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Analysis of SS316L by using Abrasive Flow Machining

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***Abstract* – Experiential test facility is designed, which comprises of a) Work holding stage, b) Tool encouraging gadget, c) Control framework, d) Electrolyte stream framework, and e) Power supply framework. The experiments were performed by selecting five parameters viz. Electrolyte Concentration (EC), Machining Voltage (V), Machining Current (C), Duty Cycle (DC), and Frequency (F). It is also found that, numerous investigations were focused mainly on process parameters one after another. Further, it is required that, the Abrasive Flow Machining (AFM) and Electro Chemical Micro Machining (ECMM) procedure is to be streamlined explicitly for every material with respect to MRR, dimensional deviation and machining cost. The present research work is planned by selecting Nickel, SDSS (5 - 6 % of Nickel content) and Inconel 600 (72% Nickel content) as a base material. The machining surfaces were additionally examined by utilizing Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM) to study the erosion mechanisms and machining process.(AFM) and Scanning Electron Microscopy (SEM) to study the erosion mechanisms and machining process.**

***Keywords* – Abrasive Flow Machining, Electro Chemical Micro Machining, Erosion Mechanism, Taguchi Design of Experiments.**

I. INTRODUCTION

The new framework rising up out of advancement might be comprised by mechanical, electro mechanical, pressure driven, warm, or other such components. In these lines, this research attempts to develop the process of Electro Chemical Micro Machining (ECMM) for Nickel and its composites.

In ECMM process, the work piece is associated with anode and the miniaturized scale apparatus is associated with cathode and they are set inside the electrolyte with a little hole between them. On the application of sufficient electrical energy, positive metal particles leave from the work piece and machining happens. Electrolyte flow expels the machined particles from the terminal hole. To proceed with the machining process, the terminal hole must be kept up by moving the device at required rate.

Assembling machine parts having complex geometric shapes and profiles made up of savvy materials requiring nanometer range surface completion and dimensional precision has prompted the improvement of more up to date get done with machining techniques. It has been accounted for that last completing tasks establish the most fundamental, delicate, work serious and tedious activities which expend right around 10-15 percent of the absolute assembling costs. Rough stream machining (AFM) is a novel non-conventional machining process created as a strategy to deburr, clean, and span surfaces and edges by streaming a grating loaded media over generally hard to machine territories and surfaces. In AFM, a semi-strong medium comprising of a polymer-based bearer and abrasives in run of the mill extents is expelled through or past the surface to be machined.

Table –I: Dissolution valence for different metals.

Metal	Electrolyte	Dissolution valence
Ni	NaCl	2
Ni	$NaNO_3$	2*
Fe	NaCl	2 and 3
Fe	$NaNO_3$	2*
Cr	NaCl	6
Cr	$NaNO_3$	6

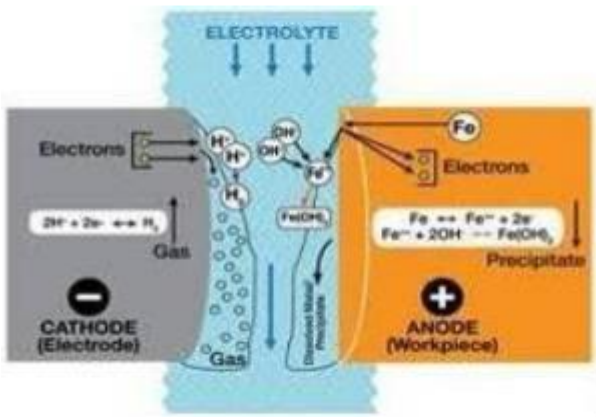


Fig .1.Mechanism of ECMM.

1.1 Advantages of ECMM

- CMM offers a few advantages over other contending advancements.
- These advantages have settled on ECM the best decision for an assortment of applications.
- The item subsequent to processing is free of burrs No-contact process standard
- The process does not cause warm or physical strain in the item Unlike other machining techniques, no upper-layer misshapening
- 3-Dimensional processing in single step (Kurita T 2006)
- High surface quality level achievable relying upon material High dimensional precision feasible (Lee S.J 2008)
- No nearby rust development on the outside of the workpiece Gives more opportunity of design an item
- ECMM is a technique with high machining velocity at low costs Low running and tooling costs (Jinjin Zhou 2005)
- The hardness, durability and warm opposition has no impact MRR is high.
- MRR is practically free on the kind of material. Hard and extreme compounds are machined at a similar speed.

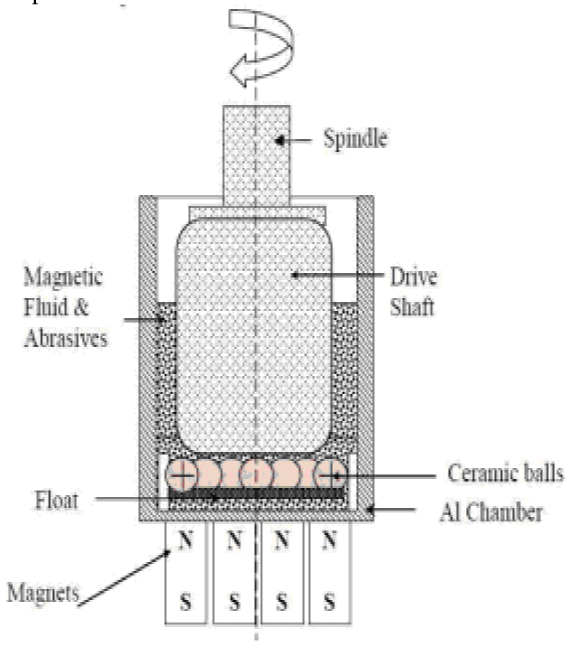


Fig.2.Schematic diagram of abrasive flow machining process.

Electrolyte recovery (small scale filtration) has empowered the cleaning of the electrolyte to a ppm level and can along these lines be reused uncertainly. The delivered slop can frequently be reused, contingent upon creation and henceforth ecologically adequate Subsequently, ECMM has developed as a most generally utilized non-regular innovation for machining miniaturized scale/meso scale parts.

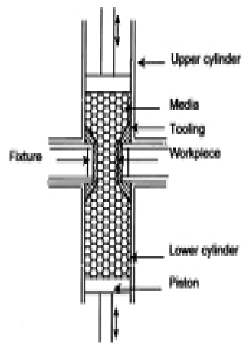


Fig .3.Schematic diagram of MAFM process.

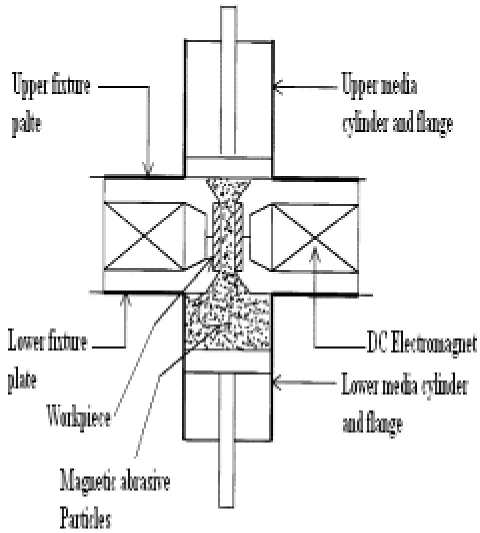
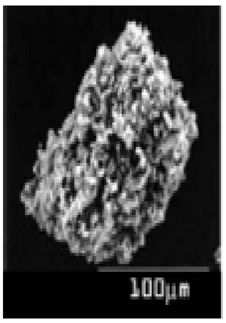


Fig. 4 .Schematic diagram of the magnetic float polishing (MFP)

II. LITERATURE REVIEW

Throughout the previous three decades, a ton of research works have been done to comprehend the process system, streamlining of process parameters, and its capacity for finishing different materials. This section exhibits a far reaching survey on the hypothetical and exploratory examinations on MFAAF process.



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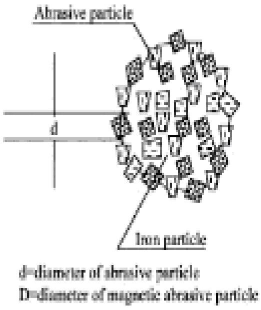

Fig .5. Bonded MAPs.

Numerous trial examinations have been done to think about the impact of process parameters by the researchers on both barrel shaped and level surfaces for MFAAF process. The exploratory plan for finishing barrel shaped and level surfaces.

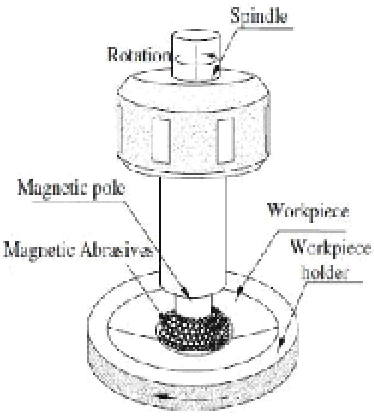

Fig .6.Schematic view of free form MFAAF process.

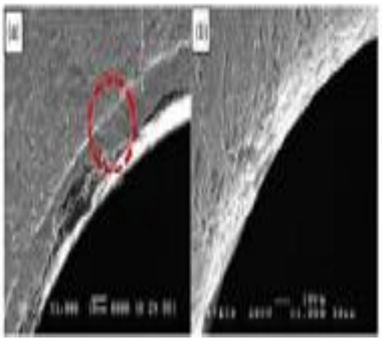

Fig .7. Bonded MAPs.

The magnetic grating particles (MAPs) are the homogeneous blend of Fe molecule and rough particles. Finishing proficiency is enormously influenced by the inflexibility of Magnetic Abrasive Flexible Brush (MAFB). As the rate sythesis of Fe powder in MAP expands, the quantity of Fe molecule that are holding the grating powder increments. The grating molecule extending from 75 to 1680 μm were utilized and found that 330 μm size Fe particles were the most productive in getting best complete in the least time.

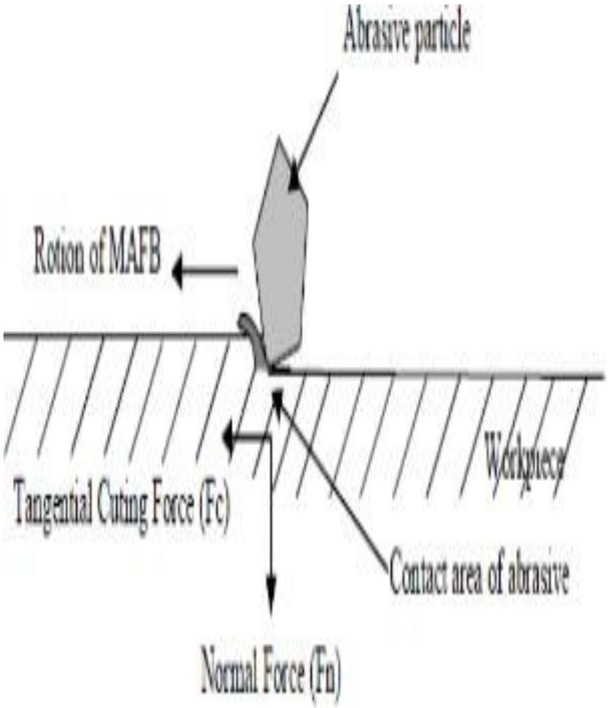

Fig .8. Schematic view of abrasive indentation and force components during MFAAF.

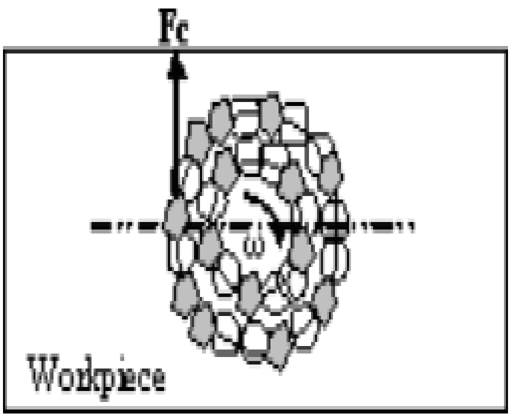

Fig. 9. Tangential force due to the rotation of MAFB .

III. RESEARCH METHODOLOGY

The work piece material used in the machining test was plunger body made of stainless steel SS446. Experiment was performed in each work piece. All work pieces were prepared in CNC machine tool with same machining condition to get same initial surface roughness value. Initial surface roughness obtained for work pieces were about 0.8 microns and nine work pieces with same initial surface roughness value were considered for experiments. All work pieces were cleaned before and after AFM with ultrasonic cleaning machine using isopropyl alcohol as cleaning agent.

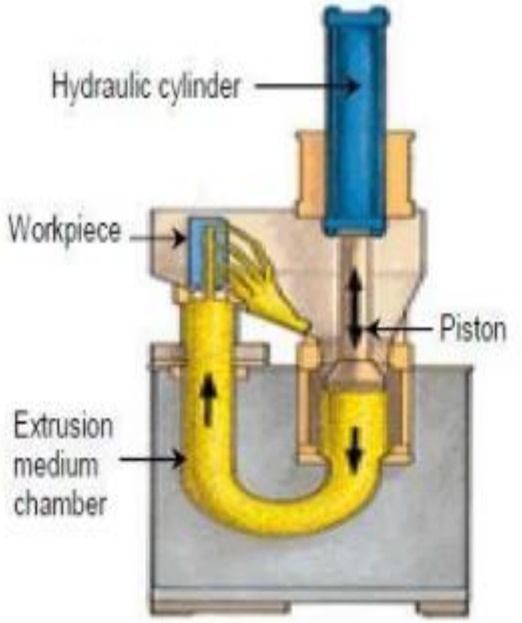

Fig .10 .SEM image (1000X) showing edge quality (a) before (b) and after MFAAF.

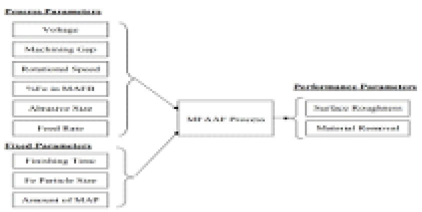

Fig.11.Unidirectional AFM process.

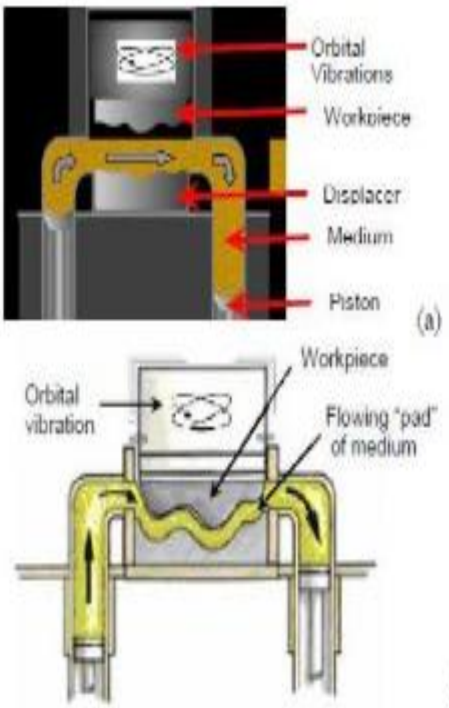

Fig. 12. Orbital AFM (a) before start of finishing, (b) while finishing.

Fig .13. Formation of Magnetic Abrasive Flexible Brush (MAFB).

Table 4.2: Mechanical properties of SS316L

Properties	Values
Density (g/cm^3)	7.99
Tensile strength ultimate (MPa)	515
Modulus of elasticity (GPa) Tension	193
Hardness (HV)	225

3.1 Selection of MFAAF Process Parameters

The distinguishing proof of key procedure parameters impacting surface completion and material expulsion was done from the thorough writing overview, pilot examinations, and set-up requirements.

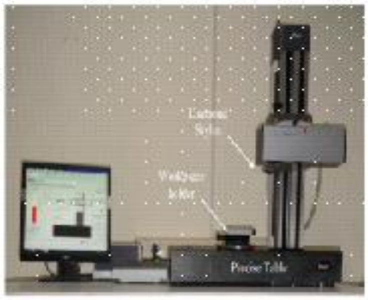

Fig .14. Block diagram of MFAAF experimental system.

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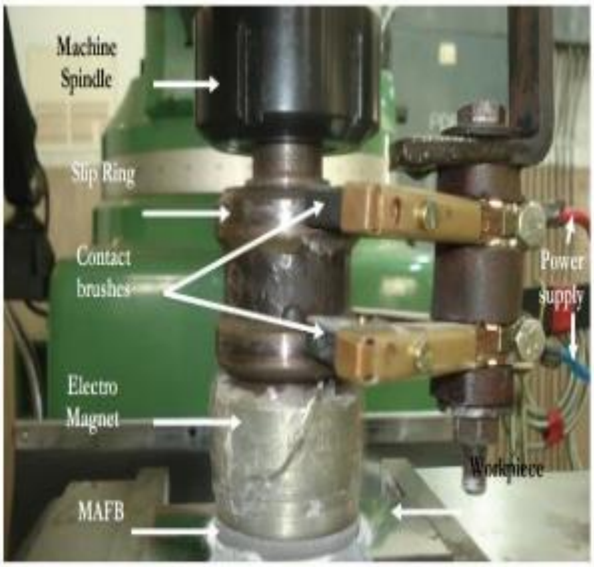

Fig.15. Photographic view of Magnetic Abrasive Flexible Brush (MAFB) at small machining gap (Voltage=22V, Machining Gap=1.75mm).

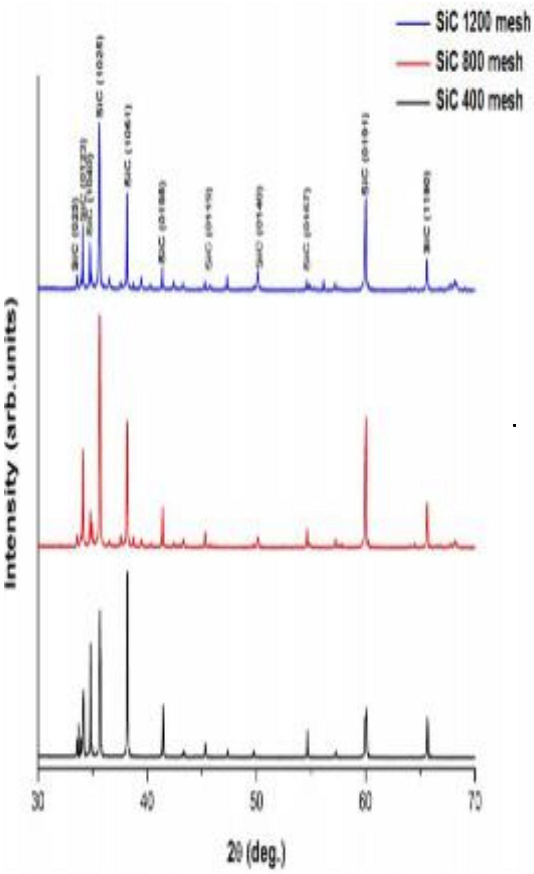

Fig.16. XRD results for Fe and SiC powders used in study.

The last surface harshness esteems were estimated at similar focuses (utilizing the format) where the underlying completion esteems were estimated after the MFAAF procedure.

$$\Delta R_a = \text{Initial } R_a \text{ Value} - \text{Final } R_a \text{ Value} \qquad \text{(Eqn. 4.1)}$$

$$\%\Delta R_a = \frac{\Delta R_a}{\text{Initial } R_a \text{ Value}} \times 100 \qquad \text{(Eqn. 4.2)}$$

Fig. 15 . Surface roughness measurement instrument.

Fig .17. Reciprocating wear testing machine.

IV. RESULTS

4.1 S/N Ratio Analysis

The calculated S/N ratios for %ΔRa and MR .The main effect plot for %ΔRa and MR are depicted .

Table- I: S/N ratios calculated for L9 Experiments

S.No	A (V)	B (mm)	C (rpm)	D (Mesh no.)	S/N ratio(dB) %ΔRa	S/N ratio(dB) MR
1	18	1.50	270	400	32.3631	31.8213
2	18	1.75	405	800	30.9111	30.3703
3	18	2.00	540	1200	31.6662	31.5957
4	20	1.50	405	1200	36.9317	37.6163
5	20	1.75	540	400	33.6049	33.9794
6	20	2.00	270	800	30.9111	30.3703
7	22	1.50	540	800	38.0422	40.2567
8	22	1.75	270	1200	36.1046	37.5012
9	22	2.00	405	400	34.1667	34.4855

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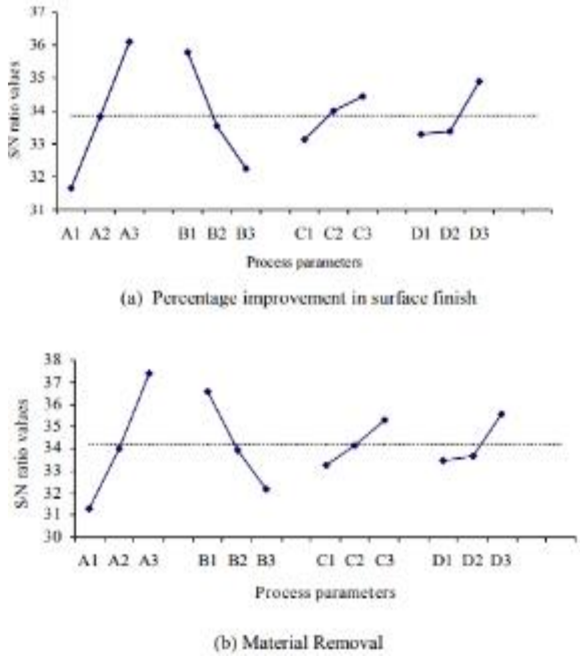

Fig. 18. Signal to noise ratio for %ΔRa and MR.

Table -II: Optimal process parameters combination for Maximum %ΔRa and MR

Optimal combinations maximum %ΔRa and MR				
Process parameter	A (V)	B (mm)	C (rpm)	D (mesh no.)
Levels	A3	B1	C3	D3
Values	22	1.50	540	1200

Table -III : ANOVA results for %ΔRa

Source	DOF	SS	MS	F-ratio	P-value
A	2	2077.65	1038.83	310.44	0.000**
B	2	1780.83	890.42	266.09	0.000**
C	2	188.79	94.39	28.21	0.000**
D	2	405.44	202.72	60.58	0.000**
Error	9	30.12	3.35		
Total	17	4482.84			

*Highly Significant ($P<0.05$); $F_{0.05,2,9}=4.2565$

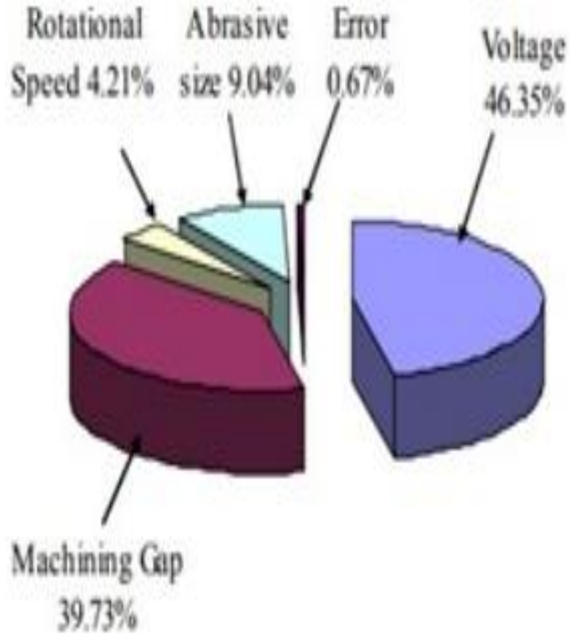

Fig .19.Percentage improvement in surface finishes (%Δ Ra).

V. CONCLUSION

Predominant procedure parameter which influences MRR shifts dependent on the Nickel content in the Nickel Alloy. The 100% unadulterated Nickel has demonstrated high pace of disintegration for the higher machining current (C). The Inconel 600 compound, which has 72% Nickel content, the obligation cycle (DC) contributed for most extreme MRR while machining current become less critical. Further, the obligation cycle (DC) was the real parameter influencing the MRR of the SDSS combination which has just 5 - 6% of Nickel content.

- The analyses were directed on level SS316L material according to the Taguchi structure system. The created observational models were utilized to examine the impact of procedure parameters on the yield reactions.
- It is found from the ANOVA results that machining current, electrolyte concentration and machining voltage have significant effect on MRR. The predicted combination of process parameter for maximum MRR is EC3V3C3DC3F1.
- The optimum combination of levels of process parameter for maximum MRR is achieved from the 8th combination i.e. EC3V2C3DC2F1. The maximum MRR obtained is 0.009577 mm^3/min.

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