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ANN based Optimization of EMD using Genetic Algorithm

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Abstract: Surface Roughness (Ra) during the process has been considered as productivity estimate with the aim to minimize it. With an intention of minimizing surface roughness is been taken as most important output parameter. This can be satisfied by selecting an optimal process environment (optimal parameter setting). Objective function is obtained by Neural Network tool of MATLAB. Then objective function is optimized using Genetic Algorithm optimization tool of MATLAB. The model is shown to be effective Surface Roughness improved using optimized machining parameters.

Keywords: EDM, WEDM, Surface Roughness, Work piece.

1. Introduction:

It is a non-traditional electro-thermal machining process, in which electrical energy is used to generate electrical spark and material removal occurs due to thermal energy produced by the spark. EDM is mainly used to machine high strength temperature resistant alloys and materials difficult-to-machine. EDM can be used to machine irregular geometries in small batches or even on job-shop basis. Work material is to be electrically conductive to be machined by EDM.

EDM machining techniques were discovered far back in the 1770s by an English Scientist. However, this technique was not fully taken advantage until 1943 when Russian scientists learned how its erosive effects could be controlled and used for machining purposes. It was developed commercially in the mid-1980s, wire EDM made lot of change that helped shape the metal working industry we see today.

Now the now concept of manufacturing uses non-conventional energy sources like light, sound, chemical, mechanical, electrical and ions. With the technological and industrial growth, devolvement of harder machining materials, which find wide application in nuclear engineering ,aerospace and other industries owing to their high strength to weight ratio, heat resistance and hardness qualities has been witnessed New developments in the field of material science have led to new engineering metallic materials, high tech ceramics and composite materials having good mechanical properties and thermal characteristics as well as sufficient electrical conductivity so that they can readily be machined by spark erosion. Non-traditional machining has improved out of the need to machine these alien materials. The machining processes are non-conventional in the sense that they do not employ traditional tools for metal removal and but they directly use other forms of energy. The problems of high complexity in size, shape and higher demand for product accuracy and surface finish can be solved through non-traditional methods.

EDM has been replacing grinding, milling, drilling and other traditional machining Operations and is now a well-established machining option in many manufacturing industries everywhere in the world. And is capable of machining hard material components or geometrically complex, which are precise and difficult-to-machine such as heat treated super alloys, ceramics, composites, carbides tool steels, heat resistant steels etc. being widely used in mould and die making industries, nuclear industries, aeronautics and aerospace. Electric Discharge Machining has also made its presence felt in the new fields such as medical, sports and surgical, optical, instruments, including automotive R&D areas.

2. Related Work:

Atul kumar and Dr D.K. Singh [8] have study variation of cutting performance with pulse on time, pulse off time, open voltage, feed rate override, wire feed, servo voltage, wire tension and flushing pressure were experiment investigated in wire electric discharge machining processes. Brass wire with 0.25 mm diameter and SKD 61 alloys steel with 10 mm thickness were used as tool and work materials. The output considered has been MRR and surface roughness. Experimentation has been competed by using Taguchi's L18 (21×37) orthogonal array under different conditions of parameters. Finally it concluded that the MRR increases with the increase in pulse on time and decrease with increase in pulse off time and open voltage. The effect of feed rate overdrive, wire feed, servo voltage, wire tension and flushing pressure on MRR is not very significant. For the surface roughness it decrease with increase of pulse off time open voltage and wire feed and increases with increase in feed rate override and servo voltage. The effect of other parameter is not significant.

Pujari Srinivasa Rao, Koona Ramji, Beela Satyanarayana [9] studied Wire-cut electric discharge machining of Aluminum-24345. Experimentation has been done by using Taguchi's L18 (21x37) orthogonal array under different conditions of parameters. The response of surface roughness is considered for improving the machining efficiency. Optimal combinations of parameters were obtained by this method. The confirmation experiment shows, the significant improvement in surface finish (1.03µm) was obtained with this method. The study shows that with the minimum number of experiments the stated problem can be solved when compared to full factorial design. All the experiments were conducted on Ultra Cut 843/ ULTRA CUT f2 CNC Wire-cut EDM machine. The size of the work piece considered for experimentation on the wire-cut EDM is 25 mm x 20 mm x 10 mm. Increasing the discharge energy generally increases surface irregularities due to much more melting and re-solidification of materials. Hence, it is found that SR tends to decrease significantly with decrease in IP and TON. The parameters wire tension and spark gap voltage are observed as significant parameters in obtaining better surface finish.

Kuriachen Basil, Dr. Josephkunju Paul, Dr. Jeoju M.Issac [10] investigates the effect of voltage, dielectric pressure, pulse on-time and pulse off-time on spark gap of Ti6AL4V alloy. It has been found that pulse on time and pulse off time have the more impact on the spark gap. The minimum spark gap was obtained as 0.040407mm. The WEDM experiments were conducted in Electronic Ultracut S1 machine using 0.25 mm brass wire as the tool electrode. Pulse on time, pulse off time, voltage and dielectric pressure are the four WEDM parameters that were selected for investigations. In this experimental study two level full factorial experiment is adopted because this gives all possible combinations of machine parameters. It can be noticed from that corresponding to minimum value of pulse off time the spark gap decreases with increase in dielectric pressure, whereas the spark gap increases with increase in dielectric pressure corresponding to maximum value of pulse off time.

Saurav Datta, Siba Sankar Mahapatra [11] experimented with six process parameters are discharge current, pulse duration, pulse frequency, wire speed, wire tension and dielectric flow rate; to be varied in three different levels. A block of D2 tool steel with 200 mm × 25 mm ×10 mm size. Data related to the process responses are material removal rate (MRR), roughness value of the worked surface and kerf has been measured for each of the experimental runs. These data have been utilized to fit a quadratic mathematical model (Response Surface Model) for each of the responses, which can be represented as a function of the six process parameter. Predicted data given by the models as per Taguchi's L18 (3*6) Orthogonal Array (OA) design have been used in search of an optimal parametric combination to achieve desired yield of the process, maximum MRR, good surface finish and dimensional accuracy of the product. Grey relational analysis has been adopted to convert this multi-objective criterion into an equivalent single objective function. It has been found that that the spark gap increases with increase in pulse on time, whereas spark gap decreases with increase in pulse off time. The pulse on time, pulse off time, the interaction of dielectric pressure and pulse off time, and interaction of pulse on time and pulse off time are significant parameters which affect the spark gap of WEDM.

Nihat, Can, Gul [12] investigated on the effect and optimization of machining parameters on kerf and material removal rate (MRR) in WEDM operations. Experimental studies were conducted using different pulse duration, open circuit voltage, wire speed, and dielectric flushing pressure. Importance levels of parameters were analysed using analysis of variance (ANOVA). The optimum machining parameter combination was obtained by using the analysis of signal-to-nois (S/N) ratio. The variation of kerf and MRR with machining parameters is mathematically modelled by using regression analysis method. Objective of minimum kerf together with maximum MRR was performed. The experimental studies were performed on a Sodick A320D/EX21 WEDM machine tool. CuZn37 Master Brass wire with 0.25mm diameter was used in the experiments. As work piece material, AISI 4140 steel with 200mm × 40mm × 10mm size was used. The results show that open circuit voltage was three times more important than pulse duration for controlling kerf, while for MRR, open circuit voltage was about six times more important than pulse duration.

3. Methodology:

This experimental work performed at Hindustan Aeronautical Limited, Lucknow . The experiment work is carried out in wire cut electro discharge machine (CHARMILLES TECHNOLOGIES ROBOFIL 300) of MMC Of Al 7075 reinforced with 10 Wt% of boron carbide (B_4C) material by varying machining parameters. The wire cut electric discharge machine is consist of a machine tool, a power supply unit and dielectric supply unit. A schematic diagram of the wire cut EDM is shown in Fig 1.

3.1 Surface Roughness

Surface roughness values of finished work pieces were measured by Mitutoyo Surface Roughness Tester SJ – 201 by a proper procedure. The Mitutoyo Surface Roughness Tester SJ – 201 is an instrument that works by gently dragging a mechanical stylus across a Surface. Surface Roughness Tester acquires data by moving the sample beneath the diamond tipped stylus. Vertical movements of the stylus are sensed by an LVDT, digitalized, and stored in the instruments memory. Its output is a digital display of measured Surface roughness value Ra and other features. Surface Roughness Standard ISO was used for measurement. The temperature of environment was 32 ± 1◦C. In this present study we have taken Ra for measuring Surface Roughness.

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Fig 1: Wire Cut EDM.

Table 1: Specification of CNC Wire EDM

WORK TABLE	
Design	Fixed Column, Moving Table
Table Size	440 x 650 x 300 mm
MAXIMUM WORKPIECE DIMENSION	
Max. Workpiece Height	20mm
Max. Workpiece Weight	7.5 kg
Main Table Transverse (X,Y)	30 x 40 mm
Aux. Table Transverse (U,V)	8 x 8 mm
Wire Electrode Diameter	0.25 mm (std.) 0.15 mm, 0.20 mm (opt.)
PULSE GENERATOR	
Pulse Generator	ROBOFILL 300
CNC Controller	EMT 100W-5
Input Power Supply	3 phase, AC, 415 V , 50 Hz
Connected Load	10 kVA
Avg. Power Consumption	6 to 7 kVA
DIELECTRIC SYSTEM	
Dielectric Unit	DL 25 P
Dielectric Fluid	Deionised water
Tank Capacity	250 Litters

Table 2: Specification of Mitutoyo surface roughness tester SJ-201

Detector	
Detection Method	Different inductance method
Measurement Range	350µm (-200 µm to + 150 µm) 1370 µin (-7880 µin to + 5900 µin)
Stylus Material	Diamond
Tip Radius	5 µm (200 µin) 2 µm (80 µin)
Measuring Force	4 MN (0.4 gf) 0.75 MN (0,075 gf) (0.75 MN measuring force type)
Radius of skid curvature	40mm (1.57 in)

Drive Unit	
Detector Drive Range	21mm (0.82 in)
Traversing speed Measurement Return	0.25 mm/s, 0.5 mm/s (0.10 in/s, 0.02 in/s) 0.8 mm/s (0.30 in/s)
Detector retraction function	Stylus UP
Bottom configure ration	V – way
Ra	Ra (0.01 µm to 100 µm)

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Fig 2: Surface Roughness Tester SJ-201

4. Result and Discussion:

This chapter covers the results of work that is based on the development and analysis for model development of surface roughness (SR) estimator for EDM machine using artificial neural network model for SR estimator and genetic algorithm dependent search of optimized input parameters for getting minimum surface roughness.

We have taken a database consist of four input voltage, current T_{on} and T_{off} and one output as surface roughness. The table 3 shows the input output data.

Table 3: Experimental Data

Voltage	Current	T_{ON}	T_{OFF}	Surface Roughness (μm)
40	6	4	9	6.146
60	6	8	9	10.542
50	10	4	7	7.376
50	10	6	7	10.619
50	6	6	7	8.571
60	14	4	5	9.708
40	14	8	9	18.446
40	6	8	9	10.097
50	10	6	9	10.246
40	6	4	5	6.752
60	10	6	7	14.652
60	6	8	9	23.846
50	10	6	7	6.571
50	10	8	7	11.517
40	14	4	9	9.727
50	10	6	7	10.219
50	10	6	7	10.726
60	6	4	9	16.144
60	14	8	5	6.288
60	6	4	5	9.061
40	14	8	5	4.326
60	14	4	9	15.821
50	14	6	7	12.706
50	10	6	7	10.425
60	6	8	5	12.801
50	10	6	7	10.325
40	14	4	5	7.824
40	6	8	5	10.453
50	10	6	5	14.041
40	10	6	7	11.695

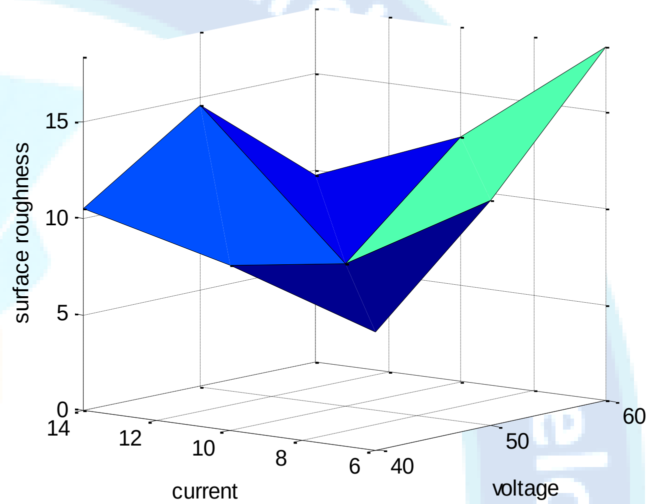

Fig 3 : Surface plot for surface roughness as a function of EDM current and voltage.

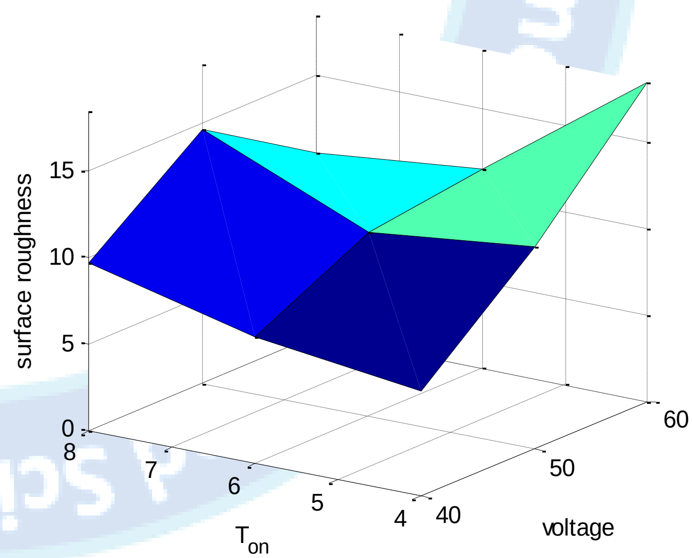

Fig 4: Surface plot for surface roughness as a function of EDM T_{ON} and voltage.

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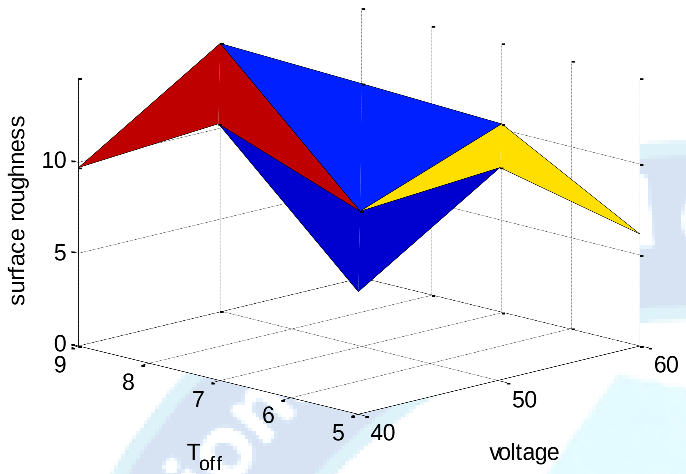

Fig 5: Surface plot for surface roughness as a function of EDM T_{OFF} and voltage.

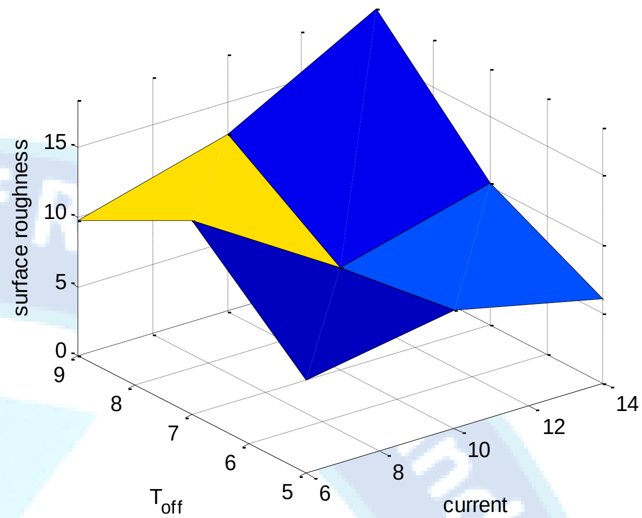

Fig 7: Surface plot for surface roughness as a function of EDM current and T_{OFF}.

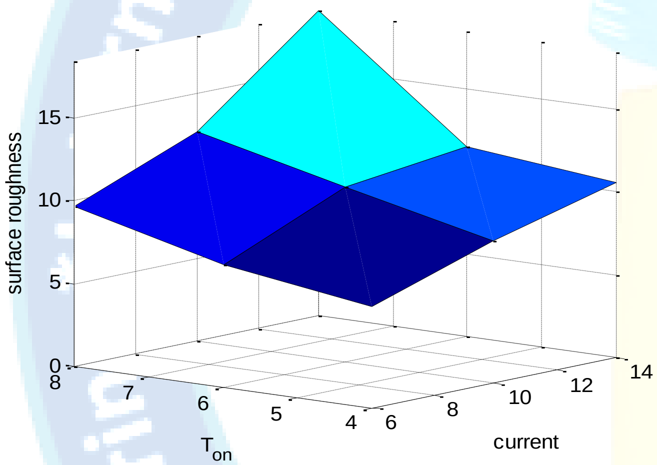

Fig 6: Surface plot for surface roughness as a function of EDM current and T_{ON}.

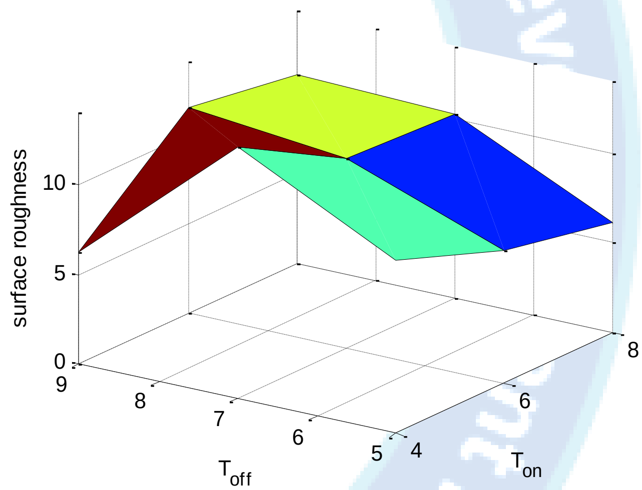

Fig 8: Surface plot for surface roughness as a function of EDM T_{OFF} and T_{ON}.

5. Conclusion:

This work used input parameters such as voltage, current, T_{ON} and T_{OFF} values processed into three levels -1 to +1 to find the optimum input parameter conditions for minimized surface roughness for EDM machine. The subsequent conclusions can be derived from the experiments and study that were done on the Aluminium alloy 7075, with zinc as the primary alloying element. Artificial Neural Network is applied as estimation method for efficiently use in quality control by estimating surface roughness during in which the experimental design is combined with the quality loss. A genetic algorithm based optimization code is developed that utilizes the ANN estimator results and optimal searching has been carried out for input parameters at which we can get minimum surface

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roughness. After getting the optimal settings of voltage, current, T_{ON} and T_{OFF} values as 40 , 14, 8, 5 the value of surface roughness was found to 3.2454 µm.

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