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OPTIMIZATION OF WIRE ELECTRICAL DISCHARGE MACHINING PROCESS PARAMETERS USING GENETICS ALGORITHM

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Abstract

The present work is focused on optimization of process parameters of wire electric discharge machining (WEDM). Genetic algorithmic (GA)tool for multi-objective optimization of Matlab is used to optimize the process parameters. Three WEDM parameters namely current, pulse on time and pulse off time are varied to study their effect on micro hardness and kerf width of machined surface of HSLA steel. Kerf and micro hardness are simultaneously optimized for their optimum values using GA.

Keywords: Genetic algorithms, Multi-objective optimization, WEDM, HSLA

1. INTRODUCTION

Wire electric discharge machining (WEDM) is widely used for manufacturing geometrically complex and hard material parts are requiring great effort to machine by conventional machining process. WEDM is a thermo-electricprocess in which material is eroded from the work-piece by a series of various spark between the work-piece and the wire electrode (tool) separated by a thin film of dielectric fluid which is endlessly forced into the machining zone to flush away the eroded particles. The movement of the wire is controlled numerically to gain the desired three dimensional shape and accuracy for the work piece

The selection of optimal cutting parameters, like the number of passes, depth of cut for each pass, feed and speed, is a major problem for every machining processes. In a workshop practice , cutting parameter are selected from machining data bases or specialized hand books, but the range given in this sources are actually starting values, and are not the most desirable values(Derelietal,2001). Optimization of cutting parameter is normally difficult work(Kumar and kumar,200), where the following features are required: knowledge of machining ; empirical equations relating the tool life , force, power, surface finish , etc, to develop genuine constrains; specification of machine tool abilities, development of an effective optimization criterion; and knowledge of mathematical and numerical optimization techniques(sonmezetal,1999).

In any optimization procedure, it is an essential aspect to identify the output of maximum value optimization objective or optimization criterion. In manufacturing process, the most commonly used optimization is specific cost, which has been used by many authors, from the beginning of the researches in this branch (Tylor,1907) to some of the most recent works. Occasionally other reference point machining time, material removal rate or tool life have been used too. However these single objective approaches have a limited value to fix the optimal cutting conditions, due to the complex nature of the machining processes, where several different and contradictory objectives must be simultaneously optimized.

Some multi objective approaches have been reported in cutting parameters optimization(Lee and tarng, 2000) but mainly they use a priori techniques, where the decision maker compound the diverse objectives into a scalar cost function. This actually makes the multi- objective problem, single objective prior to optimization (Van venduizen and lamont, 2000).

In the posteriori techniques, the decision maker is presented with a set of controlled optimal candidate solutions and chooses from that set. These solution are optimal in the wide range that no other solution in the search space are superior to them when all optimization objectives are simultaneously considered (Abbas S etal.,2001). They are also known as Pareto-optimal solutions.

2 GENETIC ALGORITHM

The genetic algorithms is a development algorithm that operators to extract most desirable solutions without any assumptions about the search space. GA are computerize search optimization algorithms and work with support or population of results as against to traditional optimization technique and develop the setof optimum solution using the principle of natural genetics and natural selection.

Genetic algorithm is very effective stochastic search technique that tries to follow natural evolution. Operators like crossover, mutation etc. are used to generate the offspring chromosomes. The crossover operation is a process of mix two parent chromosome searches several paths simultaneously starting with initial population. Each individual element in the population is called a chromosome. Each chromosome can represent a feasible solution containing a sequence /string of binary or real numbers known as genes. At the time of evolution process, a new generation of chromosomes comes in the place of the current population. The new population may contain both parent chromosomes and newly generated chromosomes and formation of one or two new chromosomes. Mutation refers to a process of modifying the structure of selected chromosomes by randomly changing one or more genes. The block diagram of the GA is given in Fig.1.

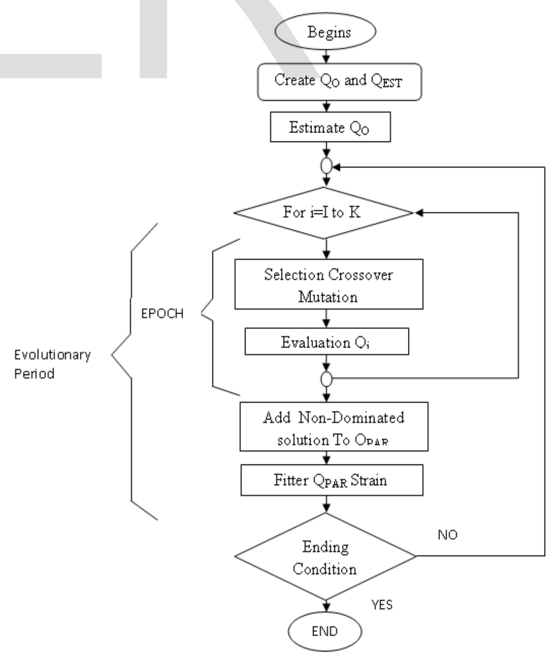

Figure 1: Genetic Algorithm block diagram

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A fitness function represented the objective of the problem is used to estimate the chromosomes. The chromosomes with high fitness among the parent and offspring will be selected for the next generation. The process repeats until the resolution of the stopping criteria that can be either a limited number of generations are reached or no further improvement in solution.

3 EXPERIMENTATION

The experiment was conducted on the material high strength low alloy (HSLA) steel of rectangular shape (200mm*50mm*15mm) using the WEDM. Table 1 shows the chemical composition of the workpiece used.

Table1 : Chemical composition of HSLA

Element	Concentration (%)
Fe	98.3
C	0.18
Si	0.04
Mn	1.35
S	0.025
Ph	0.027
Ni	0.012
Mo	0.014
Al	0.004
Other	<0.002

HSLA posses the greater resistance to corrosion than carbon steel . HSLA steels is widely in truck frames, brackets, crane booms and rail due to its superior properties such as higher impact and shock resistance.

Design of experiments (DOE) is a branch of applied statistics deals with planning, controlling, analyzing and clarifying controlled tests to evaluate the factors that control the value of a parameter or group of parameters. In present study the process parameters current, pulse on time, and pulse of time was varied and the kerf and microhardness was measured as the responses. The levels of these process parameters selected for study are given in Table 2.

Table 2: Level of process parameters

Factor	Symbol	Unit	Level -1	Level -2	Level -3
Current	A	A	2	3	4
Pulse on time	B	µs	15	20	25
Pulse off time	C	µs	3	4	5

Total 9 experiments were performed using L9 orthogonal design and regression analysis was performed on the experimentally observed values of responses kerf and width using MINITAB software and GA tool of MATLAB was applied for multi-objective optimization of the kerf and microhardness.

4 RESULT AND DISCUSSION

The experimentally observed values of the responses micro-hardness and kerf are given in Table 3.

Orthogonal array L9 (33) of the experimental runs and results

Exp. No.	A	B	C	Hardness	Kerf width (µm)
1	1	1	1	175	236.84
2	1	2	2	180	263.16
3	1	3	3	155	266.5
4	2	1	3	201	210.53
5	2	2	1	138	236.84
6	2	3	2	146	210.53

7	3	1	2	220	219.3
8	3	2	3	189	263.16
9	3	3	1	177	271.93

The regression analysis of these responses has given the following equations for the microhardness and kerf for the selected process parameters.

Micro hardness=179.7+12.67 A-3.93 B + 9.17 C

Kerf=196.9-2.0 A+2.74 B -0.9 C

These equations are used as fitness function of the GAmulti tool of the Matlab for getting the minimum possible value of kerf and maximum possible value of microhardness. The optimized values of the responses at different levels are shown in Table 4.

Table 4. The optimized values of the response at different levels.

x(1)	x(2)	x(3)	Microhardness	kerf
2.014784	24.99303	3.015977	134.6612	258.6369
2.132025	24.56864	3.017972	137.8328	257.2378
2.055572	23.51734	3.035931	141.1604	254.494
2.296088	23.70515	3.165723	144.6599	254.4108
2.104778	22.78464	3.27447	146.8508	252.1733
2.095535	21.65129	3.040743	149.0445	249.2968
2.18316	20.59724	3.167583	155.4602	246.1193
2.249114	19.56756	3.110844	159.8222	243.2171
2.23001	18.33236	3.116484	164.4862	239.8658
2.209511	17.07255	3.107279	169.0931	236.4632
2.278553	15.86369	3.300672	176.4921	232.8388
2.479507	15.82716	3.55638	181.5266	232.1067
2.362396	15.11897	3.468522	182.0203	230.4795
2.995368	15.45584	3.745102	191.2525	229.8877
2.795599	15.25571	4.017244	192.0034	229.4939
3.553619	15.33646	3.871253	199.9515	228.3305
3.87853	15.0203	4.728376	213.1704	226.043
3.996993	15.00191	4.995733	217.1952	225.5151

From the regression equation of microhardness and kerf it is evident that an increment in current and pulse off time the microhardness increases and kerf gets decreases. However, the increment of pulse on time decreases the microhardness and increases the kerf. The multi objective optimization of both the responses provided the A3B1C3 as the optimized level of process parameter which not only maximizes the microhardness but also minimizes the value of kerf. So, it may be concluded that an increment in current, decrement in pulse on time and increment of pulse on time simultaneously satisfies both the objectives.

5. CONCLUSION

In the present paper, Wire EDM process parameters are successfully optimized using Genetic Algorithm technique (GA). The effects of current, pulse on-time, and pulse off-time, are experimentally investigated in machining of HSLA steel using NC Wire-cut EDM process. The GA method was used to optimize the WEDM parameters for HSLA steel. Based on the results of the present study, optimum combination was found as A3B1C3 i.e., current of 4 A, pulse on-time of 15 µs, and pulse OFF time of 5 µs, it is the recommended levels of the controllable parameters of the WEDM machining process as the optimization involving multi-performance characteristics with minimization of the kerf width and maximization of the micro-hardness are simultaneously considered.

REFERENCES

[1] Shandilya, P; Jain, P. K. & Jain, N. K. (2011). Wire electric discharge machining of metal matrix composites, DAAAM International BOOK 2011, Vol. 10, Chapter 30, pp. 383-400, 978-3-901509-84-1

[2] Ho, K.H.; Newman, S.T.; Rahimifard, S., & Allen, R.D. (2004). State of art in wire electrical discharge machining (WEDM), International Journal of Machine Tools and Manufacturing, Vol. 44, 2004, pp. 1247-1259

[3] Saha, P.; Tarafdar, D.; Pal, S. K.; Srivastava, A.K. and Das, K. (2009). Modeling of wire electro-discharge machining of TiC/Fe in situ metal matrix composite using normalized RBFN with enchanced K-means clustering technique, International Journal of Advanced Manufacturing Technology, Vol. 43, 2009, pp. 107-116

[4] Shandilya, P.; Jain, P. K. and Jain, N. K. (2012). Prediction of Surface Roughness During Wire Electrical Discharge Machining of SiCp/6061 Al MMC, International Journal of Industrial and Systems Engineering, Vol. 12, No. 3, 2012, pp. 301-315

[5] Gao, Q.; Zhang, Q.; Su, S., & Zhang, J. (2008). Parametric optimization model in electrical discharge machining process, Journal of Zhegiang University Science A, Vol. 9, No.1,2008,pp.104-108

[6] Montgomery D.C. (2001). Design and analysis of experiments, John Wiely and Sons, New York

[7] Rao, S.S. (1991). Optimization theory and Applications, Wiely Eastern Limited, New Delhi

[8] Kuriakose, S; Shunmugam, M.S. (2005). Multi-objective optimization of wire-electro discharge machining processby nondominated sortinggenetic algorithm. Journal of Material Processing Technology, Vol. 170, No. 1-2, 2005, pp. 133-141

[9] Shandilya P.; Jain, N.K. & Jain, P.K (2011). Experimental studies on WEDC of SiCp/6061 Al metal matrix composite, Key Engineering Materials, Vol. 450, 2011, pp. 173-176

[10] Myers, R.H. & Montgomery, D.C. (2002). Response surface methodology: process and product optimization using designed experiments, Second edition, 2002, Wiley, New York

[11] Sameh, S. H. (2009). Study of the parameters in electric discharge machining through response surface methodology approach, Applied mathematical modeling, Vol. 33, 2009, pp. 4397-4407

[12] K. Deb (2000). Multi-objective optimization using evolutionary algorithms, Wiley, Chichester, 2000

[13] Kumar, R. (2010). Comprehensive Design Strategy for a Reconfigurable Manufacturing System, Department of Mechanical & Industrial Engineering, Indian Institute of Technology Roorkee, India