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INFLUENCE OF PROCESS PARAMETERS ON SURFACE ROUGHNESS, MATERIAL REMOVAL RATE AND WIRE CONSUMPTION IN WIRE ELECTRO DISCHARGE MACHINING OF CASTED MAGNESIUM ALLOY

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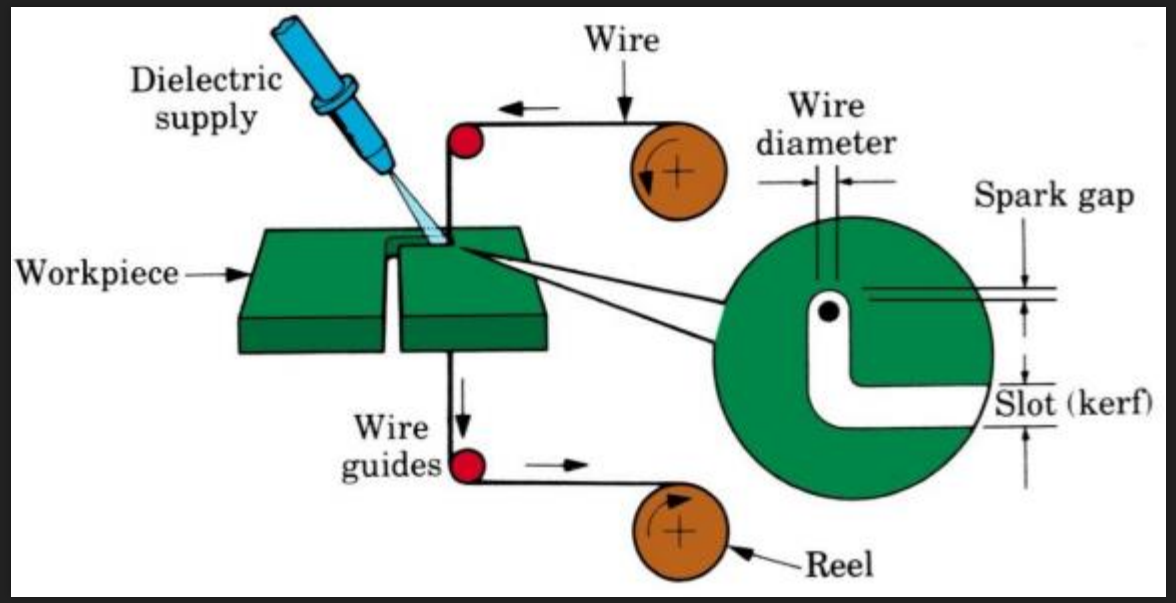
Magnesium Alloys

Magnesium (Mg) alloys are widely used in ***aerospace***, ***automotive***, ***electronics and communication***, ***biomaterials*** and ***sport equipment*** fields because of their specific strength and low density.

AIM OF STUDY

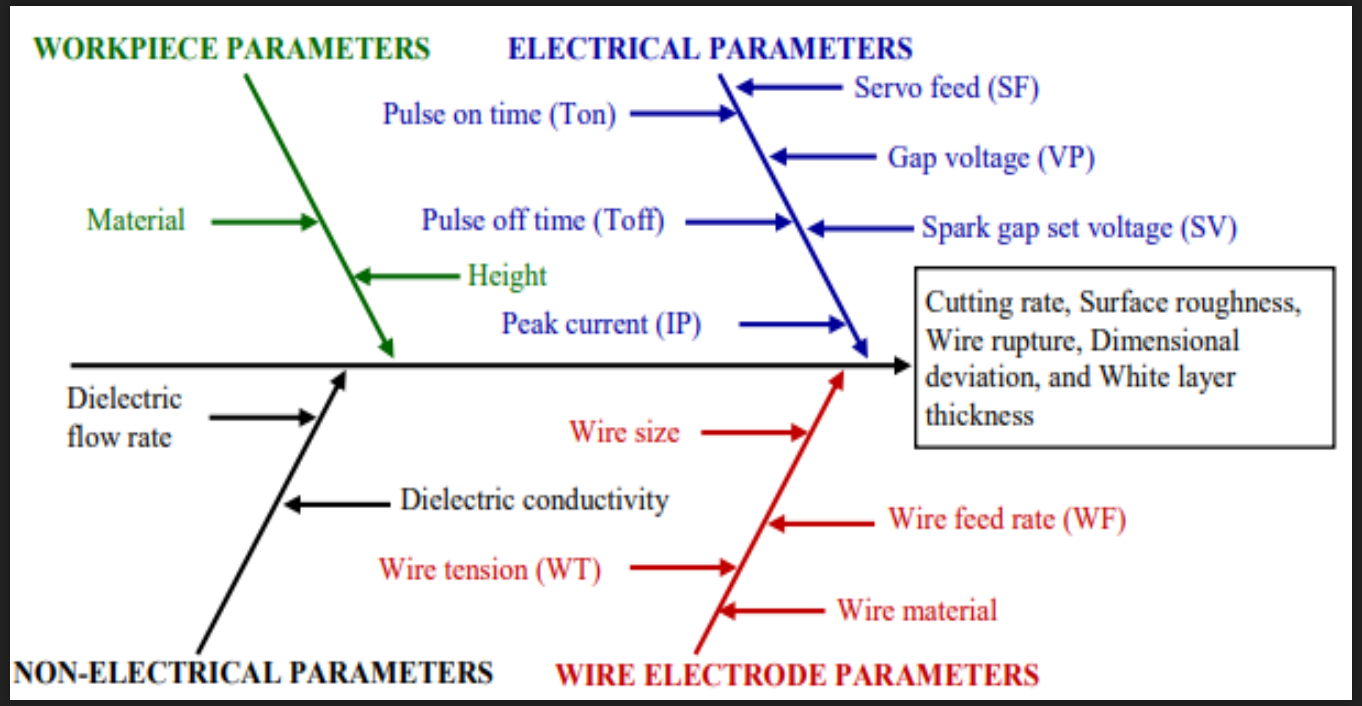
- In this study, wire EDM characterization of casted AZ91 magnesium alloy has been experimentally identified with different wire EDM parameters like pulse on time (Ton), pulse off time (Toff) and servo voltage (SV). In order to reduce the number of experiments, Taguchi L9 experiment design was used and some results related with process parameters such as ***cutting speed (Vc) mm/min***, ***total process time (Tp) min, kerf width (KW) µm , material removal rate (MRR) g/min, surface roughness (Ra) µm and amount of used wire (AUW) g*** were obtained.

WEDM PROCESS



Wire-EDM process using a thin copper wire as the tool electrode transforms electrical energy to thermal energy for cutting materials. With this nature, any electrically conductive material can be cut by using WEDM, regardless of the hardness, ranging from public metals, including copper, aluminum, tool steel, and brass, to uncommon new alloys such as tungsten carbide, cast alloys, Inconel, titanium and carbide.

WEDM factors and performance measures



EXPERIMENT DESIGN

Cutting Parameters	Level 1	Level 2	Level 3
Pulse on Time T_{on} (µs)	0.4	0.5	0.6
Pulse off Time T_{off} (µs)	22	32	42
Servo Voltage SV (Volt)	30	40	50

Table 1. Variable input parameters and their levels

Taguchi L9 experimental design containing 3 factors with 3 level was used and shown in Table 1. Hence, 27 experiments were reduced to 9 experiments by using this method. Besides variable input parameter, wire tension (WT) of 5 kgf and wire feed (WF) of 5 m/min were assigned as stable. Moreover, brass wire with diameter of 0,25 mm was used.

EXPERIMENT RESULTS (INPUT / OUTPUT)

Experiment Number	INPUT PARAMETERS			OUTPUT RESULTS					
	Ton	Toff	SV	Vc	Tp	KW	MRR	Ra	AUW
	µs	µs	v	mm/min	min	µm	g/min	µm	g
1	0,4	22	30	1,318	16,68	560	0,0282	3,660	32,129
2	0,4	32	40	1,241	17,71	288	0,0136	3,672	34,640
3	0,4	42	50	0,823	26,70	284	0,0089	4,102	54,994
4	0,5	22	40	1,325	16,60	454	0,0230	3,980	31,686
5	0,5	32	50	1,041	21,13	290	0,0115	3,980	41,506
6	0,5	42	30	1,313	16,75	318	0,0159	3,786	34,518
7	0,6	22	50	1,592	13,81	718	0,0437	4,278	27,936
8	0,6	32	30	1,344	16,36	446	0,0229	4,280	33,925
9	0,6	42	40	1,282	17,15	716	0,0351	4,284	34,867

Table 2. Taguchi L9 experiment design and obtained results

- ✓ Cutting speed (Vc) and Total process time (Tp) was recorded during process.
- ✓ Kerf width (KW) and Material removal rate (MRR) were calculated by using formulas given below.

MRR = Cutting speed x kerf width x thickness of machined part x density of machined part

Kerf width = Diameter of the wire + 2 (Gap width)

- ✓ Surface roughness (Ra) was measured by surface roughness meter.
- ✓ Amount of used wire (AUW) was weighed with precision scales.

EFFECT OF PROCESS PARAMETERS ON Vc, MRR and Ra

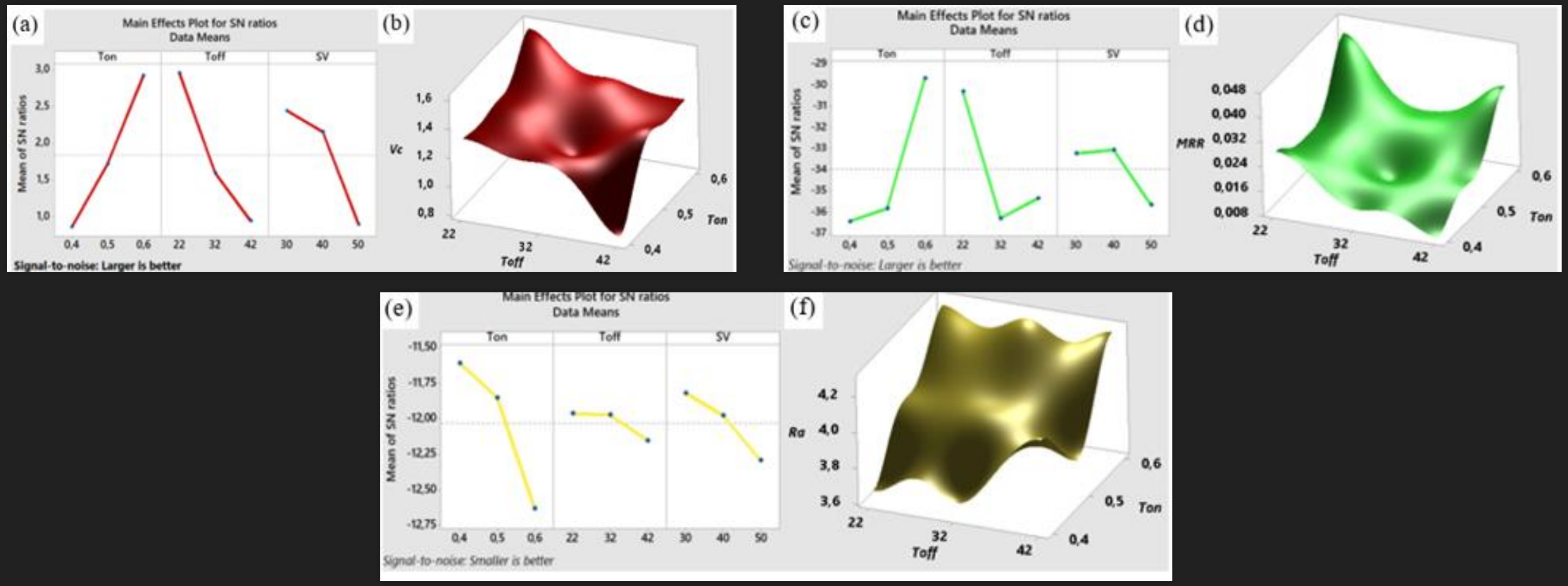
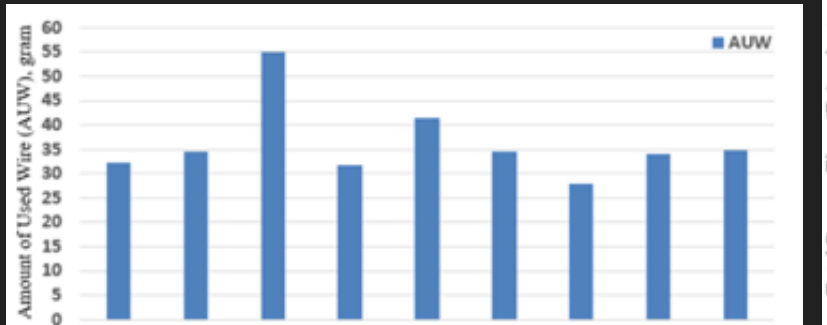


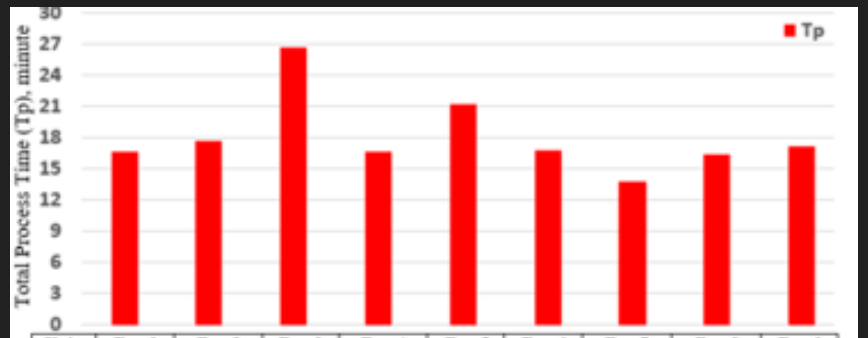
Figure 3: a) Main effects plot for SN ratios (Vc), b)Effect of Ton and Toff on Vc, c)Main effects plot for SN ratios (MRR), d) Effect of Ton and Toff on MRR, e) Main effects plot for SN ratios (Ra), f) Effect of Ton and Toff on Ra

EFFECT OF PROCESS PARAMETERS ON AUW, Tp and KW

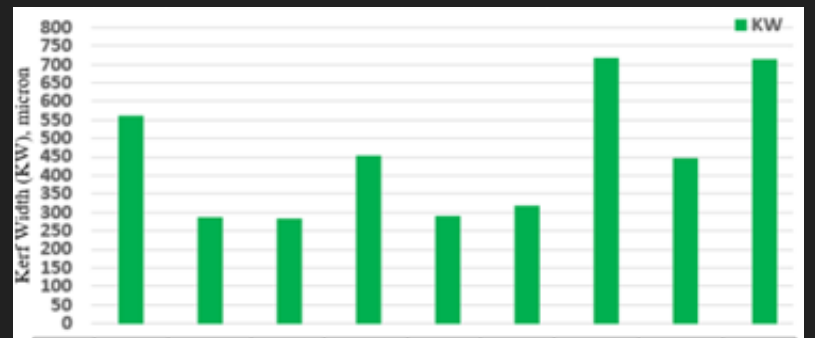
Change of AUW, Tp and KW for each experiment



Units	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6	Exp 7	Exp 8	Exp 9
µs	Ton:0,4	Ton:0,4	Ton:0,4	Ton:0,5	Ton:0,5	Ton:0,5	Ton:0,6	Ton:0,6	Ton:0,6
µs	Toff:22	Toff:32	Toff:42	Toff:22	Toff:32	Toff:42	Toff:22	Toff:32	Toff:42
V	SV: 30	SV: 40	SV: 50	SV: 40	SV: 50	SV: 30	SV: 50	SV: 30	SV: 40



Units	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6	Exp 7	Exp 8	Exp 9
µs	Ton:0,4	Ton:0,4	Ton:0,4	Ton:0,5	Ton:0,5	Ton:0,5	Ton:0,6	Ton:0,6	Ton:0,6
µs	Toff:22	Toff:32	Toff:42	Toff:22	Toff:32	Toff:42	Toff:22	Toff:32	Toff:42
V	SV: 30	SV: 40	SV: 50	SV: 40	SV: 50	SV: 30	SV: 50	SV: 30	SV: 40



Units	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6	Exp 7	Exp 8	Exp 9
µs	Ton:0,4	Ton:0,4	Ton:0,4	Ton:0,5	Ton:0,5	Ton:0,5	Ton:0,6	Ton:0,6	Ton:0,6
µs	Toff:22	Toff:32	Toff:42	Toff:22	Toff:32	Toff:42	Toff:22	Toff:32	Toff:42
V	SV: 30	SV: 40	SV: 50	SV: 40	SV: 50	SV: 30	SV: 50	SV: 30	SV: 40

AUW was weighed by using precision scale, maximum and minimum AUW was obtained as 54,994 g and 27,936 g respectively.

Tp is affected by Ton, Toff and SV and Tp values have been read from WEDM screen after each experiment and it varied between 13,81 min and 26,70 min

KW had the biggest value of 718 µm in 7th experiment with Ton of 0,6 µs, Toff of 22 µs and SV of 50 V, lowest value of 284 µm in 3rd experiment with Ton of 0,4 µs, Toff of 42 µs and SV of 50 V

CONCLUSION

From this experimental study, the following major conclusions can be presented;

- It can be commented that Ton has the most effect on cutting speed which increased by increasing of Ton. On the other hand, Toff and SV decreased the value of Vc. Besides, Toff and SV took place in 2nd and 3rd rank respectively about effecting the Vc. Furthermore, it is possible to see that high Ton and low Toff values leads a high Vc in Figure 3b.
- In terms of effect on MRR, Ton is the first, Toff is the second and SV is in the last row. Furthermore, Ton of 0.6 µs, Toff of 22 µs and SV of 40V presented the best results for maximum MRR value.
- The SR value is low at low Ton but it increases when Ton increases. Also, the SR decreases as the Toff increases.
- Tp is affected by T_{on}, T_{off} and SV and Tp values have been read from WEDM screen after each experiment and it varied between 13,81 min and 26,70 min. Also, an increase in Tp also increased AUW as expected.
- KW had the biggest value of 718 µm in 7th experiment with T_{on} of 0,6 µs, T_{off} of 22 µs and SV of 50 V, lowest value of 284 µm in 3rd experiment with T_{on} of 0,4 µs, T_{off} of 42 µs and SV of 50 V.
- Although Taguchi L9 experimental design reduces the number of experiments from 27 to 9, it should be noted that outputs are approximate to exact results. Finally, using a Taguchi design which includes more experiments can be recommended to obtain closer outputs to exact results.

REFERENCES

- [1] Bhattacharya, A., Das, S., Majumder, P., Batish, A. 2009., "Estimating the effect of cutting parameters on surface finish and power consumption during high speed machining of AISI 1045 steel using Taguchi design and ANOVA", Prod. Eng. Res., Volume 3, Pages 31–40.
- [2] Sharman, A.R.C., Hughes, J.I., Ridgway, K. 2006., "An analysis of the residual stresses generated in Inconel 718TM when turning", J Mater Process Technol., Volume 173, Pages 359–367.
- [3] Thomas, A., El-Wahabi, M., Cabrera, J.M., Prado, J.M. 2006. "High temperature deformation of Inconel 718", J Mater Process Technol., Volume 177, Pages 469–472.
- [4] Srivastava, A., Dixit, A.R., Tiwari, S. 2014., "Experimental investigation of wire EDM process parameters on aluminium metal matrix composite Al2024/SiC", International Journal of Advance Research and Innovation, Volume 2(2), Pages 511-515.
- [5] Liao, Y.S., Huangb, J.T., Chen, Y.H. 2004., "A study to achieve a fine surface finish in Wire-EDM", Journal of Materials Processing Technology, Volume 149, Pages 165–171.
- [6] Hashmi, M.S.J., 2017., Comprehensive Materials Finishing, Elsevier, ISBN 978-0-12-803249-7, Dublin, Ireland.
- [7] Garg, R., 2010., "Effect of process parameters on performance measures of WEDM", PhD Thesis, National institute of Technology.
- [8] Singh, V., Kumar, J. 2015., "Optimization of machining parameters in rough cut WEDM operation of EN 18 die tool steel using response surface methodology", Journal of Material Science and Mechanical Engineering, Volume 2(7), Pages 76-81.
- [9] Doley, H., Tamang, S.K., Samanta, S. 2017., "Experimental study and development of an emprical model for SR and MRR in CNC WEDM of AZ31B magnesium alloy based MMNC", Journal of Production Engineering, Volume 20(2), Pages 25-33.
- [10] Ishfaq, K., Mufti, N.A., Jawad, M., Sajid, M., Jahanzaib, M. 2018., "Analysis of the effect of WEDM process parameters on the formation of HSS form tool", Advances in Science and Technology Research Journal, Volume 12(1), Pages 89–98.
- [11] Bobbili, R., Madhu, V., Gogia, A. 2015., "Multi response optimization of wire-EDM process parameters of ballistic grade aluminum alloy", Engineering Sci. and Tech., Volume 18(4), Pages 720–726.
- [12] Wire selection, Last access: 07.05.2019., https://www.novotec-edm.com/wire-selection,
- [13] Kanekar, K.S., Meshram, D.B. 2015.,"Investigation and optimization of EDM performance measures using empirical data analysis", Int. Journal of Research in Eng. and Tech., Volume 4(8), Pages 213-223.
- [14] Sudhakara, D., Prasanthi, G. 2014., "Review of research trends: Process parametric optimization of WEDM", International Journal of Current Engineering and Technology, Volume 2, Pages 131-140.
- [15] Taweel, H.E., Safty, E. 2005., "Modeling the machining parameters of WEDM of Inconel 601 using RSM", Journal of Materials Processing Technology, Volume 169, Pages 328–336.
- [16] Minitab 18 Support,"What is the signal-to-noise ratio in a Taguchi design",Last access date: 12.06.2019,https://support.minitab.com/en-us/minitab/18/help-and-how-to/modeling- statistics/doe/supporting-topics/taguchi-designs/what-is-the-signal-to-noise-ratio/
- [17] Soundararajan, R., Ramesh, A., Mohanraj, N., Parthasarathi, N. 2016., "An investigation of material removal rate and surface roughness of squeeze casted A413 alloy on WEDM by multi response optimization using RSM", Journal of Alloys and Compounds, Volume 685, Pages 533-545.

THANK YOU FOR LISTENING.