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Effect of Input Process Parameters on Cutting Speed for Al/Al$_2$o$_3$ MMC in Wire EDM

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Abstract: In the present study the effect of input process parameters on cutting speed has been investigated experimentally in wire electrical discharge machining (WEDM). The experiments had been conducted under different input parameters which were varied, those parameters are: Pulse on time (T_{on}), Pulse off time (T_{off}), Spark gap voltage (SV), Peak current (IP), Wire feed (WF) and Wire Tension (WT). Brass wire having 0.25 mm diameter and Al/Al$_2$O$_3$ MMC plate having dimensions140 mm×70 mm×12 mm were used as tool and work piece material. Based on analysis of variance it was found that four parameters i.e., T_{on}, T_{off}, SV, IP and three interactions were significant for cutting speed. Based on effect plots it was found that pulse on time and pulse off time are the most significant factors for cutting speed. The best parameters at which maximum cutting speed can be obtained are – pulse on time = 1.20 µs, pulse off time =16µs, peak current =190A, spark gap voltage = 20V, wire feed = 7m/min and wire tension = 1000 gram.
Keywords: Wire EDM, ANNOVA, MMC, Cutting speed

I. INTRODUCTION

In current manufacturing, Wire electrical discharge machining (WEDM) is one of the most widely used machining process. Although many non conventional machining processes like laser machining and abrasive jet machining are available but the equipment used in those processes are too much expensive, also many problems occur like poor surface quality etc. WEDM is widely accepted machining process which is used to produce intricacies and complex shapes of material. In WEDM the material removal is done by controlled erosion through a series of repetitive sparks between electrodes i.e., work piece and tool. The electrode is a thin wire made up of copper, brass or tungsten of diameter ranging from 0.05-0.30mm. The wire electrode is pulled through the work-piece from a supply spool onto a take-up mechanism. On application of a suitable voltage, discharge occurs between the wire electrode and the work-piece in the presence of a flood of de-ionized water of high insulation resistance.

A metal matrix composite (MMC) is composite material with at least two constituent parts, one being a metal necessarily, the other material may be a different metal or another material, such as a ceramic or organic compound. When at least three materials are present, it is called a hybrid composite. Metal matrix composites (MMCs) are newly advanced materials with light weight, high specific strength, good wear resistance and a low thermal expansion coefficient. They have proven to be important advanced materials that serve as alternatives to many conventional materials, particularly when light-weight and high strength components are needed such as in the automotive, aerospace, defense and other industries. Aluminium oxide (Al_2O_3) which is also called alumina, possesses strong ionic inter bonding giving rise to its desirable material characteristics, it exists in various crystalline phases which is most stable hexagonal alpha phase at elevated temperatures, alpha phase alumina is the strongest and stiffest of the oxide ceramics, its dielectric properties, hardness and good thermal properties make it best choice for wide range of applications. High purity alumina can be used for both oxidizing and reducing atmospheres to 1925^{0}C

It resists attack by all gases except wet fluorine and is resistant to all common reagents except hydrofluoric acid and phosphoric acid. The composition of ceramic body can be changed to enhance particular desirable material characteristics. In current research work 20% Al_2O_3 reinforced Al matrix composite has been used.

II. LITERATURE REVIEW

Many researchers have worked in Wire electrical discharge machining. Azhiri et. al. presented the experimental study while machining of Al/Sic aluminium matrix by dry WEDM process.it was found that pulse on time and current have significant effect on CV. It was concluded in exploratory experiments that oxygen gas and brass wire results in higher cutting velocity and oxygen gas can create a chemical reaction, also increases corrosion rate of work piece [1]. Meena et. al. Investigated the Parametric Effects during Nonconventional Machining of Particle reinforced AL-SiC AMC by CNC Wire cut EDM. It was concluded that, Maximum cutting speed and MRR can be achieved at high value of Mesh size, and at low value Wt. % of Sic Particles. It was also found that smooth machining can be achieved at high value of Mesh size and at low value Wt. % of Sic Particles [2]. Shandilya et. al. described the response surface methodology (RSM) and artificial neural network (ANN) based mathematical modeling for the average cutting speed of SiCp/6061 Al metal matrix composite, during wire electric discharge machining (WEDM). It was found by the combined effect of input process parameters that, the voltage is more significant parameter on average cutting speed than pulse-off time and wire feed rate. Voltage was found to be more significant parameter on average cutting speed than pulse-off time and wire feed rate for 10% SiCp/6061 Al [3]. Patil et. al. investigated to examine the effect of electrical as well as non-electrical parameters on the performance of WEDM of (Al/Al_2O_3p) MMC with varying volume fractions i.e., 10 % and 22%. It was found that presence of protruding ceramic particles was significant on surface of both composites. For A6061 alloy the cutting rates varied from 43.2 and 220.8 mm^2/min. It ranged between 16.8 to 141.6 mm^2/min for 10% Al/Al_2O_3p MMC and 9.6 to 110.4 mm^2/min for 22% Al/Al_2O_3p MMC [4]. Yan et. al. examined the machining of Al_2O_3p/6061Al composite on WEDM. A negatively polarized brass wire with a diameter of 0.25 mm was used as the tool. WEDM was used to cut both the 10 and 20 vol. % Al_2O_3particles reinforced 6061Al alloys-based composite and 6061Al matrix material itself Many conclusions were drawn from experimental work, 6061Al alloy obtained the highest cutting speed than the two Al_2O_3p/6061Al composites, and both the composite materials yielded similar cutting speeds[5]. Rozenek et. al. presented experimental investigation for the effects of input machining parameters i.e., discharge current, voltage, pulse on-time and pulse off-time) on the machining feed rate and surface roughness for machining of metal matrix composite AlSi7Mg/Sic and AlSi7Mg/Al_2O_3.The surface roughness and feed rate tends to increase with increase of discharge energy. The value of feed rate V and surface roughness R_a drops slowly with decrease in voltage. The maximum cutting speeds are also low for AlSi7Mg/Sic and AlSi7Mg/ Al_2O_3 composites than the cutting speed of aluminium alloy; these are approximately 3 and 6.5 times lower. With the increase in pulse on time it resulted in higher values of feed rate and surface roughness parameter. The machining feed rate of WEDM is significantly dependent on the kind of reinforcement [6]. Fard et. al. in their work carried out experimental investigation, modeling and multi Characteristics optimization of dry wire electrical discharge machining (WEDM) process while machining of Al/Sic aluminium matrix composite (AMC Firstly, a series of exploratory experiments were conducted and it was found that brass wire and oxygen gas resulted in higher cutting velocity. Results showed that oxygen gas and brass wire guarantee superior cutting velocity. According to ANOVA, pulse on time and discharge current were found to have significant effect on CV and SR[7].Guo et. al. investigated into shaping particles reinforced material by wire-EDM with high-travelling speed It was found to have little influence by electrical parameters on surface roughness but selection of electrical parameters had an important effect on cutting rate. It was investigated that high machining efficiency can be obtained at high voltage, high pulse duration, large machining current, and at proper pulse [8].

From literature survey it is observed that reasonably extensive work has been published on WEDM. However, very less work has been reported for machining of $Al/Al2_2O_3$ MMC to the best of the knowledge of present authors. The present work is an attempt towards optimization of WEDM of $Al/Al2_2O_3$MMC

III. EXPERIMENTATION

Experiments were performed on ELEKTRA SPRINTCUT wire-cut EDM machine according to Box Behken Design (BBD). Each time when an experiment was performed, a particular set of parameter combination was chosen and work piece was cut. A 5mm × 5mm rectangular cut was taken on the work piece. CNC code for cutting was generated through ELAPT software which was supplied by the manufacturer. Figure 1 shows the complete job after WEDM.

Figure 1Complete job profile after WEDM

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IV. RESULTS AND DISCUSSION

For cutting speed linear and quadratic models has been recommended by Design Expert software. Table 1 shows ANOVA for quadratic model at 95% confidence level. Based on analysis of variance as shown in Table 1, four parameters i.e., T_{on}, T_{off}, SV, IP and three interactions are found to be significant for cutting speed. It shows that the F value of the model is 69.87 and corresponding p value is less than 0.0001. It reveals that there is only 0.001% chance such that large F value of model can occur due to noise. Lack of fit of 0.8836 implies that it is not significant relative to pure error. Thus quadratic model is significant at 95% confidence interval. The determination coefficient, R^2 is the ratio of the explained variation to total variation and is the degree of fit. The response model fits better to the actual data and shows less difference between predicted and actual values when R^2 approaches to unity. The obtained value of $R^2 = 0.8839$ is in reasonable agreement with the adjusted R^2 of 0.9123. Figure 3 shows the normal probability plot of residuals for cutting speed. In the graph it is shown that errors are normally distributed as most of the residuals are clustered along straight line.

The mathematical relationship for correlating the cutting speed and the considered process variables is obtained as follows:

Cutting speed =

$$46.66786 + 174.96194 \times T_{on} - 4.99365 \times T_{off} + 0.70200 \times SV - 0.21615 \times IP - 93.00278 \times T_{on}^2 + 2.52396 \times Ton \times T_{off} - 0.055703 \times T_{off} \times SV + 0.018115 \times T_{off} \times IP \quad (1)$$

All the sources having probability less than 0.05 represents factor of statistical significance for the response. In addition to all the individual factor effects, two factor interactions are also found to be significant as shown in table 1. Figure 2 shows the plot of experimental and predicted data for cutting speed. It shows that equation 1 is adequate to give the actual relationship between process parameters and responses.ANOVA for response surface of reduced quadratic model of cutting Speed has been shown in Table 1 below.

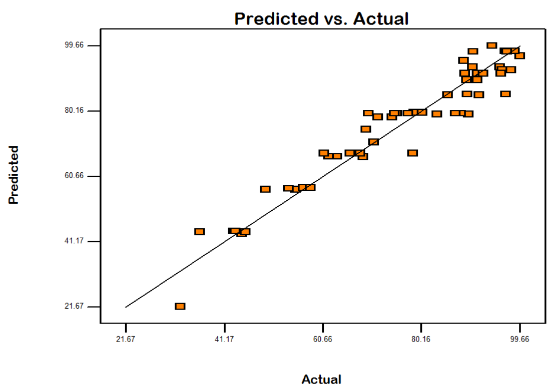

Figure 2Actual versus predicted plot for cutting speed

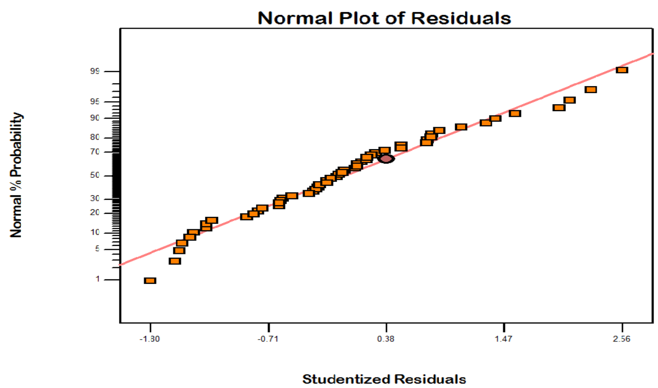

Figure 3 Normal probability plots of residuals for cutting speed

Table 1 ANOVA for response surface of reduced quadratic model of cutting Speed

Source	Sum of Squares	DOF	Mean Square	F Value	Prob.> F (p-value)	Remarks
Model	16996.19	8	2124.52	69.87	<0.0001	significant
A	10026.64	1	10026.64	329.77	<0.0001	significant
B	3432.28	1	3432.28	112.89	<0.0001	significant
C	967.36	1	967.36	31.82	<0.0001	significant
D	1032.15	1	1032.15	33.95	<0.0001	significant
A^2	934.15	1	934.15	30.72	<0.0001	significant
AB	293.55	1	293.55	9.65	0.0033	significant
BC	158.87	1	158.87	5.22	0.0270	significant
BD	151.21	1	151.21	4.97	0.0308	significant
Residual	1368.23	45	30.41			
Lack of fit	1105.97	40	27.65	0.53	0.8836	Not significant

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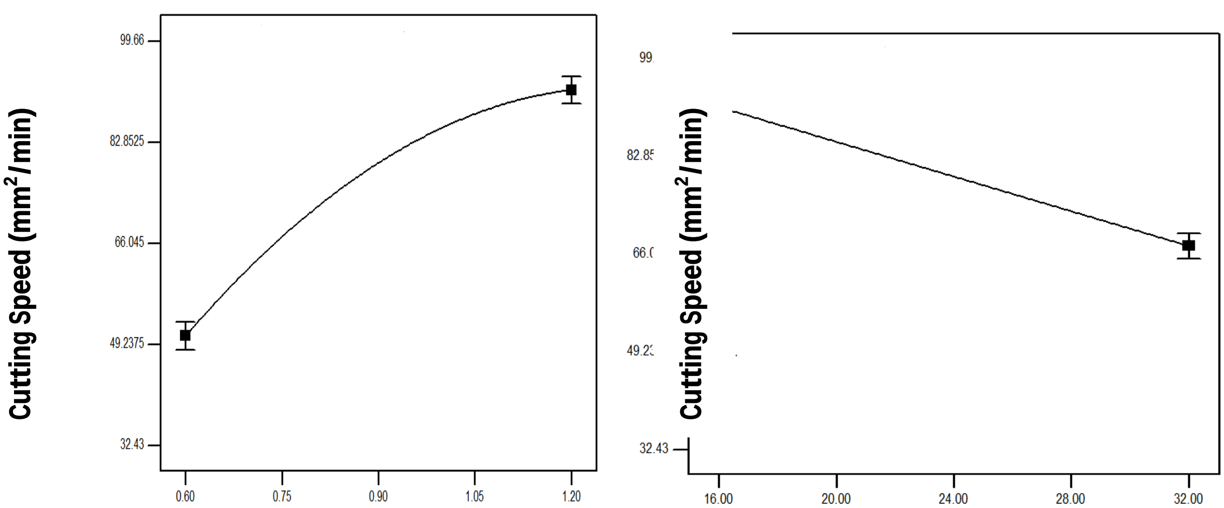
Pure error	262.26	5	52.45			
Corrected total	18364.42	53				

Standard Deviation	5.51	R-Squared	0.9255
Mean	75.68	Adj R-Squared	0.9123
Coefficient of Variation	7.29	Pred R-Squared	0.8839
PRESS	2132.76	Adeq Precision	34.611

Legend: A- Pulse on time, B- Pulse off time, C- Spark gap set voltage, D- Peak current, E-Wire tension rate, F- Wire feed

The main effect plots for cutting speed are shown in figures 4 and 5. These plots show that the cutting speed is mainly affected by T_{on}, T_{off}, Ip and SV. When pulse on time was increased by 0.6 to 1.2 µs, the cutting speed increased significantly from 49.823 to 87.365mm^2/min. The increase in cutting speed is due to the fact that higher pulse on time increases the discharge energy which leads to rapid melting of the material. More material will get melted and vaporized and hence there will be increase in cutting speed. The present result matches the previous results obtained by [Anish et al. 2013; Tarang et al. 1995; Sarkar et al. 2006]. Increase in pulse off time decreased the cutting speed. Less discharge energy on the work piece reduces the rate of metal erosion thus decreasing the cutting speed. The cutting speed significantly improved when pulse off time was reduced. Cutting speed increased from 66.045 to 90.235mm^2/min when pulse off time was decreased from 32 to 16 µs. Similarly decreasing the spark gap voltage, cutting speed improved .Cutting speed for spark gap voltage has been assessed between 70 to 87mm^2/min.
With the increase in peak current from 130 to 190 A, the cutting speed slightly increased from 72 to 80 mm^2/min. The increase in cutting speed is due to increase in discharge energy which is caused due to higher peak current that will result into increased heat density. Thus the heat will result into faster cutting speed due to erosion and melting of the material. This is similar to the results found by [Yan et al, 2005; Tarang et al., 1995; Anish et al., 2013]. Based on effect plots it has been found that pulse on time and pulse off time are the most significant factors rather than spark gap voltage and peak current which influence cutting speed. According to the trends as obtained the best parameters at which maximum cutting speed can be obtained are – pulse on time = 1.20 µs, pulse off time =16µs, peak current =190A, spark gap voltage = 20V, wire feed = 7m/min and wire tension = 1000 gram.



A: Pulse on Time (µs) B: Pulse off Time (µs)

Fig 4 Effect of pulse on time and pulse off time current on cutting speed

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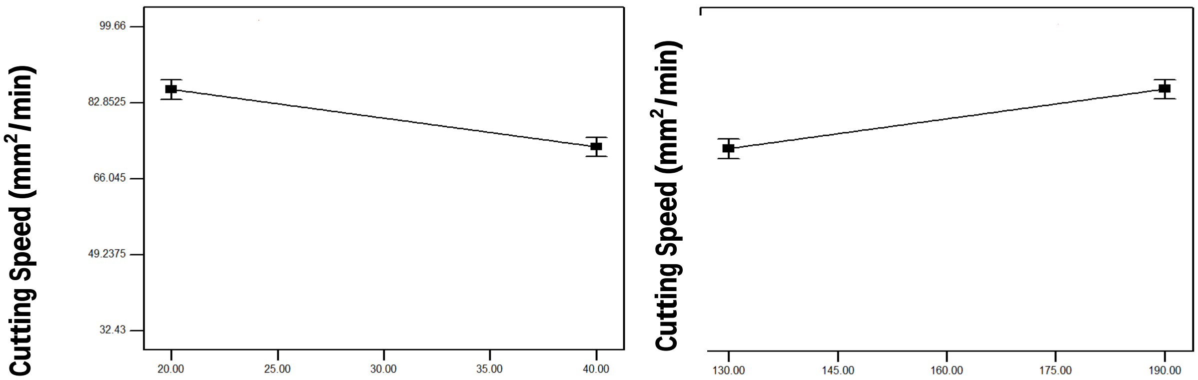
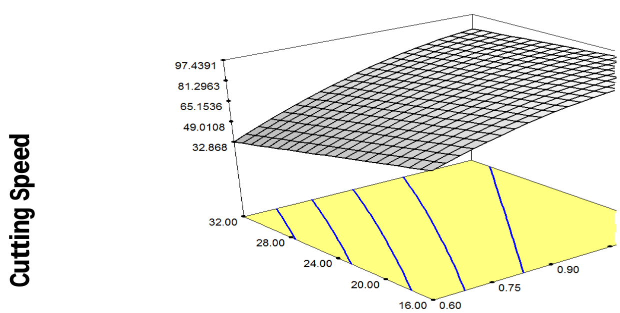
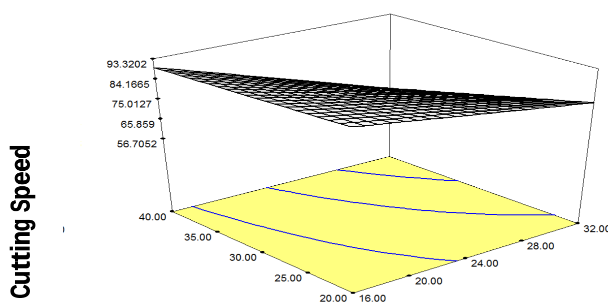


C: Spark gap voltage (V) D: Peak current (A)

Fig 5Effect of spark gap voltage and peak current on cutting speed

For cutting speed three interactions have been found to be significant as shown in figures 6 to 8. These interactions are $T_{on} \times T_{off}$, $T_{off} \times$ SV and $T_{off} \times$ IP. Prob.>F value of these interactions are 0.0033, 0.0270 and 0.0308 respectively. When pulse off time was kept at 16.00 and pulse on time was varied from 0.60 to 1.20, cutting speed increased significantly from 32.868 to 97.439mm^2/min. The cutting speed also increased significantly when pulse off time was set at higher level i.e. 32.00 and pulse on time was unchanged. When pulse off time was decreased from 32 to 16 µs, increment in the cutting speed was observed from 76.026 to 90.258mm^2/min. When pulse off time was varied from 16 to 32 µs, at constant peak current of 130A, cutting speed was found to be decreased from 91.286 to 5.842mm^2/min.

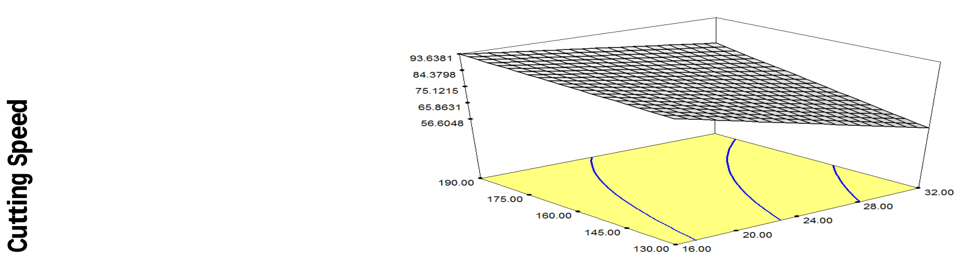




B: Pulse off Time A: Pulse on Time D: Spark gap voltage B: Pulse off Time

Fig 6 Interaction plot between pulse on time and pulse off time on cutting speed

Fig 7 Interaction plot between pulse on time and pulse off time on cutting speed



D: Peak Current B: Pulse off Time

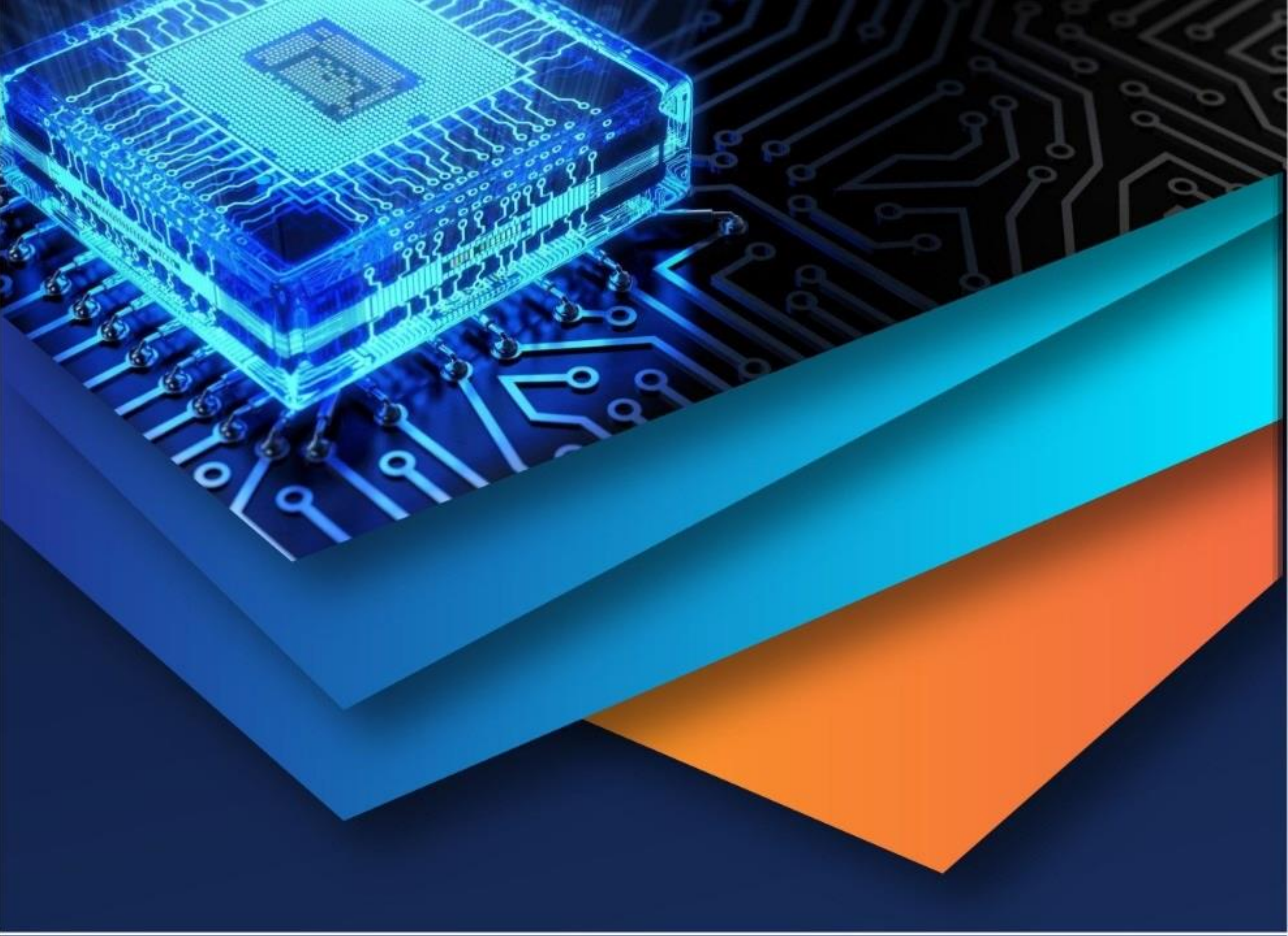
Fig 8 Interaction plot between pulse off time and peak current on cutting speed

V. CONCLUSIONS

In this study the effect of input process parameters on machining output (Cutting speed) of Al/Al_2O_3 MMC was investigated experimentally. It was found that T_{on}, T_{off}, SV, IP and three interactions were significant for cutting speed. When pulse on time was increased by 0.6 to 1.2 µs, the cutting speed increased significantly from 49.823 to 87.365mm^2/min. The cutting speed significantly improved when pulse off time was reduced. Cutting speed increased from 66.045 to 90.235mm^2/min when pulse off time was decreased from 32 to 16 µs. Similarly decreasing the spark gap voltage, cutting speed improved .Cutting speed for spark gap voltage has been assessed between 70 to 87mm^2/min. With the increase in peak current from 130 to 190 A, the cutting speed slightly increased from 72 to 80 mm^2/min. According to the trends as obtained the best parameters at which maximum cutting speed can be obtained are – pulse on time = 1.20µs, pulse off time =16µs, peak current =190A, spark gap voltage = 20V, wire feed = 7m/min and wire tension = 1000 gram.

REFERENCES

[1] Azhiri, R.B., Teimouri, R., Baboly, M.G. and Leseman, Z., 2013. "Application of Taguchi, ANFIS and grey relational analysis for studying, modeling and optimization of wire EDM process while using gaseous media", International Journal of Advanced Manufacturing Technology, 71:279–295.
[2] Meena, K.L., Manna, A., Banwait, S.S., Jaswanti., 2013. "Parametric Effects during Nonconventional Machining of PR-AL-SiC-MMC, s by CNC Wire cut EDM". International Journal of Engineering and Innovative Technology (IJEIT) Volume 3, Issue 1, July 2013. ISSN: 2277-375
[3] Shandilya, P., Jain, P.K., Jain, N.K., 2013. "RSM and ANN Modeling Approaches For Predicting Average Cutting Speed During WEDM of SiCp/6061 Al MMC", Procedia Engineering 64 (2013) 767– 774.
[4] Patil, N.G. and Brahmankar, P.K., (2010). "Some studies into wire electro-discharge machining of alumina particulate-reinforced aluminium matrix composites", Int J Adv Manuf Technol 48:537-555
[5] Yan B.H., Tsai, H.C., Huang, F.Y., Lee, L.C., 2005. "Examination of wire electrical discharge machining of Al2O3p/6061Al composites", Int Mach Tools Manuf 45:251–259
[6] Rozenek, M., Kozak, J., Dalbrowski, L., Eubkowski, K., 2001. "Electrical discharge machining characteristics of metal matrix composites", J Mater Process Technol 109:367–370
[7] Fard, R.K., Afza, R.A, Teimouri, R., 2013. "Experimental investigation, intelligent modelling and multi characteristics optimization of dry WEDM process of Al-SiC metal matrix composite", Journal of Manufacturing Processes 15(2013) 483-494
[8] Guo, Z.N., Wang, X., Huang, Z.G., Yue, T.M., 2002. "Experimental investigation into shaping
[9] Sarkar, S., Mitra, S. and Bhattachyraya, B., 2006. "Parametric optimization of wire electric discharge machining of γ titanium alumnide alloy through an artificial neural network model", International Journal of AdvancedManufacturing Technology, Vol. 27, pp. 501-508
[10] Tarng, Y. S., Ma, S. C. and Chung, L. K., 1995. "Determination of optimal cutting parameters in wire electrical discharge machining", International Journalof Machine Tools and Manufacture, Vol.35, pp.1693-1701.
[11] Anish K., Vinod K., Jatinder K., 2013. "Multi-response optimization of process parameters based on response surface methodology for pure titanium using WEDM process", Int J Adv Manuf TechnolDOI 10.1007/s00170-013-4861-9



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