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Analyzing the Consequences of Procedure Parameters on Multi Responses

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ABSTRACT--*On this paper, improvement of WEDM system parameters was focused on. The enhancement changed into cleared out machining of AMMNCs test of carbon Nano tube supported al 5056. Experimentations were finished as with regards to Taguchi design of examinations for different mixes of system parameters like heartbeat on-schedule, beat off-time, water pressure, Height present day to check the reactions like disposal value, floor harshness, kerf width and apparatus wear. A blended WAPAS-Taguchi S/N proportion Analysis is utilized to explore the impacts of procedure parameters on Responses and to recognize the most satisfying parameter setting in EDM of AMMNC. From the ANOVA, it's demonstrated that beat on time is most fundamental enter parameter followed by method for top present day, beat off time and water pressure influencing the reactions. It is resolved that higher outcomes are acquired from WASPAS-S/N proportion investigation; subsequently it is right to recognize the greatest parameters assessment through the blending of techniques.*

Keywords-- *WEDM system parameters WASPAS-Taguchi S/N ratio evaluation, responses & optimization.*

I. INTRODUCTION

Aluminum steel matrix composites are becoming used pretty in aerospace, marine and automobile industries. Machining of those composites via traditional machining scheme is difficult.

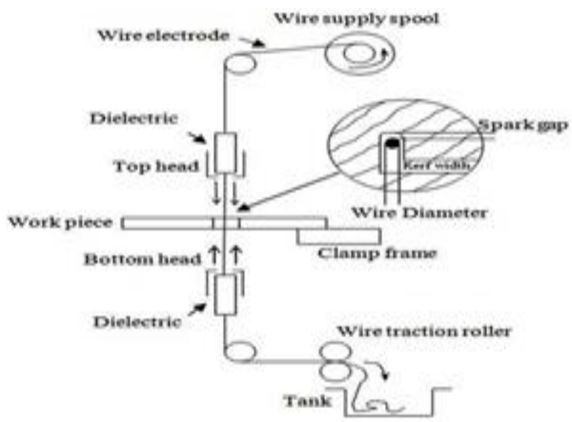

Figure 1: Working Principle of WEDM.

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This is regularly due to severe trends in particular houses of composites. WEDM is extra convenient technique used for shaping of complicated contours on aluminum steel matrix composites. WEDM, also called discharge wire cutting, can be a thermos electric powered process throughout which fabric is eroded from the paintings piece by means of a sequence of discrete sparks between the paintings piece and a wire electrode (tool) separated through a thin movie of dielectric fluid (generally deionized water) that's continuously fed to the machining zone to flush away the eroded debris. The motion of the twine is managed numerically to comprehend the required3-dimensional shapes and accuracy of the paintings piece. The cord is guided via sapphire or diamond manual and stored directly by means of a high fee of wire tension, which is vital to avoid tapering of the reduce surface. Excessive frequency dc pulses are added between the cords and work piece, inflicting spark discharges inside the slim gap between the two.

A circulation of dielectric fluid is directed, commonly coaxially with the wire, to flood the gap between the cord and paintings piece. The power deliver for the WEDM is actually same as that for conventional EDM. Except that the prevailing wearing capability of the cord i.e. limited up to but 20 a. moreover, spark frequencies used are up to 1 MHz, to offer a great floor end on the work piece. There’s no mechanical touch among the wire and paintings piece in WEDM. Studied the effect of method parameters on MRR and kerf in WEDM of SiCp/6061 ALMMC.

K. kanlayasiri and s. boonmungb studied on dc53 die metallic and studied the effect of machining variables on Roughness of floor of twine-EDM DC53 die metallic. a. b. puri and b. Bhattacharyya analyzed cord lag phenomenon in WEDM. The geometrical inaccuracy optimized thanks to wire lag phenomenon in WEDM. Okay. Zakariaa et al. [4] investigated production of hybrid metal substances by considering optimization of cord EDM cutting parameters. l. arunkumar and B. k. Raghunath investigated the effects of cutting-edge, pulse on time and pulse off time in discharge machining Overall performance on material elimination charge and equipment put on fee of mg/SiCp metal matrix composites.

Yonghua Zhao examined the recital of EDM carving of sic wafers and therefore the vital functions of EDM of a sic single crystal. Ibrahim Maher tested the WEDM for refining technique parameters. Provided an operative version to guesstimate the electrode wear of EDM. Considered the effect of assorted procedure parameters like Pulse on-time, pulse off-time, wire anxiety, present day, upper flush and lower flush in machining of AMMCs. A few authors [10–15] accomplished investigations to optimize the method parameters in discharge machining of steel matrix composite and other substances. Supported the contribution of numerous researchers, it determined that confined work has been stated on machining of aluminum steel matrix Nano composite and multi response optimization.

1.1 Application of AMMNCs

The AMMNCs are used in many software as these possess the following capabilities.

- Fundamental weight financial savings due to energy-to weight ratio.
- Fantastic dimensional stability.
- Better improved temperature stability, i.e., creep resistance.
- Drastically progressed cyclic fatigue characteristics.

With respect to polymer matrix composite, MMCS gives the subsequent blessings.

- Higher energy and stiffness.
- Higher provider temperatures.
- Better electrical Conductivity (grounding, space charging).
- Better thermal conductivity.
- Better transverse homes.
- Stepped forward becoming a member of traits.
- Radiation survivability

II. EDM OF AMMNCS

1.2 Material

An aluminum metal matrix Nano composite work material is used in this paper for conducting EDM studies, which is prepared by reinforcing a weight percentage (1.1%) of Carbon Nano tube (CNT) material with Al5056 through stir casting process. The composition of Al5056 and CNT particles of average size about30nm are given in table 1 and 2.

Table 1: Chemical Composition

Al 5056	Elements of Al 5056 in Percentage							
	Si	Fe	Cu	Mn	Mg	Cr	Zn	Al
	0.3	0.35	0.1	0.1	4.0	0.05	0.1	95

Table 2: Physical Properties of CNTs

Property	SWCNT (Single Walled CNT)
Thermal Conductivity (W/(m K))	6000
Electrical Conductivity (S/cm)	102-106
Specific Gravity (g/cm3)	0.8
Electron Mobility (cm2/(V s))	10^5
Coefficient of thermal expansion (K-1)	Negligible
Thermal stability in air (centigrade)	>600

2.2 Design of Experiments and EDM Experiment

Choosing process parameters is a vital step for machining in WEDM. Inappropriate assortment of process parameters leads to wire breakage, short circuit and high surface roughness. Based on the literature, the following parameters and their levels are considered for testing of this work as given in table 3.

Table 3: Process Parameters and its Levels

S. No.	Process Parameters	Symbol	Level 1	Level 2	Level 3
1	Pulse on-time (µs)	A	102	104	106
2	pulse off-time (µs)	B	42	44	46
3	Water pressure($\frac{kg}{cm^2}$)	C	0.25	0.3	0.35
4	Peak current(amp)	D	1	1.5	2

The experimental design, L9 OA (Table 4) is developed based on parameters and its levels. Experiments are conducted on developed composites according to this design using wire cut EDM for different combinations of parameters and the experimental responses such as Surface Roughness, Material removal rate, Kerf width and Tool wear rate are measured and recorded (Table 4)., the machined work piece are shown below in figure 2.

- Of the many, surface roughness is very significant parameter in machining process. The objective is to maintain the desired roughness, by that maintaining the desired quality. The surface roughness is dignified using Talysurf.
- The material removal rate (MRR) is the quantity of material that is detached per minute. MRR is affected by the type of machine along with the possessions and features of the work piece that is being cut, it is calculated by using following equation.

$$MRR = (2SG + d\ tL\ T)/ \qquad (2.1)$$

$$SG = (\ker fwidth - d)/\ 2 \qquad (2.2)$$

Where MRR = Volume of material removed/min, d= dia. of wire, Length = Total path length t= thickness of work piece, T = cutting time in min.

- Kerf width is amount of wobble created during cutting and amount of material pulled out of the sides of the cut above the required width of the work-piece which feed in the program for cutting. After machining, obtained width is measured by microscope. Kerf width is calculated as difference between programmed widths and obtain width and it is expressed in mm.
- Tool wear terms the steady eroding of material on electrode due to steady operation. In this work, tool (electrode) is a brass material and amount of material eroded from the wire is calculated by micrometer of least count 0.0001mm. Wire diameter is measured before and after every machining experiment by micrometer. Tool wear is the difference of diameters of wire before and after machining.

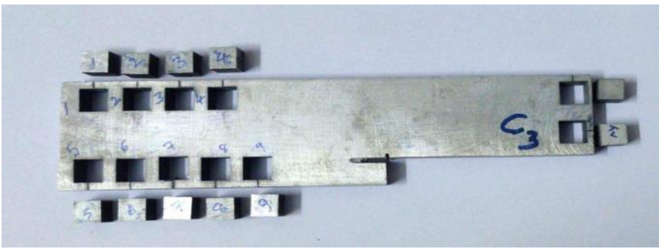

Figure 2: AMMNC Work Piece after Machining.

Table 4: Design of Experiments (OA 9) and Responses

S. No.	**Ton**	**Toff**	**Wp**	**Ip**	**Ra (µm)**	**MRR (mm^3/min)**	**KW mm**	**TW Mm**
1	1	1	1	1	0.463	0.031	0.292	0.041
2	1	2	2	2	0.421	0.038	0.330	0.058
3	1	3	3	3	0.478	0.039	0.343	0.062
4	2	1	2	3	0.488	0.041	0.349	0.038

5	2	2	3	1	0.430	0.049	0.341	0.043
6	2	3	1	2	0.638	0.051	0.326	0.072
7	3	1	3	2	0.736	0.048	0.356	0.046
8	3	2	1	3	0.587	0.056	0.341	0.052
9	3	3	2	1	0.526	0.059	0.372	0.71

III. PROCESS PARAMETERS OF USING WASPAS METHOD

In this paper, optimization of process parameters is done in two stages, firstly by WASPAS method and secondly through Taguchi S/N ratio analysis.

1.3 Stage-1: WASPAS Method

The machining responses (Table 4) are analyzed using WASPAS method for identification of optimum machining Parameters using its steps as in the following.

Steps in WASPAS Method

Step 1: Set the initial decision matrix (responses, Table 4)

Step 2: Normalize the decision matrix using the following equations:

$$\bar{X}_{ij} = \frac{X_{ij}}{\max_i X_{ij}} \quad \text{for maximization} \tag{3.1}$$

$$\bar{X}_{ij} = \frac{\min_i X_{ij}}{X_{ij}} \quad \text{forminimization} \tag{3.2}$$

Normalized values (Table 5) are calculated for each response the using equation 3.1 and 3.2 for maximization (response MRR) and minimization (responses Ra, KW, TW) respectively.

Table 5: Normalization Values

Exp. No.	Ra	MRR	Kerf Width		Tool Wear
1	0.90929	1.76769	1		0.92683
2	1	1.56414	0.88485		0.65517
3	0.88075	1.74247	0.85131		0.6129
4	0.8627	1.24546	0.83668		1
5	0.97907	1.75269	0.8563		0.88372
6	0.65987	1	0.89571		0.52778
7	0.57201	1.06835	0.82022		0.82609
8	0.71721	1.27468	0.8563		0.73077
9	0.80038	1.24149	0.78495		0.53521

Step 3: Determination of Weights for the Responses

The weights for each response are evaluated using the equations 3.3, 3.4 and 3.5, values are given in table7 by processing the Pij data (Table6) is the weight of the j^th criterion

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{m} X_{ij}} \text{ is normalized matrix} \quad (3.3)$$

Entropy value

$$e_j = -k \sum_{i=1}^{m} P_{ij} \ln(P_{ij}) \quad (3.4)$$

Here $k = \frac{1}{\ln(m)}$, m = 9

$$W_j = \frac{(1-e_j)}{\sum_{j=1}^{n}(1-e_j)} \quad (3.5)$$

Table 6: P_{ij} for Responses

Exp. No.	Pij for Ra	Pij for MRR	Pij for KW	Pij for TW
1	0.097126	0.084707	0.095738	0.084886
2	0.088316	0.095731	0.108197	0.120083
3	0.100273	0.085933	0.112459	0.128364
4	0.10237	0.120225	0.114426	0.078675
5	0.090203	0.120225	0.111803	0.089027
6	0.133837	0.149736	0.106885	0.149068
7	0.154395	0.140156	0.116721	0.095238
8	0.123138	0.117469	0.111803	0.10766
9	0.110342	0.12061	0.121967	0.146998

Table 7: Weights for Responses

Response	Weightage
Ra	0.187318
MRR	0.534877
KW	0.170525
TW	0.10728
Sum	1

Step 4: Calculation of Weighted Sum (Q_1) and Weighted Product (Q_2) Values

In WASPAS method, two criterion are used. The first criteria of a mean weighted sum is calculated regarding total relative importance of i^th using Equation 3.6.

$$Q_i^{(1)} = \sum_{j=1}^{X} \bar{w}_{ij} \quad (3.6)$$

The total comparative significance of the i_{th} alternative is calculated for mean weighted product using the Equation.3.7.

$$Q_i^{(2)} = \prod_{j=1}^{X} \bar{w}_{ij} \quad (3.7)$$

Step 5: Calculation of Wasspas Grade (Q)

Equation 3.8 gives a subjective accumulation of additive and multiplicative values. This metric is referred as Wasspas Grade.

$$Q_i = 0.5Q_i^{(1)} + 0.5Q_i^{(2)} \quad (3.8)$$

$Q^{(1)}$, $Q^{(2)}$ and Q are calculated using the Equation 3.6, 3.7 and 3.8 respectively and are shown in table 8.

Table 8: Weighted Aggregated Values of WASPAS

Exp. No.	Q(1)	Q(2)	Q	Rank	S/N Ratio
1	1.38578	1.321466	2.707246	1	8.65056
2	1.245117	1.188919	2.434036	4	7.72654
3	1.307909	1.213203	2.521113	3	8.03184
4	1.077724	1.061134	2.138858	5	6.60364
5	1.361697	1.29236	2.654057	2	8.47820
6	0.867844	0.847714	1.715558	9	4.68811
7	0.907076	0.883768	1.790844	8	5.06115
8	1.040562	1.007475	2.048038	6	6.22676
9	1.005239	0.966222	1.971461	7	5.89577

After calculating average WASPAS grade values (Q), the best parameter combination A_1 B_1 C_1 $D_1$is determined, Which is corresponding to the higher average WASPAS value represents better quality.

1.4 Stage-2 Taguchi S/N Ratio Analysis

There are few methods which aim to be seeking out the best combination of parameters which has lowest variance. Taguchi's approach is one such famous technique. SNR measures how the response varies relative to the nominal or goal fee below unique situation.

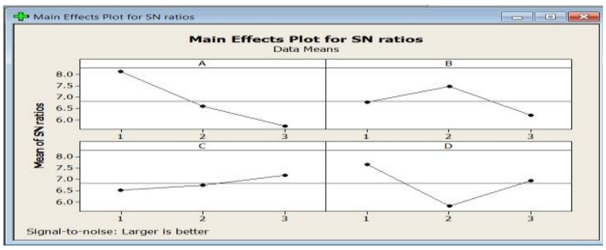

Figure 3: S/N Ratio Plots.

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Right here, Taguchi s/n ratio evaluation is conducted on the average WASAS index values to training session the most efficient parametric values using Minitab software program (table 9). The maximum effect plot obtained from Minitab is proven in figure 3. The finest Parameters mixture received from this analysis (table 9) is a1b2c3d1 that is like better manner of s/n ratios. The S/N ratios of WASPAS grade are given in table 8.

Table 9: Optimal Parameters and Order from S/N Ratio Analysis

Level	A	B	C	D
1	8.136	6.772	6.522	7.675
2	6.590	7.477	6.742	5.825
3	5.728	6.205	7.190	6.954
Delta	2.408	1.272	0.669	1.850
Rank	1	3	4	2

IV. CONTRIBUTION OF PROCESS PARAMETERS ON RESPONSE

Contribution of method parameters closer to responses are decided via acting ANOVA on Wasspas grade the use of Minitab software program and effects are proven in table 10. it is located that pulse on time (a), pulse off time (b), water strain (c), top current (d) have an effect on the compound responses by way of 53.07%, 13.09%, 29.51% and 4.33% respectively. The percentage numbers depict that the coronary heart beat on time, top modern sizeable effect on responses.

Table 10: ANOVA of WASPAS Grade

Parameter	DF	SS	MS	F	P	% Contribution
TON	2	0.58322	0.29161	3.67	0.057	53.08
TOFF	2	0.14381	0.07190	0.73	0.502	13.09
WP	2	0.04760	0.02380	1.75	0.215	4.33
Ip	2	0.32423	0.16211	0.59	0.572	29.51
Error	2	0.02160	12453.75		1.7393	
Total	10	1.09886				

V. COMPARISON AND VALIDATION OF RESULT

The optimal parameter setting obtained from combined WASPAS- S/N ratio method is confirmed experimentally and compared with the confirmation results of the parameter setting corresponding to higher WASPASS grade as given in table 11. From the results, it is evident that the combination obtained WAPAS- S/N ratio method gives best result.

Table 11: Confirmation and Comparison of Results

Criteria	Higher WASPAS Grade	WAPAS- SNR Method
Optimal parameter setting	A1B1C1D1	A1B1C3D3E3
Ra (µm)	0.463	0.42
MRR (mm^3/min)	0.031	0.031

Kerf Width(mm)	0.292	0.277
Tool wear(mm)	0.041	0.039

VI. CONCLUSION

In this paper, WASPAS Taguchi s/n ratio analysis is utilized to analyze the consequences of procedure parameters on multi responses and to decide the highest quality parameter putting in EDM of advanced AMMNC. The following conclusions are derived from the effects of the present work. Within the gift work, parameters of twine EDM have been optimized for acquiring better MRR and lower surface roughness, kerf width, tool wear values. From the ANOVA, it's far indicated that pulse on time is most essential enter parameter followed by using peak cutting-edge, pulse off time and water pressure. It is far located that better outcomes are acquired from WASPAS-S/N ratio, as a result it's miles very correct to judge the highest quality parameters based totally on obtained consequences of s/n ratio evaluation through integration. This work may be prolonged by considering in addition more EDM process parameters with wider variety and different AMMNCs to examine its have an impact on multi responses.

REFERENCES

1. P. Venkataramaiah and Dileep (2011). AHP-DENG'S similarity based optimization of WEDM process parameters of Al/SiCp Composite. Journal of Materials Science and Technology, vol. 6, no. 1, pp. 1–14.
2. Kohzoh (2013). Study of EDM cutting of single crystal silicon carbide. Science Direct Precision Engineering, vol. 38, pp. 92– 99.
3. M. Ibrahem, L. H. Ling (2012). Improve WEDM performance at different machining parameters. IFAC, pp. 105–110.
4. H. C. Dong WonKim (2014). Electrode wear estimation model for EDM drilling. Robotics and Computer-Integrated Manufacturing, vol. 36, pp. 70–75.
5. S. Rajesh, K. Ramji (2010). Optimization of machining parameters for cutting AMMC's on wire cut EDM. International Journal of Engineering Trends and Technology, vol. 23, no. 2.
6. R., Maurya, N., Singh, P., & Gupta, S. Optimization of process parameters in electric discharge machining process.
7. Cao, Y., Huang, L., Li. Y., Jermsittiparsert, K., Ahmadi-Nezamabad, H., & Nojavan, S. 2020. "Optimal Scheduling of Electric Vehicles Aggregator under Market Price Uncertainty Using Robust Optimization Technique." International Journal of Electrical Power & Energy Systems 117: 105628.
8. Yu, D., Wang, Y., Liu, H., Jermsittiparsert, K., & Razmjooy, N. 2019. "System Identification of PEM Fuel Cells Using an Improved Elman Neural Network and a New Hybrid Optimization Algorithm." Energy Reports 5: 1365-1374.
9. Tian, M., Ebadi, A., Jermsittiparsert, K., Kadyrov, M., Ponomarev, A., Javanshir, N., & Nojavan, S. 2019. "Risk-Based Stochastic Scheduling of Energy Hub System in the Presence of Heating Network and Thermal Energy Management." Applied Thermal Engineering 159: 113825.
10. Yu, D., Wnag, J., Li, D., Jermsittiparsert, K., & Nojavan, S. 2019. "Risk-Averse Stochastic Operation of a Power System Integrated with Hydrogen Storage System and Wind Generation in the Presence of

Demand Response Program." International Journal of Hydrogen Energy (In press), DOI: 10.1016/j.ijhydene.2019.09.222.

11. Jabarullah, N., Jermsittiparsert, K., Melnikov, P., Maseleno, A., Hosseinian, A., & Vessally, E. 2019. "Methods for the Direct Synthesis of Thioesters from Aldehydes: A Focus Review." Journal of Sulfur Chemistry (In press), DOI: 10.1080/17415993.2019.1658764.
12. Jiao, Y., Jermsittiparsert, K., Krasnopevtsev, A., Yousif, Q., & Salmani, M. 2019. "Interaction of Thermal Cycling and Electric Current on Reliability of Solder Joints in Different Solder Balls." Materials Research Express 6 (10): 106302.
13. Yu, D., Ebadi, A., Jermsittiparsert, K., Jabarullah, N., Vasiljeva, M., & Nojavan, S. 2019. "Risk-constrained Stochastic Optimization of a Concentrating Solar Power Plant." IEEE Transactions on Sustainable Energy (In press), DOI: 10.1109/TSTE.2019.2927735.
14. Jermsittiparsert, K., Sriyakul, T., Sutduean, J., & Singsa, A. 2019. "Determinants of Supply Chain Employees Safety Behaviours." Journal of Computational and Theoretical Nanoscience 16 (7): 2959-2966.
15. Sriyakul, T., Singsa, A., Sutduean, J., & Jermsittiparsert, K. 2019. "Effect of Cultural Traits, Leadership Styles and Commitment to Change on Supply Chain Operational Excellence." Journal of Computational and Theoretical Nanoscience 16 (7): 2967-2974.
16. Sutduean, J., Singsa, A., Sriyakul, T., & Jermsittiparsert, K. 2019. "Supply Chain Integration, Enterprise Resource Planning, and Organizational Performance: The Enterprise Resource Planning Implementation Approach." Journal of Computational and Theoretical Nanoscience 16 (7): 2975-2981.
17. Singsa, A., Sriyakul, T., Sutduean, J., & Jermsittiparsert, K. 2019. "Willingness of Supply Chain Employees to Support Disability Management at Workplace: A Case of Indonesian Supply Chain Companies." Journal of Computational and Theoretical Nanoscience 16 (7): 2982-2989.
18. Jermsittiparsert, K. & Chankoson, T. 2019. "Behavior of Tourism Industry under the Situation of Environmental Threats and Carbon Emission: Time Series Analysis from Thailand." International Journal of Energy Economics and Policy 9 (6): 366-372.
19. Romprasert, S. & Jermsittiparsert, K. 2019. "Energy Risk Management and Cost of Economic Production Biodiesel Project." International Journal of Energy Economics and Policy 9 (6): 349-357.
20. Kasayanond, A., Umam, R., & Jermsittiparsert, K. 2019. "Environmental Sustainability and its Growth in Malaysia by Elaborating the Green Economy and Environmental Efficiency." International Journal of Energy Economics and Policy 9 (5): 465-473.
21. Jermsittiparsert, K, Sriyakul, T., & Rodoonsong, S. 2013. "Power(lessness) of the State in the Globalization Era: Empirical Proposals on Determination of Domestic Paddy Price in Thailand." Asian Social Science 9 (17): 218-225.
22. Jermsittiparsert, K, Sriyakul, T., & Pamornmast, C. 2014. "Minimum Wage and Country's Economic Competitiveness: An Empirical Discourse Analysis." The Social Sciences 9 (4): 244-250.
23. Jermsittiparsert, K., Pamornmast, C., & Sriyakul, T. 2014. "An Empirical Discourse Analysis on Correlations between Exchange Rate and Industrial Product Export." International Business Management 8 (5): 295-300.
24. Jermsittiparsert, K., Sriyakul, T., Pamornmast, C., Rodboonsong, S., Boonprong, W., Sangperm, N., Pakvichai, V., Vipaporn, T., & Maneechote, K. 2016. "A Comparative Study of the Administration of

Primary Education between the Provincial Administration Organisation and the Office of the Basic Education Commission in Thailand." The Social Sciences 11 (21): 5104-5110.

25. Jermsittiparsert, K., Trimek, J., & Vivatthanaporn, A. 2015. "Fear of Crime among People in Muang-Ake, Lak-Hok, Muang, Pathumthani." The Social Sciences 10 (1): 24-30.
26. Jermsittiparsert, K. & Akahat, N. 2016. "Fear of Crime among Students of Kalasin Rajabhat University." Research Journal of Applied Sciences 11 (2): 54-61.
27. P. V. Ramaiah (2016). Application of Taguchi, Fuzzy-Grey Relational Analysis for Process Parameters Optimization of WEDM on Inconel-825. Indian Journal of Science and Technology, vol. 8, no. 35.
28. N and Dalgarnob. K. W. (2014). Effect of wire EDM cutting parameters for evaluating of Additive Manufacturing Hybrid Metal Material. Proc. of 2nd International Materials, Industrial, and Manufacturing Engineering Conference, 4-6, Indonesia, pp. 532 – 537.
29. Arunkumar. L, Raghunath. B. K. Electro Discharge Machining Characteristics of Mg/SiCPMetal matrix Composites by Powder Metallurgy Techniques. International Journal of Engineering and Technology.
30. Kanlayasiri. K, Boonmung. S (2006). Effects of wire - EDM machining variables on surface roughness of newly developed DC 53 die steel: Design of experiments and regression model. Journal of Materials Processing Technology, 192–193, pp. 459– 464.
31. B. Puri, B. Bhattacharyya (2004). An analysis and optimization of the geometrical inaccuracy due to wire lag phenomenon in WEDM," International Journal of Machine Tools & Manufacture, vol. 43, 2003, pp. 151–159.
32. Dr. G. Krishnaiah (2016). Optimization of process parameters using AHP and VIKOR when turning aisi 1040 steel with coated tools. International Journal of Mechanical Engineering and Technology, vol. 8, Iss. 1, pp. 241–248.
33. P. Shandilya, P. K. Jain, N. K. Jain (2011). Wire electric discharge of metal matrix composite. Damm International scientific book, pp. 383-400.
34. Saravanakumar, A., Santarao, K., & Nandini, G. Influence of alumina nano powder mixed dielectric fluid in electric spark machining of aisi d3 steel. Carbon (c), 2, 2–3.
35. R. K. Bhuyan, and B. C. Routara (2016). Optimization the machining parameters by using VIKOR and Entropy Weight method during EDM process of Al–18%SiCp Metal matrix composite. Decision Science Letters, vol. 5, pp. 269–282.
36. Bhattacharyya, B. (2014). Analysis of traveling wire electrochemical discharge machining of Hylam based composites by Taguchi method. International Journal of Research in Engineering & Technology, 2(2), 223–236.