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Experimental Research on Abrasive Flow Machining

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***Abstract* – The effects of the Abrasive flow machining process and the field of electrochemical smaller scale machining process is uncovered the extraordinary capability of its accuracy machining. 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. To minimize the number of experiments, it also planned to make use of Taguchi design of experiments with ANOVA, in terms of %ΔRa and MR. Hereditary Algorithms are utilized to establish an empirical relationship between process parameters and material removal rate (MRR).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.**

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

I. INTRODUCTION

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.Electrochemical machining (ECM) was created during late 1950s and mid 1960s and used to machine hard to-cut materials in aviation and other substantial businesses for forming and completing tasks. It is an anodic disintegration process dependent on the marvel of electrolysis, whose laws were built up by Michael Faraday. In ECM, electrolytes fill in as conveyor of power. ECM offers various advantages over other machiningmethods

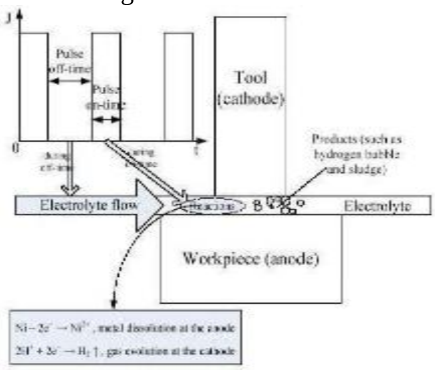

Fig .1.Physical Model of ECMM.

II. LITERATURE REVIEW

Magnetic Field Assisted Abrasive Finishing (MFAAF) process is a propelled finishing process, created to conquer the disadvantages in the customary finishing processes. The MFAAF has been started in the USA and it was first referenced in a patent by Harry P. Coats in 1938 (Kremen et al., 2013).

2.1 The Oretical Investigations on MFAAF Process

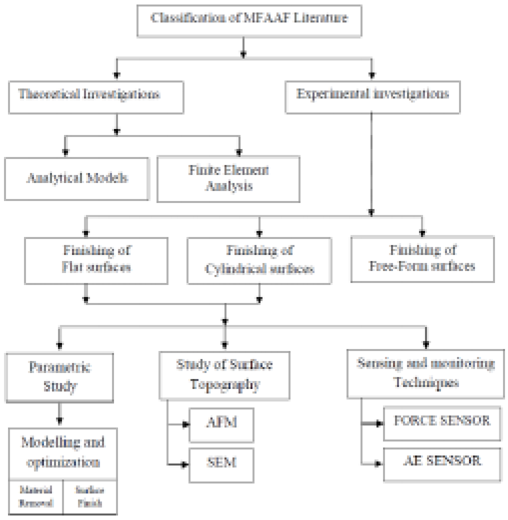

Fig.2.Classifications of Literature review in MFAAF process.

It was discovered that the fringe speed of magnet, magnetic transition thickness and working hole are huge in improving the surface completion of the workpiece. Shinmura. MFAAF process for finishing of level work pieces, treated steel (SUS304) utilizing alumina abrasives blended with iron powder.

III. RESEARCH METHODOLOGY

The process is especially valuable for hard to arrive at interior sections, twists, holes, and edges. Specific advantages are the directional completions delivered, which streamline the stream coefficient of certain work-pieces, and the splendidly shaped, digressively mixed radii framed on edges, which improve high-and low-cycle weariness quality of certain work-pieces. In AFM, a semisolid media comprising of a polymer based transporter and abrasives in explicit extent is expelled under strain through or over the surface to be machined.

Usually utilized AFM is Two-path AFM in which two vertically contradicted chambers expel medium forward and backward through entries framed by the work piece and tooling . AFM is utilized to deburr, span and clean hard to arrive at surfaces by expelling a rough loaded polymer medium with uncommon rheological properties. It is broadly utilized finishing process to complete confused shapes and profiles. The polymer rough medium which is utilized in this process, has simple flowability, better self-deformability and fine scraping capacity.

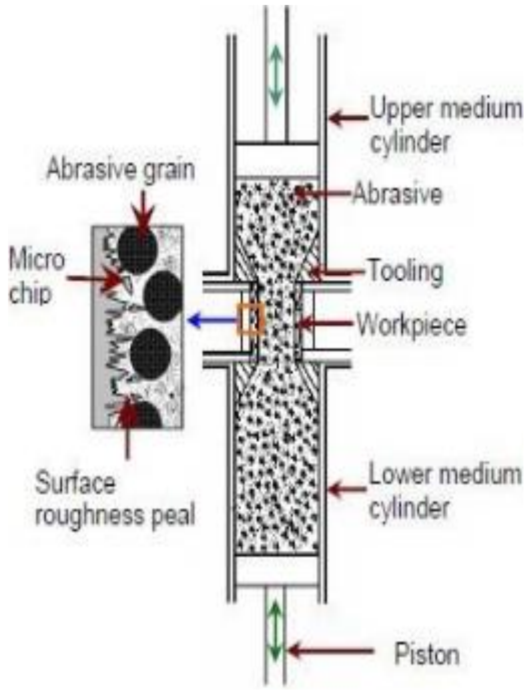

Fig. 3.Principle of material removal mechanism in two ways AFM process

3.1 Classification of AFM Machine

One way AFM process: One way AFM process device is furnished with a using pressurized water impelled responding cylinder and an expulsion medium chamber adjusted to get and expel medium uni-directionally over the inner surfaces of a work piece having interior entries shaped .

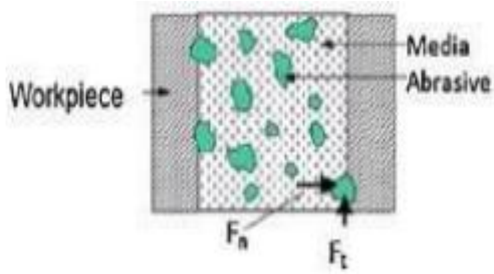

Fig.4.Two-way flow process illustration.

3.2Process Parameters and Their Influence on Quality Characteristics

Machining parameters of AFM and the rheological properties of the rough medium are two key factors that will influence the effectiveness in the cleaned process. The surface exactness can be constrained by changing the AFM parameters, the tests demonstrated that not just the temperature could genuinely impact the thickness of the medium yet in addition a little increment in the temperature would definitely lessen the medium consistency in AFM. The outcomes additionally present that the medium consistency increments with the grating focus yet diminishes with the rough size. Silicone elastic (a sort of polymer gel) with high consistency and low stream rate is a decent grating medium that can without much of a stretch clean the WEDM surface to a smooth completion

these original thoughts he and Tisza proposed that the superfluid period of the fluid could be portrayed by a two-fluid model, the dense and non-consolidated iotas being distinguished separately with the superfluid and typical segments. In 1941 Landau composed a striking paper wherein he proposed that superfluidity can be comprehended regarding the extraordinary idea of the thermally energized conditions of the fluid: the outstanding phonons and rotons.

IV. STATEMENT OF THE PROBLEM

Analyses are to be directed to comprehend the impact of the different ECMM parameters on MRR. Measurable and enhancement techniques assume an important job in displaying the machining parameters and playing out the improvement of machining parameters for accomplishing the chose targets. Further research is expected to streamline the ECMM process parameters for the most generally utilized materials like Nickel, Super Duplex Stainless Steel and Inconel 600 is need of great importance since utilization of these materials has developed in numerous businesses.

V. RESEARCH METHODOLOGY

All work pieces were cleaned before and after AFM with ultrasonic cleaning machine using isopropyl alcohol as cleaning agent. Plunger
Body.

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Fig .5. Plunger body.

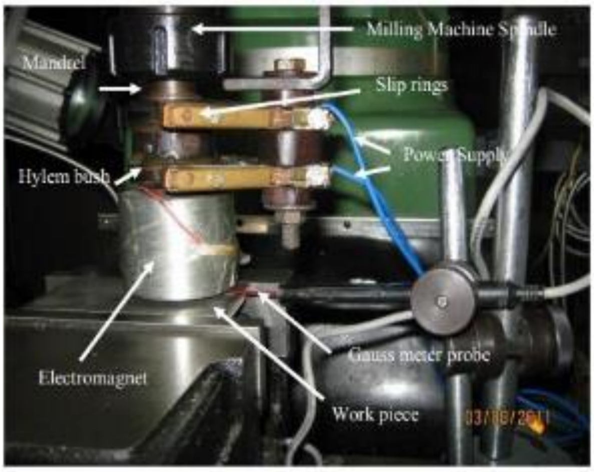

Fig.6. Experimental arrangement for flux density measurement in the air gap.

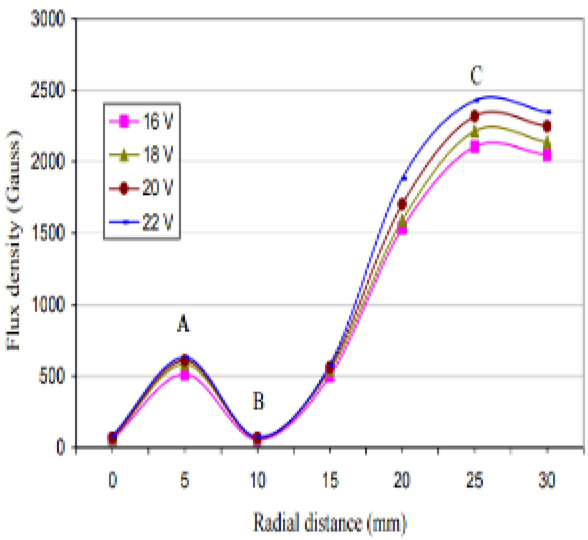

Fig .7.Flux density curve at different voltages with 1.5mm air gap on SS316L.

5.1 Selection of MFAAF Process Parameters

The different procedure parameters influencing the result of MFAAF procedure has been delineated. 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. As the quantity of procedure parameters are more, the accompanying most impacting parameters are distinguished from the writing
i)Voltage provided to the electromagnet
ii)Machining hole
iii)Rotational speed of the electromagnet
iv)Size of the rough powder v) Mixing proportion vi) Feed rate

5.2 Feed Rate during the MFAAF

Process the temperature of the workpiece surface raises due to the rubbing action of MAPs and heat generated in the electromagnet coil. Mishra et al., reported that the temperature rise was in the range of 34 to 51° C. If the electromagnet is continuously used on the same location without any linear relative motion (feed) for more than 30 minutes resulted in burning marks on the work surface .

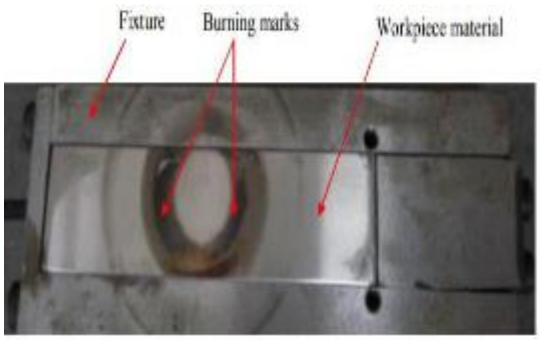

Fig 8: Burning marks on work piece at zero feed rate (machining time 30 minutes)

5.3 Material Removal

The material expulsion (MR) is determined by estimating the underlying and last weight of the completed workpieces utilizing an accuracy gauging equalization and it is given by the accompanying condition: Material Removal(in mg) = Initial load of work piece – Final load of work piece.

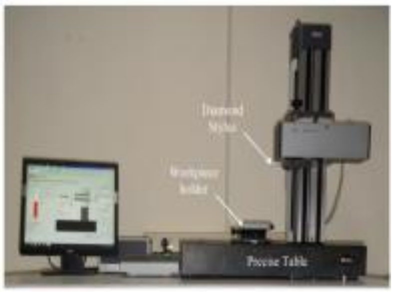

Fig .9. Surface roughness measurement instrument.

VI. EXPERIMENTAL SETUP

The current machine apparatuses (machine or processing) can be utilized for MFAFF process by including a polarizing unit (electromagnet or changeless magnet) to the machine. In this investigation, a MFAAF arrangement

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was intended for completing of plane surfaces and it was incorporated with a processing machine. The trial arrangement comprises of an accuracy vertical processing machine, electromagnet axle get together, polarization unit, instrumentations and PC based information procurement framework.

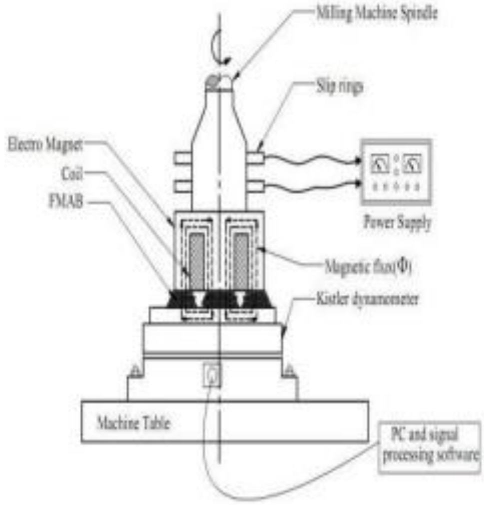


Fig.10.Schematic view of MFAAF experimental setup

6.1Wear Study Experimentation

The wear testing machine essentially comprises of responding arm with an example holder on which the ball is fixed and a lower holder for the level example. The ball responds over the level example. Accordingly wear either jumps out at the ball or to the example or for both.

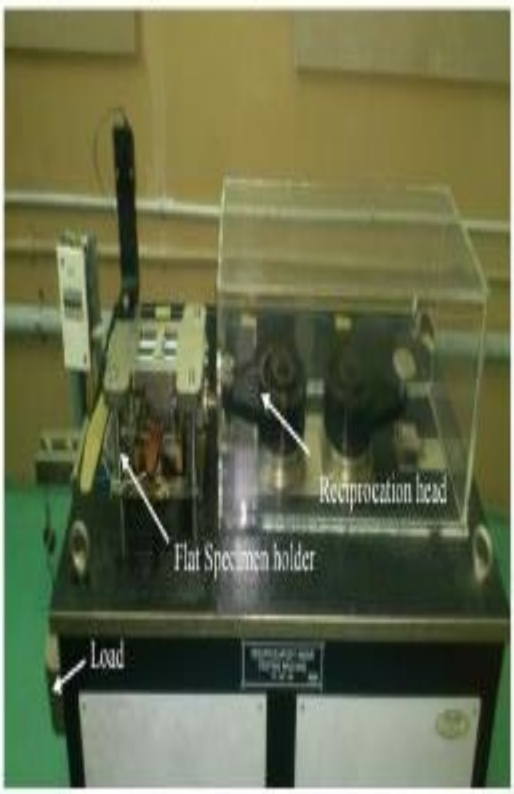
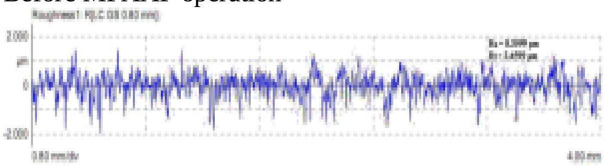


Fig.11.Reciprocating wear testing machine.

VII. DATA ANALYSIS & VALIDATION

Phase-I: Results of L9 Experiments

Before MFAAF operation



After MFAAF operation

Table –I: Experimental Matrix (L9), and its output responses (%ΔRa, MR)

S.No	A (V)	B (mm)	C (rpm)	D (Mesh no.)	Ra Before MFAAF (µm)	Ra After MFAAF (µm)	%ΔRa (%)	MR (mg)
1	18	1.50	270	400	0.3564	0.2084	41.51	39
2	18	1.75	405	800	0.3599	0.2335	35.12	33
3	18	2.00	540	1200	0.2439	0.1505	38.31	38
4	20	1.50	405	1200	0.3298	0.0981	70.24	76
5	20	1.75	540	400	0.2956	0.1541	47.89	50
6	20	2.00	270	800	0.4615	0.2994	35.12	33
7	22	1.50	540	800	0.3599	0.0725	79.82	103
8	22	1.75	270	1200	0.4428	0.1600	63.86	75
9	22	2.00	405	400	0.4169	0.2039	51.09	53

Table -II : 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); $F_{0.05,2,9} = 4.2565$

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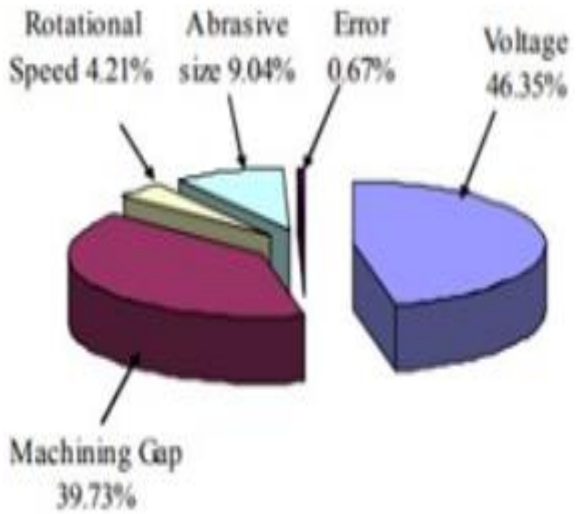

Fig .12. Percentage improvement in surface finishes (%Δ Ra).

7.1 Validation of Regression Models

It is seen that the greatest rate deviation for the anticipated estimations of %ΔRa and MR utilizing the relapse model is observed to be 5.96% and 6.76% separately. These outcomes demonstrate the viability of the proposed straight relapse models for foreseeing and investigating the performance parameters of MFAAF process.

Table -III: Validation results for the regression models.

S.No	A (V)	B (mm)	C (rpm)	D (Mesh no.)	%ΔRa (%) Expt.	Predicted Value	% deviation	MR (mg) Expt.	Predicted Value	% deviation
1	18	1.6	300	600	39.9	38.81	2.83	38	35.43	6.76
2	19	1.8	450	800	43.5	43.89	0.72	45	45.06	0.12
3	21	1.9	500	1000	53.7	56.97	5.96	64	65.62	2.53

7.2Effect of Process Parameters

ON %ΔRa AND MR The created direct relapse Eqns. 4.3 and 4.4 were utilized for examining the impact of various procedure parameters on %ΔRa and MR to get further understanding about the MFAAF procedure which are displayed in the accompanying sub areas.

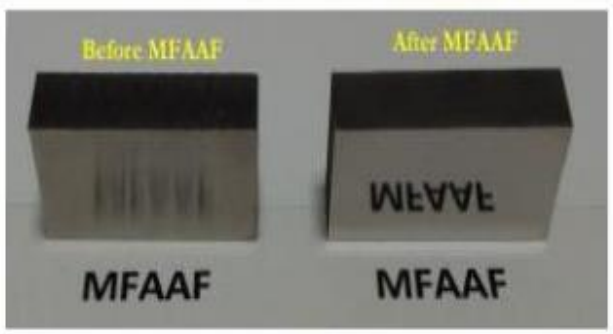

Fig .13. Workpiece sample before and after MFAAF process.

VIII. RESULTS & DISCUSSIONS

The procedure parameters towards MRR, investigation was finished by Taguchi technique utilizing Minitab 15 programming. The tables incorporate positions dependent on delta measurements, which look at the overall size of impacts. The delta measurement is the most astounding less the least S/N Ratio for each factor. Minitab appoints positions dependent on delta esteems; rank 1 to the most astounding delta esteem, rank 2 to the second most noteworthy,

Nickel the means of MRR and Delta value are calculated using Taguchi methodology. Based on the delta value, the process parameters are ranked for its influence on MRR. Table 4 shows the means, delta value and the ranks of process parameters for Nickel.

Table -IV: Response table for Means – NICKEL

Level	EC	V	C	DC	F
1	0.003305	0.003134	0.002223	0.003921	0.005131
2	0.003944	0.004149	0.004176	0.004004	0.003643
3	0.004924	0.004889	0.005774	0.004248	0.003399
Delta	0.001619	0.001755	0.003550	0.000327	0.001732
Rank	4	2	1	5	3

The above tabulated mean values are plotted as table 4 to pictorially represent the contribution of each process parameter on MRR.

IX. CONCLUSIONS

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.

The obligation cycle (DC) was the real parameter influencing the MRR of the SDSS combination which has just 5 - 6% of Nickel content.

Higher the Nickel content, the machining current is progressively huge factor influencing MRR and DD.

MFAAF process for completing of SS316L material and concentrates the impact of procedure parameters superficially complete improvement, material evacuation and cutting powers produced during MFAAF process.

%ΔRa and MR are fundamentally affected by the abnormal state voltage of 22V, low level machining hole of 1.5mm, higher work size of 1200 work pursued by higher rotational speed of 540 rpm.

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