency discharges cause melting and vaporization of material on the surface of both electrodes. To enhance the material removal EDM operates in a non-conducting fluid, the dielectric fluid.

Wire Cut Electric Discharge Machining:

New materials created and/or demanded by space age technology sometimes cannot be economically cut using conventional cutting tools. Special, super-hard materials, normally quite expensive, are required. Synthetic diamonds or diamond compounds that are almost impossible to grind are very expensive, but are cut effectively by WEDM Wire EDM uses brass, tungsten, or copper as its material for the electrode tool wire. Deionized water is used for the dielectric fluid. Almost like the standard EDM, the wire is eroded and slowly fed. Although it is similar to standard EDM, higher currents and lower rest times make this process much faster

Objectives:

- To investigate the effect of machining parameters on the performance of wire electro discharge
- Optimization of the machining parameters for EDM wire cutting
- To validate circularity for different diameters
- Accuracy and finish during wire electric discharge machining (EDM) for circularity and surface finish

Problem statement:

The flexibility and rigidity of the wire electrode depends on the tension. Thus, the wire tension affects the accuracy of cutting path and the interaction between reinforced particles and wire electrode. The wire tension is the foremost contributing factor to circularity. The interaction between wire tension and pulse on time is the second contributing factor in this case. The combination of over and undercuts are the main reason of circularity error. Best circularity was obtained at the medium particle size, medium wire tension and medium pulse on time.

2.0 Literature review:

Wheeldon JM, Shingledecker JP (2017) In order to predict the surface finish and material removal rate while machining D2 tool steel, developed the empirical models. It was observed that there was no single combination of levels of the different factors that could be optimal under all situations. To locate the optimal machining parameters, the non-dominated point approach was applied, using explicit enumeration of all possible combinations and the dynamic programming method.

Klocke F, Zeis M, Klink a., Veselovac D.(2016) an investigation to study the effects of spark cycle and pulse on-time on wire EDM of metal foams, metal bond grinding wheels, sintered Nd-Fe-B magnet, and carbon–carbon bipolar plate. Although results presented are machine-dependent, this research provides the guidelines and procedures for the development of wire EDM process for machining new engineering materials to achieve different manufacturing objectives, either the high MRR, miniature features, or a compromise between the two. This study also demonstrated the capability of wire EDM process to machine different advanced materials

Ugur Esme, M. Kemal Kulekci (2015) optimized the trim cutting operation of WEDM of γ- TiAl alloy for a given machining conditions by desirability function approach and pareto-optimization algorithm and superior performance as compared to desirability function approach. Response Surface Methodology (RSM) was used to develop a prediction model of surface roughness for machining mild steel. The experiments was carried out with TiN-coated tungsten carbide (CNMG) cutting tool, for machining mild steel work-piece covering a wide range of machining conditions.

Selvarajan L, Narayanan CS, (2014) the studies have been concentrated on other types of steels. In recent years, along with other types of steels, AISI D3 steel has also emerged as an important material for industrial applications. Despite extensive research on WEDM process, determining the desirable operating conditions during WEDM of AISI D3 steel, in industrial setting, still relies on the skill of the operators and trial-and-error methods. So the aim of the present work is to obtain the optimum machining conditions for WEDM of AISI D3 steel, for minimizing the surface roughness based on Taguchi technique. Experiments were carried out to study the effect of various parameters viz. pulse peak current, pulse on time, pulse off time, and wire feed, on the surface finish

Ebeid et al. (2013) had proposed a knowledge based system for the selection of an optimal setting of process parameters. It also helps in diagnosing the machining conditions particularly for WEDM. In this study, sample outcomes for Al 6061 and alloy steel 2417 were presented in the form of particular charts. These charts help WEDM users to improve the performance of the WEDM process.

Sarkar et al. (2012) had performed investigation (experimental based) on single pass cutting of wire EDM of γ-TiAl alloy. The additive modeling approach was used to modeled the whole process. The Pareto optimization algorithm was used as optimization tool. The wire-EDM process was optimized under single constraint as well as multi-constraint condition. Twenty pareto solutions (optimal one) were searched out from the set of all 243 outputs. During the study, it was concluded that the performance parameters i.e surface roughness and dimensional deviation are independent on the pulse off time.

Data & Mahapatra (2010) had also worked in the field of WEDM. They used D2 material as work material and zinc coated copper wire (0.25 mm diameter) was used as tool electrode. They suggested and derived mathematical models (quadratic) to represent the behavior of WEDM process. They had varied six different process parameters i.e. discharge current, pulse duration, frequency of pulse, feed rate of wire, flow rate of dielectric and wire tension in three different levels. They varied these process parameters against the three performance parameters i.e. MRR, surface roughness and kerf width. After the prediction of data, they represent the effect of the parameters on selected responses by graphical representation. They also used Grey Taguchi technique for optimization of input parameters

Mahapatra et al. (2007) had used the Taguchi method for optimization of WEDM process. The zinc coated copper wire was used as tool electrode and D2 tool steel (with thickness of 10 mm) was used as work material. During this study, the effect of different process parameters i.e. peak current, pulse duration, frequency of pulse, wire feed rate, flow rate of dielectric and wire tension on performance parameters i.e. MRR, surface finish and cutting width was analyzed. They also used Taguchi method for optimizing the process parameters.

3.0 Methodology:

The wire wear rate is a direct index of the productivity of the process. The surface roughness measurements are made with a cut off value of 0.08mm and are made against the direction in which the wire travels and hence leading to higher values of surface roughness. The circularity error, perpendicularity error, circularity error and parallelism error are measured using the coordinate measuring machine. These errors are a direct index of the dimensional deviation which occurs during the electrical discharge machining process.

Experimental Procedure for Wire cut EDM:

Taguchi approach was taken as the basis for planning and conducting the experiments so that the appropriate data is collected which may be analyzed to obtain valid

Range of Significant Process Parameter for EDM Wire cut

Parameter Name	Unit	Lower limit	Upper limit
Tension	N	0.6	1
Feed	m/min	8	12
Flushing pressure	Kg/cm^2	2	4
Current	A	60	100

4.0 Results:

Standard notations

On=005

Off=016

HP=002

MA=19

SV=021

V=3

SF=0005

C=00

PARAMETERS

Materials -1a, 1b, 1c-EN24, H13, SS316

Thickness- 2a, 2b- 6mm, 10mm

Head height (gap between nozzles) - 3a, 3b- 9mm, 29mm.

LAYOUT USING AN L12 ORTHOGONAL ARRAY

Experiments	CS A	CS B	CS C
Number	Material	Height (h)	Thickness t
1	1a	2a	3a
2	1a	2b	3a
3	1a	2a	3b
4	1a	2b	3b
5	1b	2a	3a
6	1b	2b	3a
7	1b	2a	3b
8	1b	2b	3b
9	1c	2a	3a
10	1c	2b	3a
11	1c	2a	3b
12	1c	2b	3b

Experimental data of cutting speed for

D1= dia 10mm

D2= dia 12mm

P1= dia profile 1
P2= dia profile 2
D3= dia 14mm

S. no	Cutting speed mm/min					Circularity error
	D1	D2	Profile 1	Profile 2	D3	%
1	5.68	5.66	5.6	5.68	5.66	0.0069
2	5.66	5.64	5.64	5.66	5.66	0.0068
3	4.68	4.66	4.66	4.68	4.64	0.0154
4	4.64	4.62	4.60	4.62	4.64	0.0121
5	5.62	5.62	5.60	5.60	5.62	0.0099
6	5.60	5.64	5.62	5.60	5.62	0.0118
7	4.64	4.62	4.66	4.64	4.62	0.0102
8	4.60	4.58	4.62	4.60	4.62	0.0127
9	5.60	5.62	5.62	5.60	5.60	0.0318
10	5.58	5.57	5.58	5.60	5.57	0.0126
11	4.70	4.72	4.72	4.70	4.70	0.0204
12	4.68	4.66	4.66	4.68	4.66	0.0127

Conclusion:

The paper investigated the wire EDM process for establishing the control parameter. The performance characteristics are surface roughness (µm), material removal rate (mm3 /sec), Wire Wear Rate (gram/sec), and form and circularity. The model is optimized with Taguchi method for MRR. Further multiple regression analysis is useful to know the theoretical relations of the different parameters that influence the circularity.

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