International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-9 Issue-1, May 2020

Effect on Machined Surface Characterization during ECM of AISI 304 Steel

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Abstract: ***AISI 304 chrome steel which is extensively used practically altogether industrial applications is represented about half of world's chrome steel production and consumption. Due to its aesthetic view in architectures, prevalent mechanical and physical properties, weld capacity, obstruction against consumption and synthetic concoctions, it becomes as the most favored material. ECM is one of the most effective machining process because of its capacity to create totally tranquil machine parts with no need of the further completing procedure. In this paper gives the knowdge about the electrochemical machining of AISI 304 steel. Approach of the investigates are done by using Taguchi methodology to study the surface roughness, micro hardness and microstructure. Process parameters such as electrolyte concentration, electrolyte flow rate, applied voltage and feed rate has been optimized by the ANOVA using. This research work supports the industrialist for choosing parameters to accomplish anticipated outputs.***

Keywords **:** ***ECM, ANOVA, AISI 304, Taguchi Method ,EC (Electrolyte Concentration), FR(Feed Rate), EFR(Electrolyte Flow Rate), AP (Applied Voltage), SR (Surface roughness), MH (Micro hardness)***

I. INTRODUCTION

Electrochemical machining works on the Faraday law of electrolysis which express that if two anode are set during a compartment which is packed with a conductive fluid or electrolyte and high ampere DC voltage applied across them, metal are frequently exhausted structure the anode (Positive terminal) and plated on the cathode (Negative terminal). This is the fundamental standard of electrochemical machining. Right now, device is associated with the negative terminal of battery (function as cathode) and work-piece is associated with the positive terminal of battery (work as anode). The two of them are set in an electrolyte arrangement with a little separation. At the point when the DC current provided to the terminal, metal far away from work-piece. This is essential thing of electrochemical machining.[1-2]

Manuscript received on April 30, 2020.
Revised Manuscript received on May 06, 2020.
Manuscript published on May 30, 2020.
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The electrolyte is driven to the work region by the pump via a filter, pressure gauge, flow meter and lastly, it goes into the work locale from the section. At the point when the Power supply is given an optimum gap is maintained between the tool and work piece because of Faraday's laws of electrolysis, the particles have started displacing from the work piece and attempting to store over the device. Before the particles are depositing on the device, the electrolyte present among devices and work piece is pumped out. At that point the particles additionally moving alongside electrolyte without depositing on the tool. From the over the mechanism of material elimination is Ion movement and for the reason that there is no disturbance taking place in the tool, the similar tool can be able for generating an infinite number of components.[3] Hence, we can say that the wear ratio of the tool is infinity (because of no tool wear). Fig.1 displays the principle of ECM process.

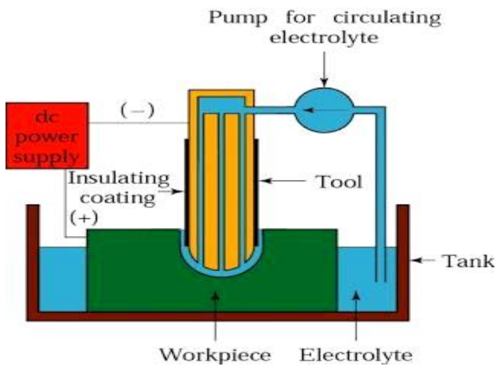

Fig 1. Principle of ECM Process

II. MATERIAL AND METHODS

Work piece material, tool material and methods have been discussed below.

A. Work piece material

AISI 304 stainless steel which is generally utilized nearly in every industrial applications is represented for approximately 50% of the world's stainless steel production and utilization therefore Stainless Steel grade 304 was used as a work piece material. Sample of the work piece material is shown in Fig 2.

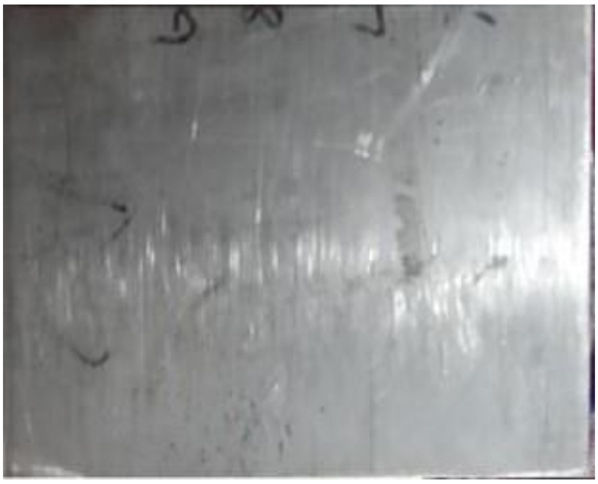

Fig.2 Work piece Material

Chemical composition of the work piece material is shown in Table 1 and mechanical and physical property of AISI 304 steel material is shown in Table 2.

TABLE 1.CHEMICAL COMPOSITION OF AISI 304 STEEL

Element	C	Mn	P	S	Cr	Ni	Fe
Weight %	0.08	2.0	0.045	0.03	18-20	8-10	Balance

TABLE 2. PHYSICAL AND MECHANICAL PROPERTY OF AISI 304 STEEL

S.No	Property	Value
1	Density	8000kg/m^3
2	Melting point	1400-1450^{0}C
3	Hardness	52-58 HRC

B. Tool material

Copper was used as a electrode tool material of machining of AISI 304 material of ECM process. Composition of the electrode tool material is shown in Table 3.

TABLE 3. COMPOSITION OF ELECTRODE TOOL MATERIAL USED

Element	Cu	Sn	Pb	Zn	Fe	P	Al
Weight %	88.91	10	0.25	0.05	0.1	0.5	0.01

III. RESEARCH METHODOLOGY

The aim of the present work was to optimize of input parameters such as applied voltage, feed rate, electrolyte concentration and electrolyte flow rate in ECM. Fig.3 shows the methodology of ECM process.

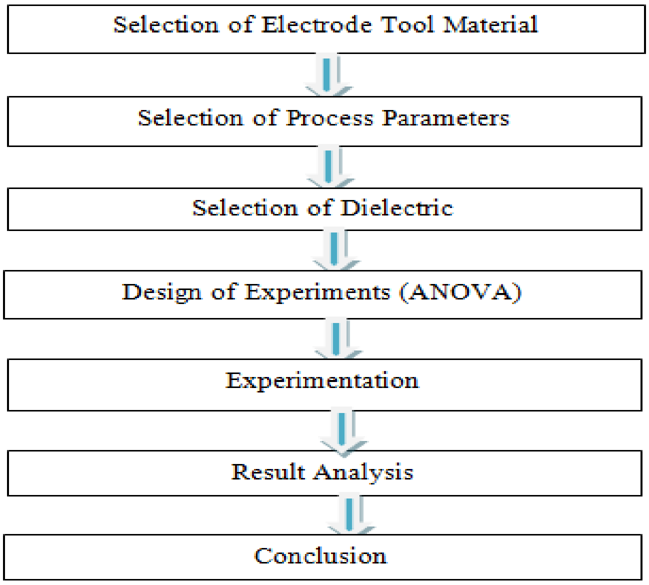

Fig 3. Flow Chart of Methodology

IV. EXPERIMENTAL WORK

A. Process Parameters

The different process parameters which plays persuasive role in the electrochemical machining process are-

- Electrolyte concentration
- Electrolyte flow rate
- Applied voltage
- Feed rate

In the current research work out of these procedure parameters electrolyte concentration, electrolyte flow rate, applied voltage and feed rate were choosen as input process parameters for electrochemical machining of AISI 304 steel [4]. Three degrees of procedure parameters are appeared in Table 4.

TABLE 4. VARIOUS PARAMETERS AND THEIR LEVELS-

S. No	Factors	Unit	1	2	3
1	Electrolyte concentration	gm/lit	200	250	300
2	Electrolyte flow rate	lit/min	80	90	100
3	Applied voltage	Volts	10	15	20
4	Feed rate	mm/min	10	12	14

B. Design of Experiment

Structure of analyses (DOE) is a system for arranging tests and dissecting the data acquired. The method permits utilizing a base number of analyses. In the current work the Taguchi Methodology was utilized to depict to limit the no of trials [5].

Retrieval Number: F9789038620/2020©BEIESP
DOI:10.35940/ijrte.F9789.059120
Journal Website: www.ijrte.org

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The design of experiments (D.O.E) selected for the electrochemical machining of AISI 304 steel was a Taguchi L9 orthogonal array, consisting of a total number of 9 experiment

TABLE 5. DESIGN OF EXPERIMENTS FOR ECM OF AISI 304 STEEL

S.No	Electrolyte concentration (gm/lit)	Electrolyte flow rate (lit/min)	Applied voltage (volts)	Feed rate (mm/min)
1	200	80	10	10
2	200	90	15	12
3	200	100	20	14
4	250	80	15	14
5	250	90	20	10
6	250	100	10	12
7	300	80	20	12
8	300	90	10	14
9	300	100	15	10

The experimental results are then transformed into a signal-to-noise (S/N) ratio [6-7]. The S/N proportion can be utilized to measure the deviation of the performance characteristics from the desired values. The classifications of performance characteristics in the investigation of the S/N proportion depend upon the output parameters to be controlled. In the current work the chose two classes which are as per the following [8].

- The smaller the better for surface roughness
- The higher-the better for hardness

V. RESULT AND DISCUSSION

Response parameters are measured after performing the experiments and the values. Obtained values are then further used for optimization of process in order to achieved the optimized values of process parameters. Three response parameters which are measured during the experimentations were surface roughness, micro hardness and microstructure. The experimental values obtained for surface roughness and micro hardness values are given in Table 6.

6. EXPERIMENTAL RESULT SHOWING SURFACE ROUGHNESS AND MICRO HARDNESS

Exp.No	EC	EFR	AP	FR	Ra	MH
1	200	80	10	10	6.01	610
2	200	90	15	12	7.35	630
3	200	100	20	14	3.97	600
4	250	80	15	14	3.87	590
5	250	90	20	10	3.13	540
6	250	100	10	12	3.70	570
7	300	80	20	12	7.01	626
8	300	90	10	14	4.12	605
9	300	100	15	10	6.11	620

AISI 304 steel the S/N Ratio of surface roughness and micro hardness in Electro chemical machining had been described in Table 7

TABLE 7. CALCULATION OF SIGNAL TO NOISE RATIO FOR VARIOUS RESPONSE FACTORS

Exp. No	S/N Ratio for Surface Roughness	S/N Ratio for Hardness
1	**-15.5775**	**55.7066**
2	-17.3257	55.7066
3	-11.9758	55.8478
4	-11.7542	55.9868
5	-9.91089	55.9315
6	-11.3640	55.5630
7	-16.9144	55.6351
8	-12.2979	55.7066
9	-15.7208	55.4170

The greater S/N ratio are desirable for better surface roughness. Parameter having larger S/N ratio is ranked first.

A. Taguchi ‘s Analysis of surface roughness

Taguchi analysis is used to design the experiments and then to research the findings obtained on MINITAB 17. It is easier to approach S/N ratio for the evaluation purpose and it has been observed that the smaller approach is better. The S/N ratio describes tha impact of uncontrollable variables on the response factors.

Table 8 indicates the response table of S/N ratio for surface roughness.

TABLE 8 . RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS FOR SURFACE ROUGHNESS

Level	EC	EFR	AP	FR
1	-14.96	-14.75	-13.0	-13.74
2	-11.01	-13.18	-14.93	-15.20
3	-14.98	-13.02	-12.93	-12.01
Delta	3.97	1.73	2.00	3.19
Rank	1	4	3	2

B. Analysis for surface roughness

The general linear model of ANOVA was used to conduct an ANOVA test which requires a response and the factors affecting the response. In Table 9 the results of the analysis of variance (ANOVA) for surface roughness R_a for S/N data which specify signal of different parameters on the surface roughness are summarized as below.

TABLE 9. ANOVA FOR SURFACE ROUGHNESS

Source	DOF	Sum of square	Mean square	% contribution
Electrolyte concentration	2	9.637	4.8187	47.93%
Electrolyte flow rate	2	1.732	0.8660	8.61%
Applied voltage	2	2.522	1.2609	12.54%
Feed Rate	2	6.214	3.1072	30.91%
Total	8	20.106		

Therefore, Electrolyte concentration have the maximum effect on surface roughness. These chart indicates that electrolyte concentration has the greatest impact on surface roughness, accompanied by machining, then electrolyte flow rate, applied voltage and feed rate , but electrolyte flow rate has the lowest impact on surface roughness . Figure 4 shows S/N ratios of the surface roughness.

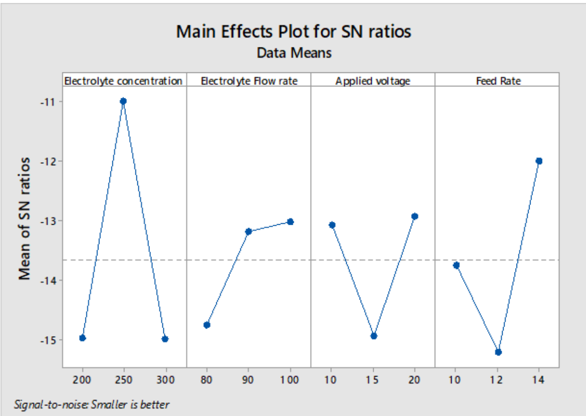


Fig. 4. S/N ratio plots of the surface roughness

C. Taguchi Analysis for micro hardness

Taguchi analysis is used to design the experiments and then to research the findings obtained on MINITAB 17. It is easier to approach S/N ratio for the evaluation purpose and it has been observed that the larger approach is better. The S/N ratio describes the impact of uncontrollable variables on the response factors. Table 10 indicates the response table of S/N ratio for micro hardness.

TABLE 10 . RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS FOR MICRO HARDNESS

Source	DOF	Sum of square	Mean square	% contribution
Electrolyte concentration	2	453.6	226.78	35.78%
Electrolyte flow rate	2	280.2	140.11	22.11%
Applied voltage	2	166.9	83.44	13.17
Feed Rate	2	366.9	183.44	34.24%
Total	8	1267.6		

D. Analysis for micro hardness

The general linear model of ANOVA was used to conduct an ANOVA test which requires a response and the factors affecting the response. In Table 9 the results of the analysis of variance (ANOVA) for micro hardness for S/N data which specify signal of different parameters on the micro hardness are summarized as below.

TABLE 11. ANOVA FOR MICRO HARDNESS

Level	EC	EFR	AP	FR
1	55.75	55.78	55.66	55.69
2	55.83	55.78	55.70	55.63
3	55.59	55.61	55.80	55.85
Delta	0.24	0.17	0.15	0.21
Rank	1	3	4	2

Therefore, Electrolyte concentration have the maximum effect on micro hardness. These chart indicates that electrolyte concentration has the greatest impact on micro hardness, accompanied by machining, then electrolyte flow rate, applied voltage and feed rate, but electrolyte flow rate has the lowest impact on micro hardness. Fig.5 shows S/N ratios of the micro hardness.

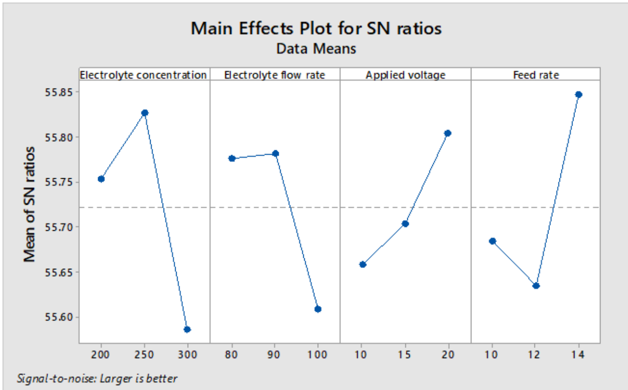


Fig. 5. S/N ratio plots of the micro hardness.

VI. CONFIRMATION TEST

The surface roughness value of AISI 304 steel in ECM had been analyzed. The confirmation test were performed with the optimum values of ECM parameters. The measured value of surface roughness is shown in Table 12.

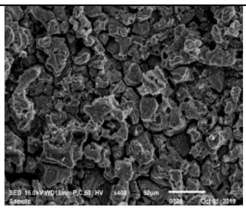
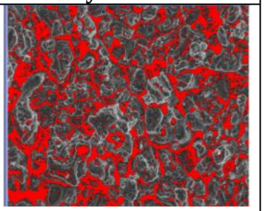
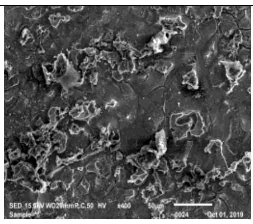
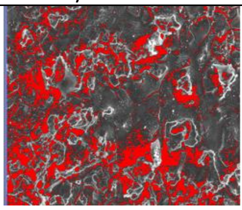
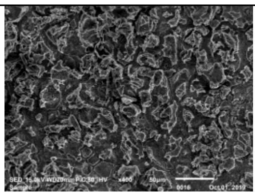
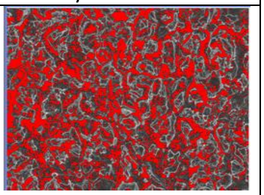
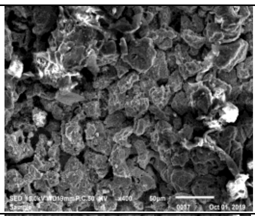
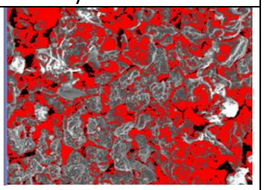
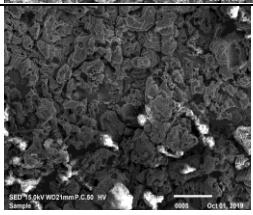
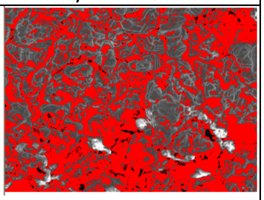
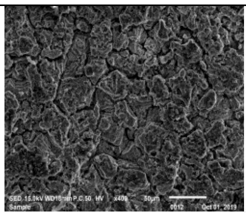
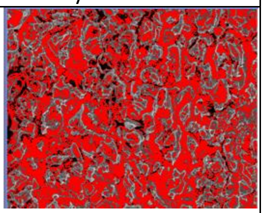
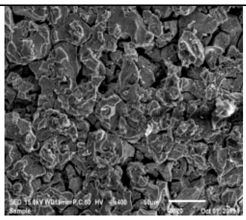
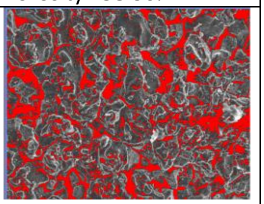
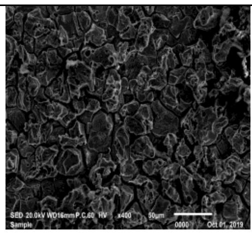
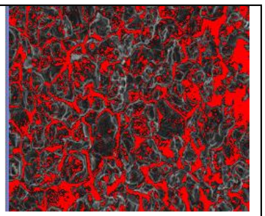
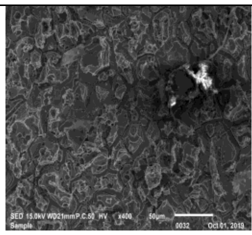
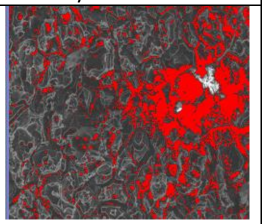
TABLE 12. RESULT OF CONFIRMATION TEST FOR SURFACE ROUGHNESS IN ECM

Response	Experimental Value	Predicted Value	% Error
Surface Roughness	3.07	3.035	1.14

VII. SEM OBSERVATION

To investigate the effect of electrolyte concentration, electrolyte flow rate, applied voltage and feed rate on machined surface topography, SEM images and porosity images of nine samples are presented in Table 13

TABLE 13. SEM IMAGES, POROSITY IMAGES & POROSITY % OF ECM SAMPLE

Sample No	SEM Images	Porosity Images & Porosity %
1		 Porosity =25.45%
2		 Porosity =21.06%
3		 Porosity =31.17%
4		 Porosity =40.15%
5		 Porosity =62.13%
6		 Porosity =58.36%
7		 Porosity =21.21%
8		 Porosity =27.10%
9		 Porosity =21.28%

The microstructure of AISI 304 steel shows that the maximum porosity of 62% is obtained for the sample having least surface roughness. Also it is observed.

The porosity % data clearly shows that the porosity % of the machined surface is inversely proportional to surface roughness.

VIII. CONCLUSION

The machining of AISI 304 steel was successfully done with copper tool by the optimizing of process parameters viz. Electrolyte concentration, electrolyte flow rate, applied voltage and feed rate. The following conclusions are drawn on the basis of experimental work and analysis of the result.

1. It had been observed that in ECM, electrolyte concentration is the most significant factor for surface roughness followed by feed rate, applied voltage and electrolyte flow rate in order.
2. It had been observed that in ECM, electrolyte concentration is the most significant factor for micro hardness followed by feed rate, electrolyte flow rate and applied voltage in order.
3. The microstructure of AISI 304 steel shows that the maximum porosity of 62% is obtained for the ECM sample having least surface roughness. Also it is observed.

The optimum input parameters for low surface roughness in ECM in AISI 304 steel obtained were 3.13µm, electrolyte concentration 200g/lit, feed rate 12mm/min, applied voltage 15 volts and electrolyte flow rate 80 lit/min. The experimental value of surface roughness obtained is 3.07 µm and the predicted value is 3.035 µm. The percentage error was 1.14% which is well with the permissible limit.

REFERENCES

1. Kumar, A., & Rao, P. S.," International Journal of Technical Innovation in Modern Engineering & Science", "Recent Developments in Electro Chemical Machining-A Review, Vol.5, No.4, April 2019.
2. Uttarwar, S. S., & Chopade, I. K.," Effect of voltage variation on MRR for stainless steel EN series 58A (AISI 302b) in electrochemical machining: a practical approach", In Proceedings of the World Congress on Engineering 2009, London, U.K. Vol 2, July 2009.

3. Thanigaivelan, R., & Arunachalam, R.," Optimization of process parameters on machining rate and overcut in electrochemical micromachining using grey relational analysis","Journal of Scientific & Industrial Research ",Vol.72, No.1, pp.36-42, January 2013.
4. Hui, C., Wang, Y. K., Wang, Z. L., & Zhao, W. S.,"Effects of complexing agent on electrochemical micro machining of stainless steel"," American Journal of Nanotechnology "Vol.2, No.1,pp.100-105, 2011.
5. Thanigaivelan R., & Arunachalam, R. M.," Experimental study on the influence of tool electrode tip shape on electrochemical micromachining of 304 stainless steel"," Materials and manufacturing processes",Vol. 25, No. 10, pp. 1181-1185, 2010.
6. Chakradhar, D., & Gopal, A. V." Multi-objective optimization of electrochemical machining of EN31 steel by grey relational analysis"," International Journal of Modeling and optimization"Vol.1 No.2, pp.113,June 2011.
7. Gnanasekaran, K., Siva, M., & Scholar, P.G ,"Investigation of Machining Characteristics of Micro ECM on SS304" :" International Journal of Engineering Science" pp .11675, May 2017.
8. Gangasagar, S. C. & Jayswal, M. T.," Effect of Different Electrodes and Process Variables On Material Removal Rate and Surface Roughness in Electrochemical Machining"," International Journal of Advances in Engineering Sciences Vol.1, No. 3, July, 2011

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DOI:10.35940/ijrte.F9789.059120
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