Experimental investigation of effects of cutting parameters on EN31 with WEDM

[1]Vikrant Aggarwal, [2]Rajeev Kumar, [3]Atul Goyal

[1]Research Scholar (PTU) , [2]Research Scholar(PTU) , [3]Ass. Professor(LLRIET, Moga)

Abstract— Wire electrical discharge machining (WEDM) is extensively used in machining of conductive materials when precision is of prime importance. The present experimental study presented in this paper aims to select the most suitable cutting and offset parameters. The effect of the different input variables on EN31 material is investigated. EN31 is a high carbon Alloy steel that achieves a high degree of hardness with compressive strength and abrasion resistance. A series of experiments have been performed on EN31 using Brass wire and keeping one of the input variables Pulse on Time(T_{ON}), Pulse off Time(T_{OFF}), Peak Current(IP), Servo Voltage(SV) and Wire Feed(WF) variable and rest of others constant. the effect of these parameters on Cutting speed, material removal rate, surface roughness, Wire wear and wire consumption were studied. the results show the significant effect on output variables with variable input.

Index Terms—About four key words or phrases in alphabetical order, separated by commas.

I. INTRODUCTION

Wire electrode Discharge machining is of great importance due to its machinability. The broad capabilities have allowed it to encompass production in aerospace and automotive industries and virtually all areas of conductive material machining.[1]-[2] . WEDM process is also being used to machine a wide variety of miniature and micro-parts in metals, alloys, sintered materials, cemented carbides, ceramics and silicon [3] **.**WEDM has proved to have tremendous potential in its applicability in the present day metal cutting industry for achieving a considerable dimensional accuracy, surface finish and contour generation feature of products or parts. Material is eroded from the work piece by a series of discrete sparks between the work piece and the wire electrode separated by a thin film of dielectric fluid which is continuously force fed to the machining zone to flush away the eroded particles. The movement of the wire controlled numerically to achieve the desired three-dimensional shape and accuracy for the workpiece. Although the average cutting speed, relative machining costs and material removal rate improved many times since the commercial inception of the machine, much more improvement is still required to meet the increasing demand of precision and accuracy by different industries. Fig. I shows the schematic representation of WEDM. Many researches had done research with different electrodes and different materials. Liao et. al. [4] performed an experimental study using SKD11 alloy steel as the work piece material and established mathematical models relating the machine performance like material removal rate (MRR), surface roughness(SR) and gap width with various machining parameters. Ranganath el. al. [5] Conducted on work materials of varying hardness like Mild steel, and HCHCr steel. Bare brass and zinc coated brass wires used to study the machining process on Electra elcut-334 machine. Results shows that the zinc coated brass wire performs better as compared to bare brass wire because of its low wear rate and lower breakage with increased discharge current conditions, and Wire failure occurs in wire-EDM process as a result of difference in wire wear rate. Tosun et. al. [6] studied the effect of the cutting parameters on size of erosion craters on wire electrode in WEDM. Brass wire of 0.25 mm diameter and AISI 4140 steel of 0.28 mm thickness used as tool and work piece materials in the experiments.

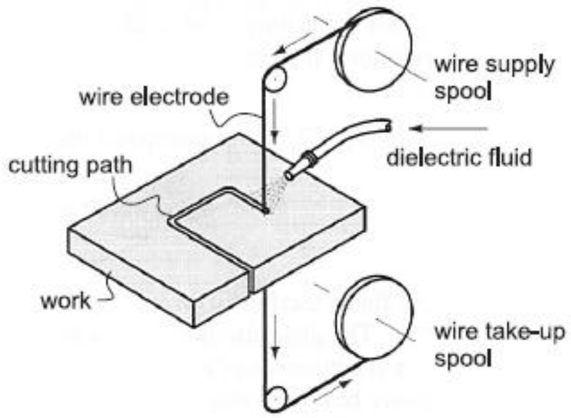

Fig. I Schematic representation of WEDM.

It was found that increase in the pulse duration, open circuit voltage and wire speed increases the crater size, whereas increase in the dielectric flushing pressure decreases the crater size. Sarkar et. al. [7] performed experimental investigation on single pass cutting of wire electrical discharge machining of γ-TiAl alloy. The process was successfully modeled using additive model. Both surface roughness as well as dimensional deviation was independent of the pulse off time. Tosun et.al [8] conducted experiment on the effect and optimization of machining parameters on the kerf (cutting width) and material removal rate (MRR) in wire electrical discharge machining (WEDM) operations. The experimental studies conducted under varying pulse duration, open circuit voltage, wire speed and dielectric flushing pressure. Mahapatra et.al [9] studied the relationships between various control factors and responses like MRR, SF and kerf by means of nonlinear regression analysis, resulting in a valid mathematical model. Finally, genetic algorithm, a popular evolutionary approach, employed to optimize the wire electrical discharge machining process with multiple objectives. The study demonstrates that the WEDM process parameters be adjusted to achieve better metal removal rate, surface finish and cutting width simultaneously. Sarkar et. al. [10] performed experimental investigation on trim cutting of wire electrical discharge machining of γ-TiAl alloy. WEDM process optimized using Minitab (statistical software package) which generally makes use of the desirability function approach. However, it was observed that lot of trial and error and manual tuning was required to obtain the true optimal solution. Singh and Garg [11] studied the effects of various process parameters on electronica sprintcut WEDM. The various process parameters were pulse on time (TON), pulse off time (TOFF), gap voltage (SV), peak current (IP), wire feed (WF) and wire tension (WT) have been investigated to reveal their impact on material removal rate of hot die steel (H-11) using one variable at a time approach. Lodhi and Aggarwal[12] carried out Experiments under varying pulse on time, pulse-off-time, peak current, and wire feed on AISI D3. An orthogonal array, the signal-to-noise (S/N) ratio, and the analysis of variance (ANOVA) were employed to the study the surface roughness in the WEDM.

II. EXPERIMENTAL SET UP

All the experiments been conducted on computer numerically controlled (CNC) wire EDM machine. The WEDM machine is of Elektra make manufactured by Electronica Machine Tools, India. Experimentation been done at Central Tool Room, Ludhiana. The EN31 material was used as workpiece of dimensions 100 mm X 100mm X20mm. Twenty Five Square slots of 8mm*8mm*20mm were cut using Brass wire of diameter 0.25mm. The various machine parameters with their range been shown in table 1.

Table 1 Parameters of WEDM machine

Process parameters	Symbols	Units	Range
Pulse on time	T_{on}	µs	100-126
Pulse off time	T_{off}	µs	14- 56
Servo voltage	SV	V	10-44
Peak Current	IP	A	70-230
Wire feed	WF	m/min	4- 12

The various input parameters under consideration are Pulse on Time (T_{ON}), Pulse off Time(T_{OFF}), Peak Current(IP), Servo Voltage(SV) and Wire Feed(WF).The experiment was planned keeping the one parameter variable and others constant. The constant values are shown in Table 2

Table 2 Constant Parameters of WEDM machine

Parameters	Values
Pulse on Time(T_{ON})	118
Pulse off Time(T_{OFF})	48
Peak Current(IP)	200
Servo Voltage(SV)	37
Wire Feed(WF)	8
Servo Feed(SF)	2300
Water Pressure(WP)	8

The various parameters with their variable levels is shown in Table 3.

Table 3 Variable Input Parameters With Their Levels

S. No.	Variable Parameters	Levels											
		L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
1	Pulse on time	110	111	112	113	114	115	116	117	118	119	120	121
2	Pulse off time	45	46	47	48	49	50	51	52	53	54	55	56
3	Peak Current	120	130	140	150	160	170	180	190	200	210	220	230
4	Wire Feed	4	5	6	7	8	9	10	11	12	-	-	-
5	Servo Voltage	20	22	24	26	28	30	32	34	36	38	40	42

III. FINDINGS

with one input variable and other constant, the graphs of the results has been made. Fig. 2 to Fig. 6 represents the variation in the cutting speed with variable input parameters.

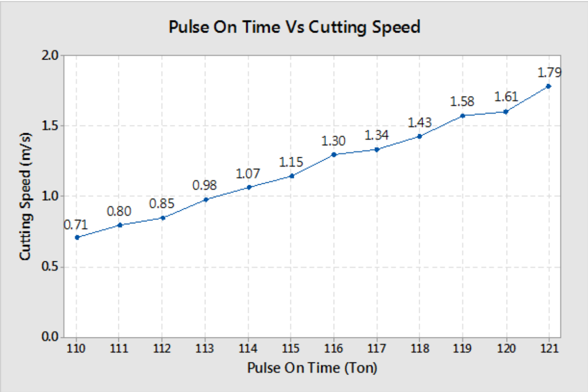

Fig. 2 Pulse On Time Vs Cutting Speed

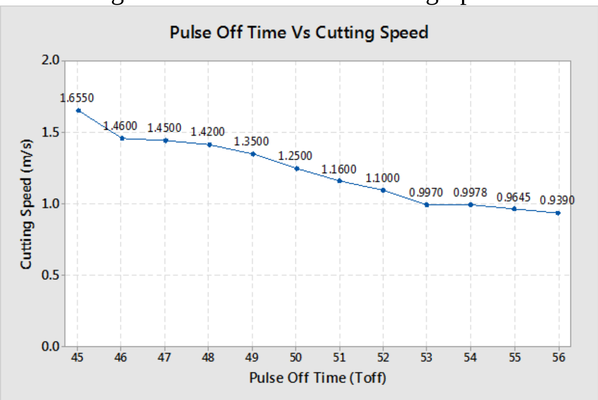

Fig. 3 Pulse Off Time Vs Cutting Speed

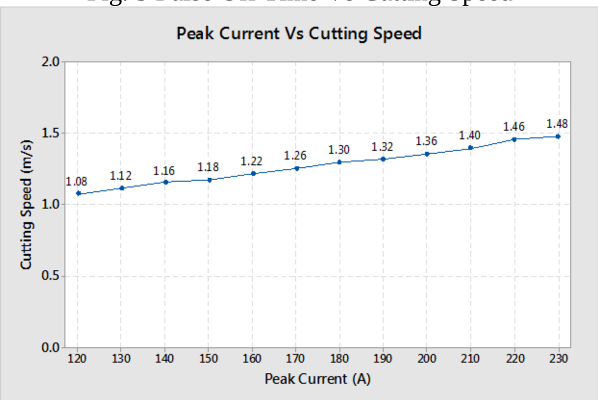

Fig. 4 Peak Current Vs Cutting Speed

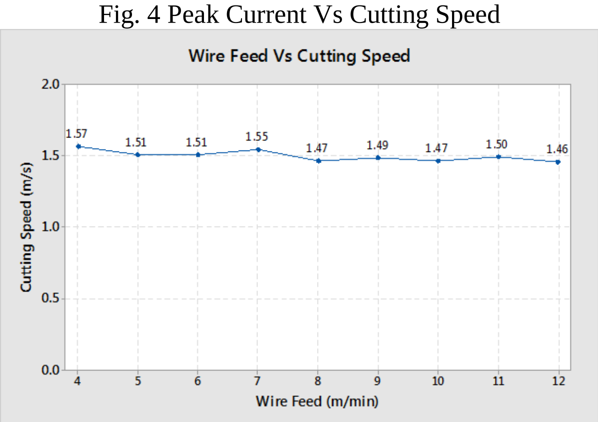

Fig. 5 Wire Feed Vs Cutting Speed

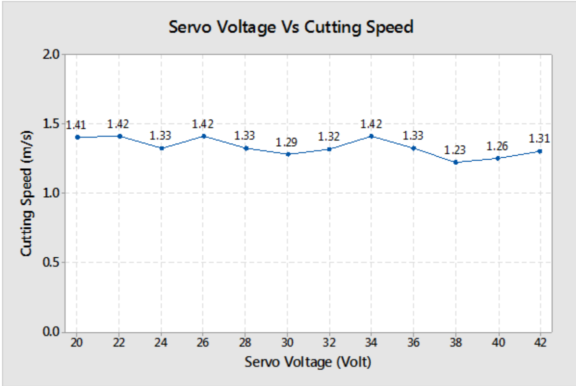

Fig. 6 Servo Voltage Vs Cutting Speed

Fig. 7 to Fig. 11 represents the variation in the Materia removal rate with variable input parameters.

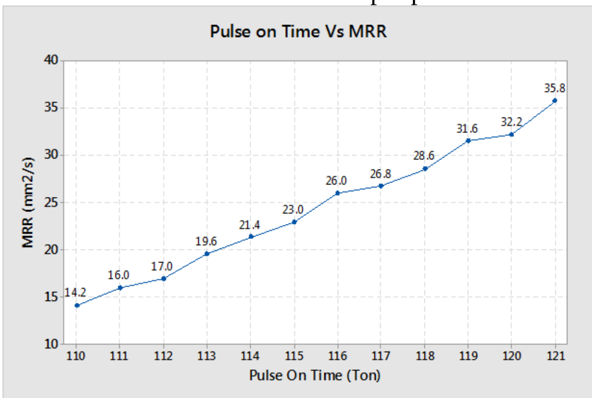

Fig. 7 Pulse On Time Vs MRR

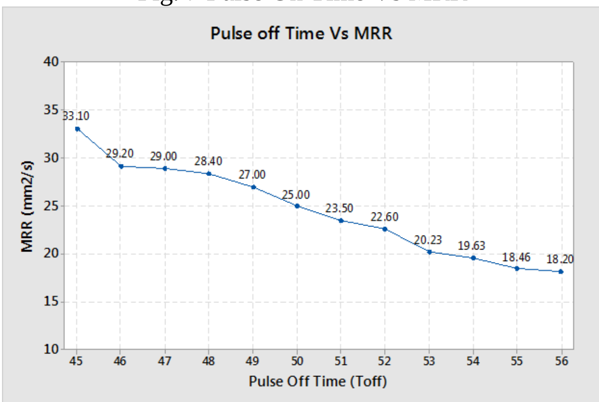

Fig. 8 Pulse Off Time Vs MRR

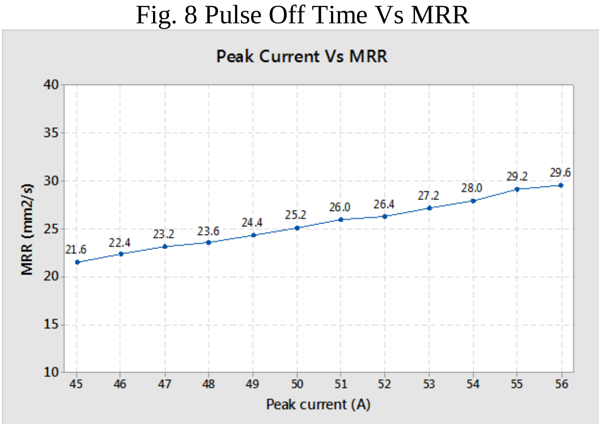

Fig. 9 Peak Current Vs MRR

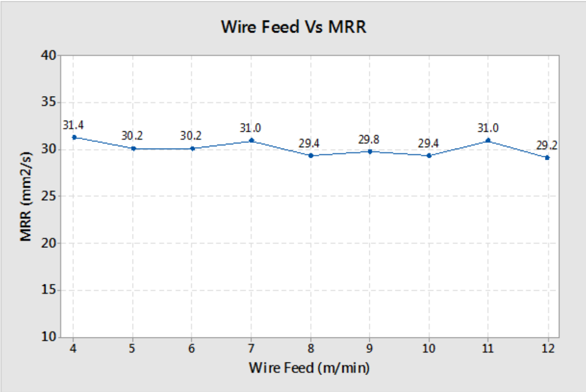

Fig. 10 Wire Feed Vs MRR

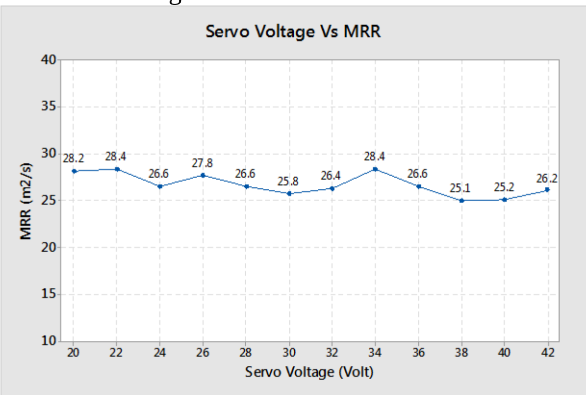

Fig. 11 Servo Voltage Vs MRR

Fig. 12 to Fig. 16 represents the variation in the Wire Consumption with variable input parameters.

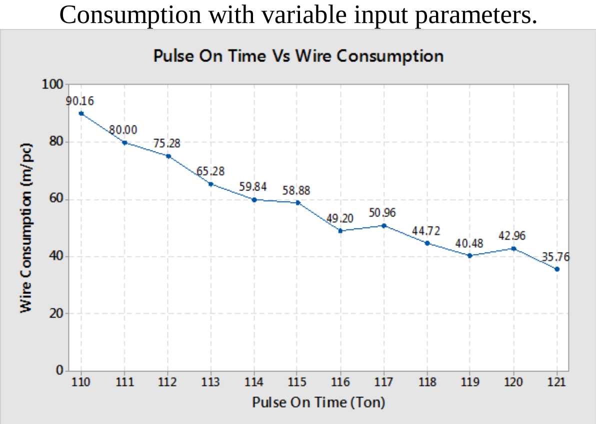

Fig. 12 Pulse On Time Vs wire Consumption

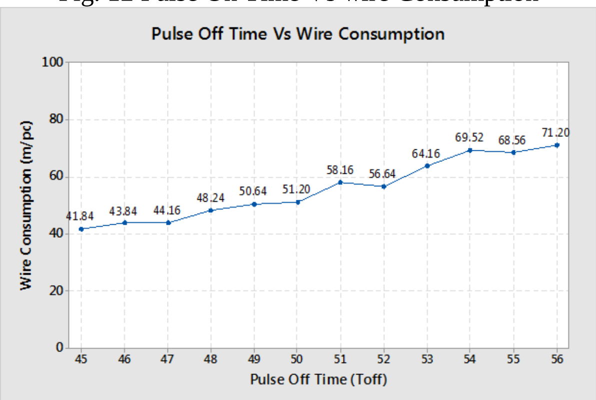

Fig. 13 Pulse Off Time Vs wire Consumption

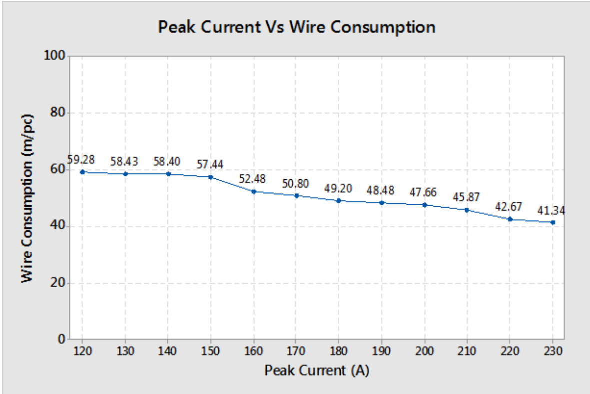

Fig. 14 Peak Current Vs Wire Consumption

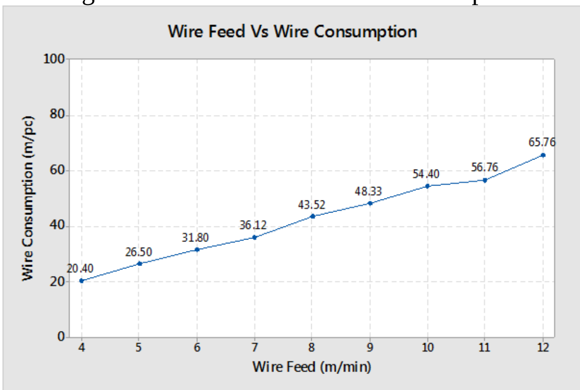

Fig. 15 Wire Feed Vs Wire Consumption

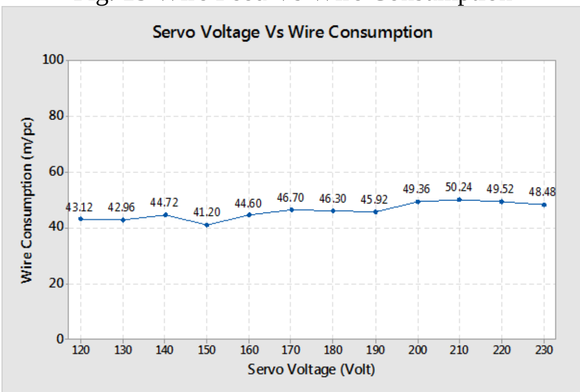

Fig. 16 Servo voltage Vs Wire Consumption

Fig. 17 to Fig. 21 represents the variation in the Wire Wear with variable input parameters.

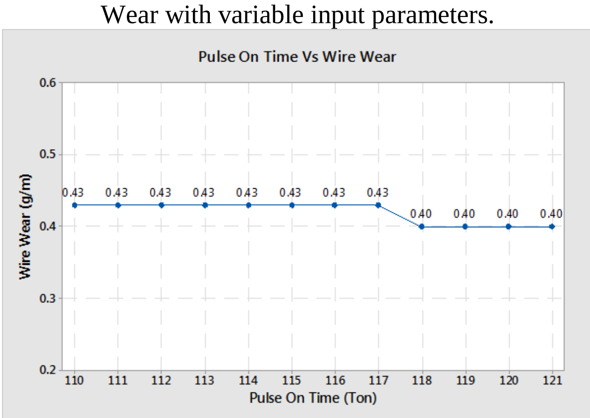

Fig. 17 Pulse On Time Vs Wire Wear

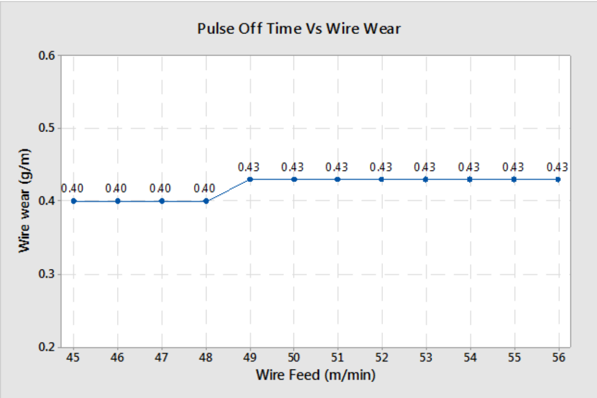

Fig. 18 Pulse Off Time Vs Wire Wear

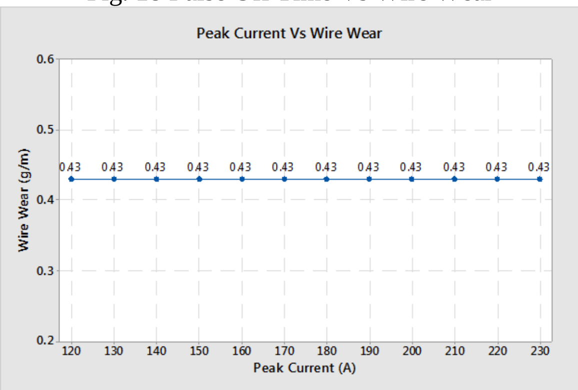

Fig. 19 Peak current Vs Wire Wear

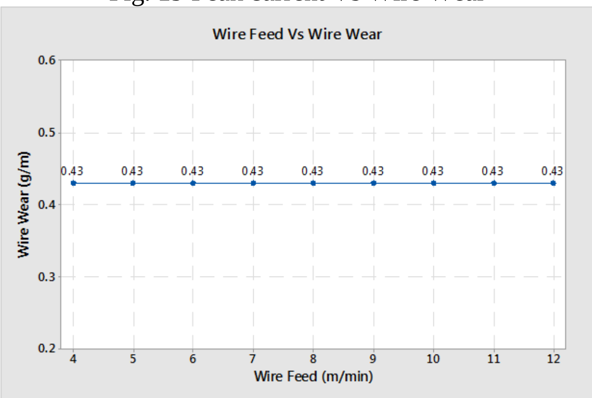

Fig. 20 Wire Feed Vs Wire Wear

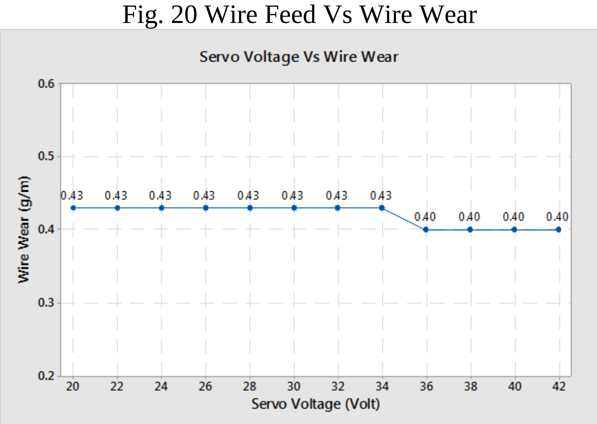

Fig. 21 Servo Voltage Vs Wire Wear

Fig. 22 to Fig. 26 represents the variation in the Surface roughness with variable input parameters.

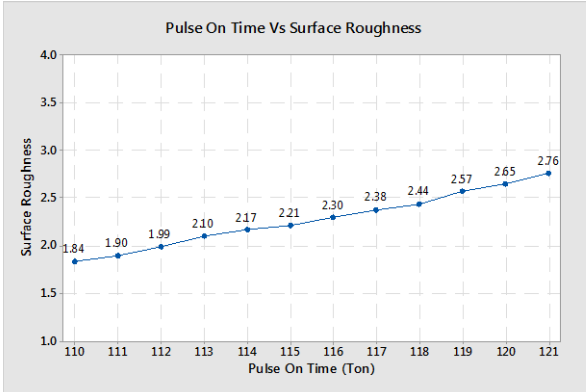

Fig. 22 Pulse On Time Vs Surface Roughness

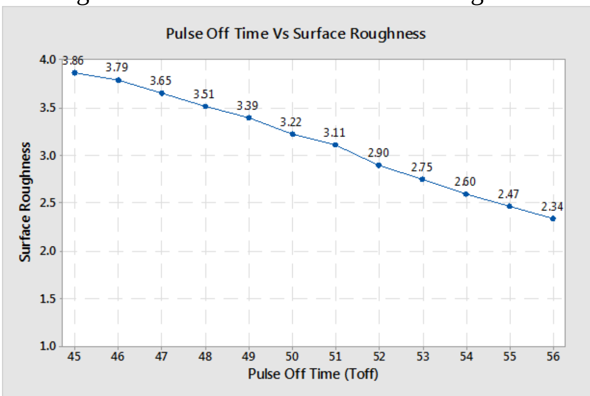

Fig. 23 Pulse Off Time Vs Surface Roughness

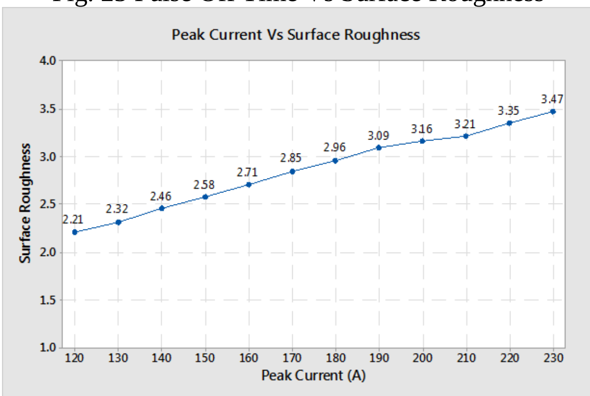

Fig. 24 Peak Current Vs Surface Roughness

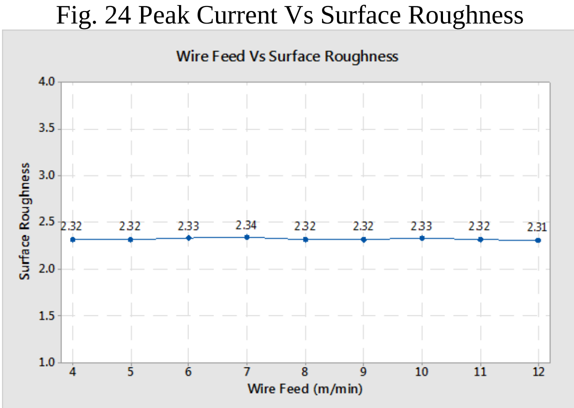

Fig. 25 Wire Feed Vs Surface Roughness

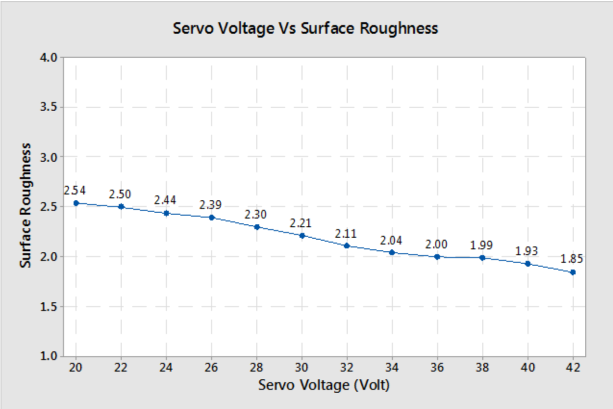

Fig. 26 Servo Voltage Vs Surface Roughness

IV. CONCLUSION

The experiment conducted on material EN 31 on WEDM. The experiment shows the effect of various parameters like T_{ON}, T_{OFF}, IP, Wire Tension and Servo Voltage on the cutting speed, surface roughness, wire wear, cutting time. Following are the conclusions of the experimentation:-

1. Cutting speed increases with increase in T_{ON} and IP & decreases with increase in $T_{OFF.}$WF and SV has no significant effect on cutting speed.

2. Material Removal rate (MRR) increases with increase in T_{ON} and IP & decreases with increase in $T_{OFF.}$WF and SV has no significant effect on MRR.

3. Wire consumption decreases with increase in T_{ON} and IP & increase with increase in T_{OFF} and WF. SV has no significant effect on Wire Consumption.

4. Input parameters has no significant effect on wire wear.

5. Surface roughness increases with increase in T_{ON} and IP & decreases with increase in SV and$T_{OFF.}$WF has no significant effect on surface Roughness.

REFERENCES

[1] J. A. Sanchez, J. L. Rodil, A. Herrero, L. N. Lopez de Lacalle, and A. Lamikiz, "On the Influence of Cutting Speed Limitation on the Accuracy of Wire-EDM Corner-cutting," J. of Materials Processing Technology,Vol.182, pp.574-579, 2007.

[2] R. Ramakrishnan and L. Karunamoorthy, "Multi response optimization of wire EDM operations using robust design of experiments," Vol. 29, pp. 105-112, 2006.

[3] R. Mukherjee, S. Chakraborty, S. Samanta, ''Selection of wire electrical discharge machining process parameters using non-traditional optimization algorithms,'' Applied Soft Computing Vol. 12, Issue 8, pp. 2506–2516, 2012.

[4] Y.S Liao , J.T Huang and Y.H. Chen ," A study to achieve a fine surface finish in Wire-EDM," Journal of Materials Processing Technology ,Vol. 149 ,pp. 165-171, 2004

[5] B.J Ranganath and A.S. Srikantappa, "Tool characteristics for better performance in wire EDM," Proc. 4th Int. Conf. on Mechanical Engineering (ICME 2001), BUET Dhaka, 2001

[6] N. Tosun, C. Cogun, and H. Pihtili," The effect of cutting parameters on wire crater sizes in wire EDM," International Journal of Advanced Manufacturing Technology, Vol. 21, pp. 857–865, 2003.

[7] S. Mitra and B. Bhattacharyya," Parametric analysis and optimization of wire electrical discharge machining of γ-titanium aluminide alloy," Journal of Materials Processing Technology, Vol. 159,pp. 286–294, 2003.

[8] N. Tosun, C. Cogun and G. Tosun, "A study on kerf and material removal rate in wire electrical discharge machining based on Taguchi method," Journal of Materials Processing Technology,Vol. 152, pp. 316-322, 2004.

[9] S.S. Mahapatra and A. Patnaik," Optimization of wire electrical discharge machining (WEDM) process parameters using Taguchi method," The International Journal of Advanced Manufacturing Technology, Vol. 34,Iss. 9-10,pp. 911-925, 2007.

[10] S. Sarkar, S. Mitra and B. Bhattacharyya, "Parametric analysis and optimization of wire electrical discharge machining of γ-titanium aluminide alloy," Journal of Materials Processing Technology, Vol.159, pp.286–294, 2005.

[11] H. Singh and R. Garg," Effects of process parameters on material removal rate in WEDM," Journal of Achievements in Materials and Manufacturing Engg., Vol.32, pp. 70-74, 2009.

[12] B.K. Lodhi and S. Agarwal,"Optimization of machining parameters in WEDM of AISI D3 Steel using Taguchi Technique," 6th CIRP International Conference on High Performance Cutting,2009.

❖❖❖