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PARAMETRIC OPTIMIZATION OF WIRE CUT EDM USING AISI 8620 STEEL

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Abstract: Wire cut EDM (WEDM) is a mostly accepted non-traditional material removal process used to manufacture components with intricate shapes and profiles irrespective of hardness. WEDM has evolved as a simple means of making tools and dies to the best alternative of producing micro-scale parts with the highest degree of dimensional accuracy and surface finish. WEDM is a specialized thermal machining process capable of accurately machining parts with varying hardness or complex shapes, which have sharp edges that are very difficult to be machined by the main stream machining processes. This study outlines the development of model and its application to estimation of machining performances. This study is about to parametric optimization of WEDM on AISI 8620 steel. In this study, it can be find out best suitable optimal solution of the input parameters. Pulse-on time, pulse-off time, machining speed taken as input parameter. It can be optimize the significance of these parameters on surface roughness and MRR which is taken as output parameter for WEDM. Brass wire is used in most applications which require very high tensile strength to provide a reasonable load carrying capacity in small diameter wire.

I. INTRODUCTION

Wire EDM is not the new on the block. It was introduced in the late 1960s', and has revolutionized the tool and die, mold, and metalworking industries. It is probably the most exciting and diversified machine tool developed for this industry in the last fifty years, and has numerous advantages to offer [1]. It can machine anything that is electrically conductive regardless of the hardness, from relatively common materials such as tool steel, aluminium, copper, and graphite, to exotic space-age alloys including hastaloy, waspaloy, inconel, titanium, carbide, polycrystalline diamond compacts and conductive ceramics. The wire does not touch the work piece, so there is no physical pressure imparted on the work piece compared to grinding wheels and milling cutters. The amount of clamping pressure required to hold small, thin and fragile parts is minimal, preventing damage or distortion to the work piece [1]. The accuracy, surface finish and time required to complete a job is extremely predictable, making it much easier to quote; EDM leaves a totally random pattern on the surface as compared to tooling marks left by milling cutters and grinding wheels. The EDM process leaves no residual burrs on the work piece, which reduces or eliminates the need for subsequent finishing operations [2]. Wire EDM also gives designers more latitude in designing dies, and management more control of manufacturing, since the machining is completed automatically. Parts thathave complex geometry and tolerances don't require you to rely on different skill levels or multiple equipment. Substantial increases in productivity are achieved since the machining is untended, allowing operators to do work in other areas. Most machines run overnight in a"lights-out" environment. Long jobs are cut overnight, or over the weekend, while shorter jobs are scheduled during the day. Most work pieces come off the machine as a finished part, without the need for secondary operations. It's a one-step process [3].

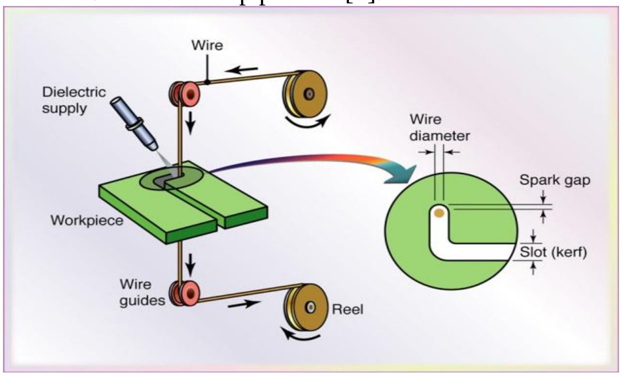

Fig.1 wire EDM process [3].

This motions of this work table and hence the work piece can be controlled or programmed through CNC machining device. The WEDM process requires lesser cutting forces in material removal. It is generally used when lower residual stresses in the work piece are desired. If the energy or power for pulse is relatively low, as in the finishing operations, then very little changes in the mechanical properties of the material are expected, due to these low residual stresses. The materials which are not stress relieved earlier can get distorted in the WEDM process.

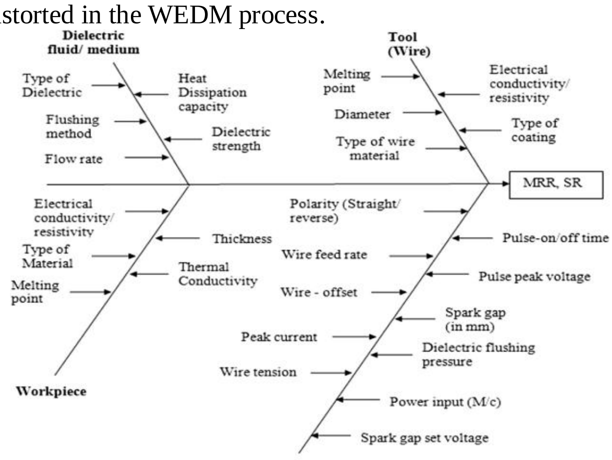

Fig. 2 Different parameters of WEDM [4].

II. MATERIAL AND EXPERIMENTAL SETUP

Base material:

CuZn37%, CuZn35%, CuZn40%

It is the original EDM wire. At the time it was thought that since Copper wire had high electrical conductivity, it would make the ideal EDM wire. Unfortunately, Copper wire has both low tensile strength and low flush ability. This soon became apparent with the development of the 2nd generation pulse type power supplies and Copper wire was soon supplanted by Brass wires. It should be noted that Copper wires are still used occasionally for applications in which Zinc (contained in brass wires or coated wires) is considered an unacceptable contaminant[7].

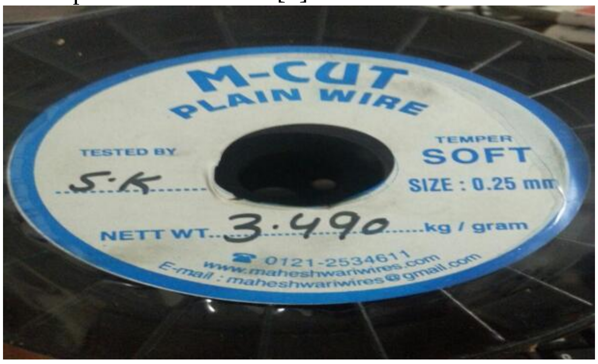

Fig.3 Wire Roll[8].

III. ANALYSIS OF RESULT

A. Design of Experiment

Taguchi technique is a powerful tool for the design of high quality systems. It provides a simple efficient and systematic approach to optimize designs for performance, quality and cost. The methodology is valuable when design parameters are qualitative and discrete. Taguchi parameter design can optimize the performance characteristics through the setting of design parameters and reduce the sensitivity of the system performance to source of variation. This technique is multi-step process, which follow a certain sequence for the experiments to yield an improved understanding of product or process performance. This design of experiments process made up of three main phases: the planning phase, the conducting Phase and analysis interpretation phase. The planning phase is the most important phase one must give a maximum importance to this phase. The data collected from all the experiments in the set are analyzed to determine the effect of various design parameters. This approach is to use a fractional factorial approach and this may be accomplished with the aid of orthogonal arrays. Analysis of variance is a mathematical technique, which is based on a least square approach. The treatment of the experimental results is based on the analysis of average and analysis of variance [5].

TABLE 1: Process Parameters with their Levels

Parameter	Unit	Level 1	Level 2	Level 3
Pulse on	µs	112	116	120
Pulse off	µs	50	55	60
M/C speed	mm/min	0.4	0.6	0.8

Taguchi's L9 orthogonal array used for experiment on wire EDM machine.

B. ANOVA Analysis

The ANOVA was used to investigate which design parameters significantly affect the quality characteristic. The ANOVA is performed by separating the total variability of the S/N ratios into contributions by each of the design parameters and the errors. The total variability of S/N ratio is measured by the sum of the squared deviations from the total mean S/N ratio [6].

TABLE 2: ANOVA for SR

Source	DF	Adj SS	Adj MS	F-value	P-value
Pulse on	2	1.02657	0.51328	27.89	0.035
Pulse off	2	0.12467	0.06234	3.39	0.228
M/C speed	2	0.18099	0.09049	4.92	0.169
Error	2	0.03680	0.01840		
Total	8	1.36903			

TABLE 3: ANOVA for MRR

Source	DF	Adj SS	Adj MS	F-value	P-value
Pulse on	2	0.0009	0.00045	43.58	0.022
Pulse off	2	0.00022	0.00011	10.55	0.087
M/C speed	2	0.00013	0.00007	6.42	0.135
Error	2	0.00002	0.00001		
Total	8	0.00127			

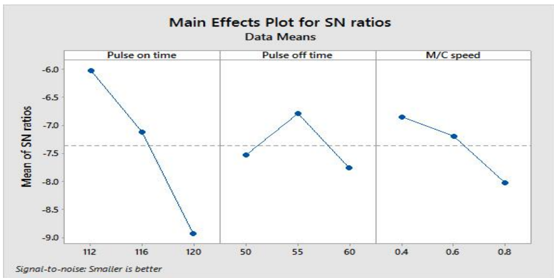

Fig.4 Main effect plot for SR

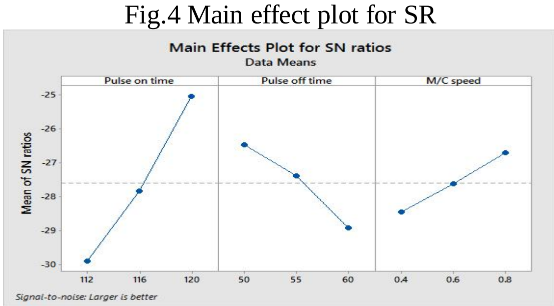

Fig.5 Main effect plot for MRR

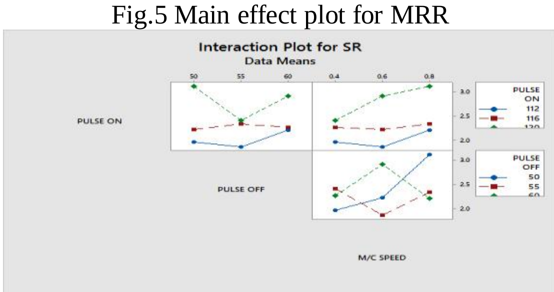

Fig.6 Interaction plot for SR

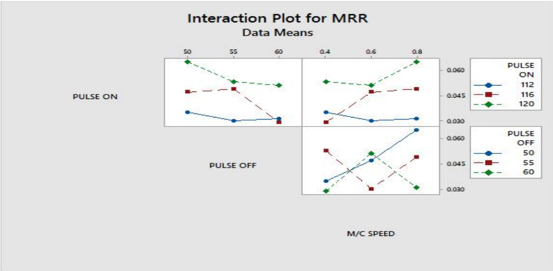

Fig.7 Interaction plot for MRR

From above analysis for surface roughness the best combination set is 112 µs, 55 µs, 0.4 mm/min. for MRR the best combination set is 120 µs, 50 µs, 0.8 mm/min.

IV. OPTIMIZATION

A. Grey relational analysis

In grey relational analysis, test information i.e. measured elements of value qualities of the item are initially standardized extending from zero to one. This procedure is known as grey relational generation. Next, in view of standardized test information, grey relational coefficient (GRC) is figured to speak to the relationship between the craved and genuine test information. At that point general grey relational evaluation is controlled by averaging the dim social coefficient relating to choose reactions. The general execution normal for the numerous reaction procedures relies on upon the ascertained grey relational evaluation. This methodology changes over a various reaction process streamlining issue into a solitary reaction enhancement circumstance, with the target capacity is general dim social evaluation. The ideal parametric blend is then assessed by boosting the general grey relational evaluation.

TABLE 4: Grey relational analysis

No.	GR-Coefficient of SR	GR-Coefficient of MRR	GR-Grade	No. of Grade
1	0.873	0.375	0.623876	3
2	1.000	0.339623	0.669812	1
3	0.649	0.346154	0.497666	7
4	0.639	0.5	0.569656	4
5	0.573	0.529412	0.551004	6
6	0.607	0.333333	0.470324	8
7	0.333	1	0.666667	2
8	0.537	0.6	0.568283	5
9	0.373	0.5625	0.467716	9

From Table 4 it is utilized that experiment no.2 has the best multiple performance conditions within 9 experiments, because it has the highest grey relational grade of 0.669812.

V. CONCLUSIONS

By performing and analyzing the experiment we can conclude that the input parameter such as Ton, Toff , machine feed are effect on material AISI 8620 Steel differently with output parameters(MRR and SR).Result of ANOVA shows that pulse on time is the most significant factor effect on SR and MRR while pulse off time is least significant on SR and MRR. By performing experiment, analysis of variance, regression analysis and optimization it can be conclude that,

- With increasing Ton time, MRR and SR are increases.
- With increasing Tofftime ,MRR decreases and SR first decrease and after that increases. .
- With increasing machine feed ,MRR and SR are increase.
- Grey rational anylisis shows that experiment no. 2 is the most suitable input parameter for cutting AISI 8620 on wire EDM. For MRR and better surface roughness the input values are Ton=112µs,Toff=55 µs, M/C speed=0.6.this experiment is most suitable for better surface roughness.
- In this experiment the maximum MRR is 0.030 gm/min and Average surface roughness is 1.859 micron.
- Second grade of grey rational analysis gives the eperiment no. 7 which is second most suitable combanition for cutting AISI 8620 on wire EDM.the input variables for this experiments are Ton=120 µs, Toff=50 µs and M/C speed=0.8 mm/min.
- In this experiment the maimum MRR is 0.065 gm/min and Average surface roughness is 3.121 micron. It suitable for getting better MRR on WEDM.

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