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Parametric Optimisation of the EDC Parameters with the TLBO Algorithm

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Abstract

Machining is one of the methods to make a product with the substrate manner which materials are removed to get the shape and size and finishing operation. One of the methods of machining is nontraditional method where atoms or molecules with the help of thermal, chemical, mechanical, electrical energy and also combination of those. One of the non-traditional machining is electrical discharge machining. Electrical discharge machining is used the various complex types of the contour in the machining object. Electrical discharge machining is method of removal of the material is in the terms of electrochemical energy. But in the electrical discharge machining tool wear is high, but this disadvantage is used as surface coating of the material which enhances the properties of the material. In the electrical discharge coating various response parameters have to be optimised. These response parameters are surface roughness, micro hardness, coated layer thickness etc. Where surface roughness parameter is to be minimised and other parameter has to be maximised with the help of TLBO algorithm.

Keywords: *Optimisation; Algorithm; TLBO; Electrical Discharge Machining; Techniques.*

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1. Background and Motivation

A manufacturing technique is the technique where a finish product makes via various operations through raw material. Some of the manufacturing techniques are casting, welding, forming, machining. In the casting method, liquid metal is the raw product and finished product is in the solid form whereas in the welding process and forming and machining process raw material and finish product both are in the solid form. In the casting technique poured liquid metal in the mould cavity and according to the shape of the cavity product will be formed. In the welding technique, we are joining of the two metals, with or without the application of heat and with or without the application of pressure. Now these days computer also involves in the manufacturing techniques like using CAD-CAM software to make the model of the product. This type of the manufacturing techniques comes under in the non-traditional manufacturing techniques. Manufacturing techniques not only makes size and shape but also enhances the property also. In the research work discusses the enhancement of the property with the one of non-traditional machining is called electrical discharge coating. In the engineering problem is one of the most important is design problem. This design problem has some parameter and criteria. So it is important to choose the correct parameter which is suits the design. Optimisation is one of the methods to find out the exact value which is the suits the environment of the parameters and variable which is takes for the calculation and different experiment data setups. To solve the any problem with the optimisation technique there is single objective as well as multi objective. This objective is minimisation as well as maximisation and minimisation and maximisation both. This problem is linear as well as nonlinear also Non-traditional machining is one of the method where atoms or molecules of the metal body will be remove with the application of thermal, chemical and pressure. One of the parameter which increases the properties of the component or material is surface coating. Surface coating is the process of coating of metal or paint in the surface of the base metal. Base metal means which surface has to be coated. Surface coating increases properties like hardness, corrosion resistance which has the wider use in the industrial areas. Another important parameter in the industry for production of the component is surface finish. Surface finish is important criteria for the machining process. It is the main parameter to define accuracy and precision of the machining process. Surface finish is provide the stability and alignment of the component like shaft and hole assembly, alignment of piston and cylinder in the internal combustion engine etc. Good surface finish reduces noises and vibration in the dynamic component. In this work from this parameters Surface coating process parameters are material deposition ratio (MDR), tool wear rate (TWR), micro-hardness (MH), discharge current, and coated layer thickness etc. so it requires that this parameters will be optimise.

2. Literature review

There are three modes of heat transfer, they arIn the electrical discharge machining process spark erosion is metal removal by an interruption of electrical discharge between tool and electrode. Generally in the EDM process tool is cathode and work-piece is anode. In the electrical discharge machining process a spark gap is maintain between the tool and electrode. Dielectric is passing medium between the tool and electrode such as transformer oil, paraffin oil etc. is used. While dielectric is generally insulator in the normal condition but voltage of the electrode and tool increases then it acts as an insulator and creates a plasma channel between electrode and tool and metal removal takes place. [2]

Heuristic procedure is used for the nonlinear problem because it is the based on the creative thinking and nature behaviour but in the case of heuristic procedure like Particle swarm optimisation, QPSO (Quantum particle swarm optimisation) trap of local minima problem creates. So, in the Meta heuristic procedure this type problem resolved with the population based algorithm where solution is based on the random solution to reach global optimum

3. Input and Output Parameters

Input and output parameters have been taken from the one of the literature [1]. Later with the use of Taguchi L18 orthogonal array has performed. Input parameters are sintering temperature, compaction pressure, duty cycle, and pulse on time and discharge current. Sintering temperature is defined us the temperature with the specialised atmospheric condition generally with the no oxygen condition. Pulse on time is the time duration for the transfer of the atoms from the one place to another. Duty cycle is the amount of the time of the arc. Compaction pressure denotes the pressure of the material when it compressed.

Table 1. Input parameters [1]

Input Parameters	Level 1	Level 2	Level 3
Sintering temperature (A)	700	900	-
Compaction Pressure (B)	100	150	200
Discharge current (C)	20	25	30
Duty Cycle (D)	42	50	58
Pulse On Time (E)	100	200	300

4. TLBO Algorithm

The teaching learning based algorithm is based on the behaviour of the teacher and learners (student) in the class room. There exists a strong dependency on the behaviour of the learners in the class on the quality of the teachers. A good teacher motivates the students (learners) and thereby in helps in improving the average performance of the class. Thus every learner of the class tries the follow the teacher and improves its own performance in the group. Similarly each learner also tries with the other learners to improve own performance. Taking the teacher and learner in the classroom in the Optimization problem developed the teaching learning based algorithm. The teaching learning based Optimization is based on the two stages first is teacher phase and second is learner phase. [6]

In each iteration best solution is considered as teacher and other solution is considered as learners. The learners not only mostly accept the instructions from the teacher, but also learn from each other. In the TLBO algorithm, an academic subject is analogous to an independent variable or candidate solution feature. The TLBO algorithm consists of two important phases, i.e. the teacher phase and the learner phase. In the teacher phase, each independent variable s in each candidate solution xi is modified according to Equation (1) and (2).

$$x'_i(s) \leftarrow x_i(s) + r\left(x_i(s) - T_f \bar{x}(s)\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (1)$$

$$where\ \bar{x}(s) = \frac{1}{N}\sum_{i=1}^{N} x_i(s) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

For i∈[1, N] and independent variables is s ∈[1, n], where N is the population size, n is the number of independent variables x_t is best individual in the population (i.e.; the teacher), r is the random number taken from a uniform distribution on [0, 1], and T_f is the teaching factor and is randomly set equal to either 1 or 2 with equal probability. The new solution obtained after the teacher phase x'_i replaces the previous solution x_i if it is better than x_i.

Table 2: Output parameters[1]

MDR	Ra	CLT	MH
0.24	13.209	111.983	355.431
0.217	15.33	99.245	390.416
0.396	16.376	67.77	415.016
0.223	13.844	70.972	406.339
0.241	12.634	71.687	404.18
0.224	13.633	90.067	394.838
0.116	10.645	46.345	405.828
0.259	12.396	60.071	401.41
0.26	12.9	73.097	411.514
0.199	13.731	46.302	413.504
0.293	11.761	59.156	384.769
0.207	16.167	102.178	393.233
0.28	12.619	50.105	392.773
0.14	12.45	70.575	424.941
0.189	14.184	73.012	442.048
0.128	10.779	47.129	414.162
0.261	11.395	49.668	445.74
0.194	11.681	58.087	455.789

As soon as the teacher phase ends the learner phase commences. The learner phase mimics the act of knowledge sharing among two randomly selected learners. The learner phase entails updating each learner based on another randomly selected learner as follows:

$$x"_i(s) \leftarrow \begin{cases} x_i(s) + r\left(x'_i(s) - x'_k(s)\right) if\ x'_i\ is\ better\ than\ x'_k \\ x'_i(s) + r\left(x'_k(s) - x'_i(s)\right)\ otherwise \end{cases} \ldots\ldots\ldots\ldots\ldots\ldots\ldots.(3)$$

For i∈[1, N] and independent variable s∈[1, n], where k is the random integer in [1, N] such that k≠i, and r is a random number taken from a uniform distribution on [0, 1]. Again, the new candidate solution obtained after the learner phase $x"_i$replaces the previous solution $x_i$if it is better than the previous solution x_i.[6]

5. Result and discussion

MDR

$$\text{MAX MDR, } f(x) = 9.453 \times A^{-0.590} \times B^{-0.358} \times C^{0.486} \times D^{-0.242} \times E^{0.260} \quad (R^2 = 0.962)$$

700≤A≤900

100≤B≤200

20≤C≤30

42≤D≤58

100≤E≤300

Table 3: Optimization value of MDR using TLBO

Parameters	Sintering temperature (A)	Compaction pressure	Discharge current (C)	Duty cycle (D)	Pulse on time (E)	Fitness value
Optimum value	700	100	30	45.7619	291.976	0.345

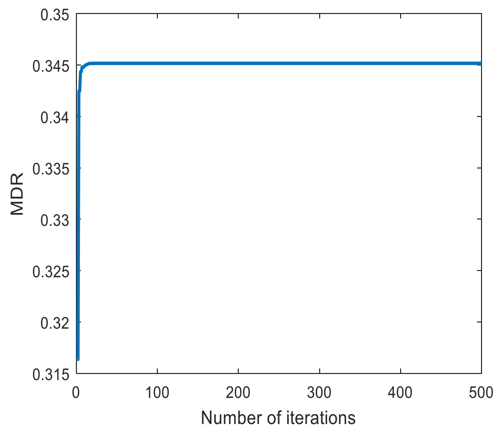

Figure 1: Convergence curve of MDR using TLBO algorithm

Using the TLBO algorithm number of iteration of the getting the optimum value of MDR is in between the 0-100 and nearly to 0 this shows its convergence is better to get the Optimization value and its fitness value is 0.345. In this case we have taken number of population size is 50 and number of iteration is taken as 500. This Optimization value of the parameter shows that only compaction pressure for the good fitness value, and pulse on time is nearly high value and discharge current value should be high and duty on cycle time should be in between high and low value.

Ra

$$\text{MIN Ra, } f(x) = 39.718 \times A^{-0.191} \times B^{-0.299} \times C^{0.309} \times D^{0.060} \times E^{0.081} \quad (R^2=0.997)$$

$700 \le A \le 900$

$100 \le B \le 200$

$20 \le C \le 30$

$42 \le D \le 58$

$100 \le E \le 300$

Table 4: Optimization value of Ra using TLBO

Parameters	Sintering temperature (A)	Compaction pressure	Discharge current (C)	Duty cycle (D)	Pulse on time (E)	Fitness value
Optimum value	845.5692	197.6838	30	57.14563	100	10.7725

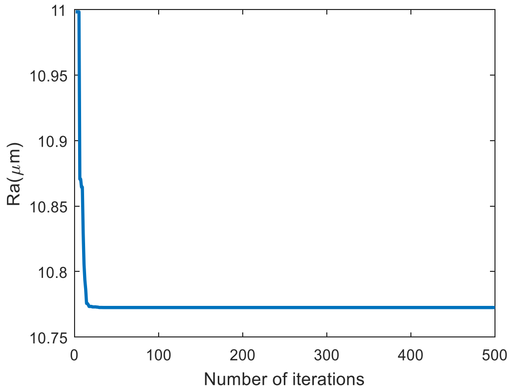

Figure 2: Convergence curve of Ra using TLBO algorithm

Using the TLBO algorithm number of iteration of the getting the optimum value of Ra is in between the 0-100 and nearly to 0 this shows its convergence is better to get the Optimization value and its fitness value is 10.7725 µm. In this case we have taken number of population size is 50 and number of iteration is taken as 500. This Optimization value of the parameter shows that only pulse on time value should be low for the good fitness value, and sintering temperature, compaction pressure and duty cycle is nearly high value and discharge current should be in between high and low value.

CLT

$$\text{MAX CLT, } f(x) = 1.64412 \times 10^{6} \times A^{-0.992626} \times B^{-0.517219} \times C^{0.583998} \times D^{-0.49049} \times E^{-0.159761}$$

700≤A≤900

100≤B≤200

20≤C≤30

42≤D≤58

100≤E≤3

Table 5: Optimization value of CLT using TLBO algorithm

Parameters	Sintering temperature (A)	Compaction pressure	Discharge current (C)	Duty cycle (D)	Pulse on time (E)	Fitness value
Optimum value	700	100	22.80972	42	100	108.345

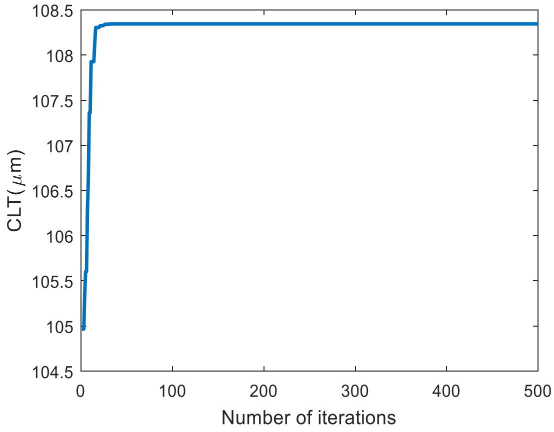

Figure 3: Convergence curve of CLT using TLBO algorithm

Using the TLBO algorithm number of iteration of the getting the optimum value of CLT is in between the 0-100 and nearly to 0 this shows its convergence is better to get the Optimization value and its fitness value is 108.345. In this case we have taken number of population size is 50 and number of iteration is taken as 500. This Optimization value of the parameter shows that all value of the parameter of the CLT discharge current, sintering temperature, duty cycle, and pulse on time and compaction pressure value should be low.

MH

$$\text{MAX} \quad \text{MH}, \; f(x) = 33.4261 \times A^{0.201769} \times B^{0.108429} \times C^{0.128357} \times D^{0.0240792} \times E^{0.0212097}$$

700≤A≤900

100≤B≤200

20≤C≤30

42≤D≤58

100≤E≤300

Table 4.20: Optimization value of MH using TLBO algorithm

Parameters	Sintering temperature (A)	Compaction pressure	Discharge current (C)	Duty cycle (D)	Pulse on time (E)	Fitness value
Optimum value	900	200	30	57.99341	300	451.004

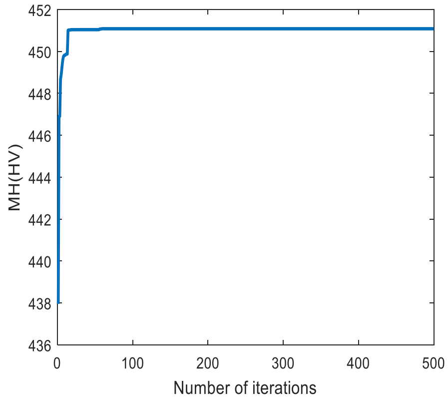

Figure 4: Convergence curve of MH using TLBO algorithm

Using the TLBO algorithm number of iteration of the getting the optimum value of MH is in between the 0-100 and nearly to 0 this shows its convergence is better to get the Optimization value and its fitness value is 451.004. In this case we have taken number of population size is 50 and number of iteration is taken as 500. This Optimization value of the parameter shows that sintering temperature, Duty on cycle and pulse on time value should be high and compaction pressure and discharge current value should be in between the high and low value.

6. CONCLUSION

This work shows the some parameter is actually optimised with the experiment value but some of them are not optimised as before. The global Optimization first constant is taken as 1.5 and second constant is just half of the first constant. This has seen that the optimised value is more converged and answer of this Optimization value nearly 0 to 50 iteration which shows that its optimised value is better. The optimum value of the average surface roughness is 10.18902 from TLBO algorithm TLBO algorithm gives better result as compared to SOPT algorithm. The optimum value of the average surface roughness is 108.345 from TLBO algorithm .From this work has been shown that optimised value of the micro hardness of the using TLBO algorithm give almost same value with the least number of iteration.

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