An Experimental Evaluation of Etching Depth for Different steels by using Photochemical Machining

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***Abstract*— Photochemical machining (PCM) used to machine metal parts employing a photoresist and etchants. It is critical non-conventional machining process.Non-conventional machining forms are broadly used within the fabricate of geometrically challenging machining components from designing fabric which are not imagable machining process.The focus of this work is parametric optimization for steel photochemical machining (PCM). Etching temperature and etching time were used as control parameters..PCM was performed with ferreous chloride as the etchant.Surface roughness and edge nonconformity were reduced, however etching depth was desired at a greater extent.The objective of the investigation is to see how control factors affect reaction parameters., viz surface roughness, etching depth, and parameter optimization with different weight rates for each performance measured.Tofulfilling this OEC is utilized by allotting diverse weight rate to reaction parameters.**

***Index Terms*— Photo Chemical Machining, Photo tool, etching, Changing etching parameters, overall evaluation criteria (OEC).**

I. Introduction

The photo chemical machining process is also named as, photo chemical etching,chemical milling, chemical etching, photo etching and even the abbreviation "PCM." The PCM industry currently plays aenergetic role in the construction of a variety of precision parts viz. micro fluidic channels, silicon combined circuits, copper printed circuit boards and attractive items having thickness less than 2mm.PCM is one of the most widely used non-traditional machining techniques, combining photographic and chemical etching techniques.The procedure begins with the part's shape being created on optically clear and excellent dimensional photographic film..The procedure begins with the creation of a needed design in AutoCAD software called a photo tool, which is then printed on a transparent sheet of plastic for etching.An experimental investigation was carried out to recognize ideal values of parameters using ferric chloride ($FeCl_3$) as an etchant. In his work talked about on assessing the ideal machining parameters required for photochemical machining of an Inconel 718 and impacts of these parameters on surface topology. The parameters considered in this examination are concentration of etchant, etching time, and etchant temperature. The experimental examination appears that etching executio n aswellassurface topology progressed.

PCM depth can be achieved by exposing fewer and fewer tests at a time.The less and more intensified light will be passing in photo tool. The photo tool is prepared by making diverse on a straightforward piecepaper.The light that comes out of various sources is determined by the photo tool's characteristics.The vitality of substance is changing with colour,This results in the photoresist fabric being less and less solidified.The enhancement of photoresist fabric is crucial for the etching handle.Less creating comes about in less carving and more creating comes about in more carving[1-3]. The idea about positive and negative type photoresist composition and its reactions with UV light is explained. Also given the comparison between positive photoresist and negative photoresist.The effect of liquid type photoresist for photochemical machining,in this article different photoresist types was described and focused on liquid photo imageable etch resists to produce functional or decorative metal parts. For parametric optimization of PCM for brass and german silver, a two-dimensional simulation model of etching was established, and the experimental study of process parameters on micro-geometry was studied.[4-6]

PCM has broadly utilized within the fabricating of lean, level and pieces made of metal that are complicated (i.e. lead outlines, colour TV veils, instruments, warm plates, reproduced circuit sheets) in gadgets, exactness engineering and enriching businesses within the past forty a long time. Presently adaysPCMindustryplays vital part in generati on of assortments of exactness parts, enriching components and to create Copper printed circuit sheets, microfluidic channels, and microfilters etc. The use of a grey-based Taguchi technique for optimising PCM process parameters in etching while taking numerous output parameters into account is described. The grey relational analysis is used to solve the PCM process in this innovative technique.The performance characteristic is a grey relation grade produced from the grey relational analysis. Depth of etching in PCM can be varied by changing temperature and time of etching.OEC analysis can be used for achieving optimum condition for etching depth and surface roughness.[7-10]. Different researchers [11-25] have reported the micro features, micro channel heat sink, textured bearing, etc. fabrication using photochemical machining on various materials and also by employing laser engraving method. The parametric analysis was also reported.

The photoresist used PCM has two types given below.

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- Positivephotoresist
- Negativephotoresist

In negative photoresist, the grey piece of the photo-tool is eliminated, and the remaining portion of the photo-tool becomes hard,and in positive photoresist contrarily like negative photoresist the portion which is dull is stay difficult and other portion will ended up milder which non solidify portion is evacuated.

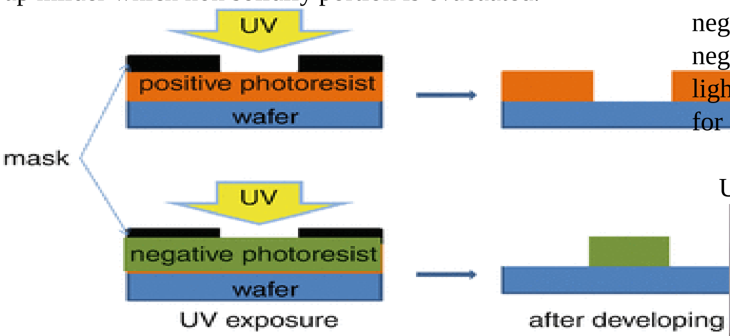

Fig.1 Types of photoresist

II. METHODOLOGY

A. Material selection

Steel is the material that was considered in this study, since it is harder than copper and aluminium, thus it is necessary to research steel machining characteristics. The specimen size used was 25mm x 25mm x 5mm (WLT). Steel flat surfaces were subjected to PCM. For experiments, Fecl3 is implemented as an etchant and a negative photoresist.

B. Experimental procedure

1) CreatingPhoto tool

The photochemical machining technique is approved once a photo is taken.Thephoto tool consists of an AutoCAD drawing with full-size versions of the desired shape printed transparent paper.

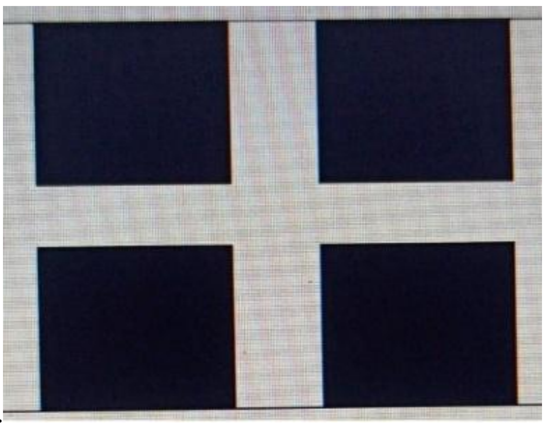

Fig.2 Photo toolinAutoCAD

Preparation of workpiece.

Afterwards planning the photo tool the steel fabric is cut into essential measure. The cleaning of thesteel plates are main task,i.e first by sand paper later bythinner(trichloroethylene or acetone). This process is carried out to ensure that the workpiece's surface is free of foreign particles, dirt, oils, and other pollutants. So to have a great hold of photoresist with the metal surface.

Coating of workpiece.

A light coating of photoresist is deposited to the metal surface after the object has been cleaned.For testing purposes, a negative type photo resister was used.The property of negative photoresist is that it solidifies when exposed to UV light.The properties of negative photoresist is different for different colors.

UV Exposure.

Fig.3 Photoresist and Developing Solution

UV Exposure.

In PCM, its essential to exposes all bearings' fabric (base metal), all bearings can have etching applied on them. The 1 KW control UV light bulb is utilized for uncovering the test. It transmits the escalated 1800 microwatt per centimeter squareat25cm remove.In conventional machiningi.e.in2D PCM prepare the tests are uncovered in as it were one heading. The coated workpiece receives the photo equipment that has been created and uncovered to for 90 seconds, used a UV source.

Fig.4 Exposure machine

DEVELOPMENT PHASE.

A solution of sodium carbonate and water is often used to produce the arrangement. After this steel plate isdiped in the developer for 90 seconds, as a result imprerssion occurred on plate. Afterwards steel plate is washed with water.Etching process relates on photoresist enhancement.

Etching

Afterwards the steel plate is kept in etching solution. The etching solution is the mixture of $FeCl_3$ and water. Due to late etching process etching of steel plate is take place. In black colour photo tool ordinary etching happen and there is no etching is there on white colour.The photoresist thickness is changing with color.

III. Experimental Analysis

Several experiments are conducted to investigate the etching behaviour of Steel fabric using i parameters such as etching time, temperature, surface roughness, as well as reaction parameters such as etching depth and surface roughness.Throughout the studies, thephotoresistbreadth, exposure time, and developing time are all kept constant.Table 1 shows the experimentation plan matrix as well as the steel response parameters that were recorded. With the help of Mitutoyo surface roughness analyzer Ra was measured and depth bythe digital micrometer.For fulfilling this OEC was used.The surface roughness of each piece of steel was measured in three places, and the average value was used to complete the study.

Table 1. Experimental design matrix for EN 1A Steel (C=0.07%) with response measures and OEC values

Expt. No.	Temp. (°C)	Time (min)	Etching Depth(mm)	Ra (µm)	OEC 1	OEC 2	OEC 3	OEC 4	OEC 5
1	40	30	0.031	0.062	15	35	50	65	85
2	40	60	0.045	2.265	20.33	19.58	19.02	18.46	88.13
3	40	90	0.073	2.721	53.28	40.74	31.34	21.94	9.4
4	40	120	0.098	0.801	95.83	90.27	86.1	81.93	76.37
5	50	30	0.035	2.041	9.44	22.02	31.47	40.92	53.51
6	50	60	0.053	5.185	21.85	16.71	12.85	9.01	3.85
7	50	90	0.085	0.191	75.71	81.42	85.71	90.08	95.71
8	50	120	0.105	4.177	88.02	72.06	60.09	48.11	32.15
9	60	30	0.042	7.157	5.25	12.26	17.52	22.77	29.78
10	60	60	0.051	9.463	8.79	6.72	5.17	3.62	1.55
11	60	90	0.093	3.341	63.78	70.66	75.83	80.99	87.87
12	60	120	0.129	2.277	**96.87**	**92.30**	**88.13**	**91.87**	**97.61**

Table 2. EN 8 Steel (C=0.35 %) experimental design matrix with response measurements and OEC values

Expt. No.	Temp . (°C)	Time (min)	Etching Depth(mm)	Ra (μm)	OEC 1	OEC 2	OEC 3	OEC 4	OEC 5
1	40	30	0.017	1.880	10.12	30.22	25.14	40.25	34.56
2	40	60	0.038	1.528	27.82	30.34	32.24	34.13	36.65
3	40	90	0.068	0.967	68.51	75.92	81.48	87.03	94.44
4	40	120	0.098	1.418	92.59	82.71	75.30	67.89	58.01
5	50	30	0.004	2.943	14.66	32.15	30.22	18.96	45.60
6	50	60	0.007	1.397	15.51	29.84	40.59	51.34	65.67
7	50	90	0.018	0.920	33.88	49.44	61.11	72.77	88.33
8	50	120	0.067	0.939	**99.85**	**99.67**	**99.53**	**99.38**	**99.20**
9	60	30	0.040	1.176	14.45	33.72	48.17	62.62	81.89
10	60	60	0.045	0.998	23.32	41.09	54.42	67.75	85.52
11	60	90	0.060	8.002	34.55	26.69	20.47	14.22	6.89
12	60	120	0.090	0.917	99.80	98.05	98.55	97.88	98.10

IV. Result andDiscussion

For Study of PCM surface roughness and etching depth of Steel was considerd. The test data examined in respect of effect of temperature and time on Ra and etching depth. From Tables 1 and 2, the bold value reflects the optimum output of all OECs, signifying the optimum performance measure condition. Figures 5, 6, and 7 illustrate the normal effect of temperature and etching time on etching depth for steel, while figures 8, 9, and 10 demonstrate the effect on surface roughness.The lowest etching depth value was found at 40°C temperature and 30 minutes, while the highest value was found at 60°C temperature and 120 minutes.According to OEC research, the ideal conditions for EN 1A steel are 60°C temperature and 120 minutes, while the ideal conditions for EN 8 steel are 50°C temperature and 120 minutes.

A. Effect of Temperature and Etching Time on Etching Depth

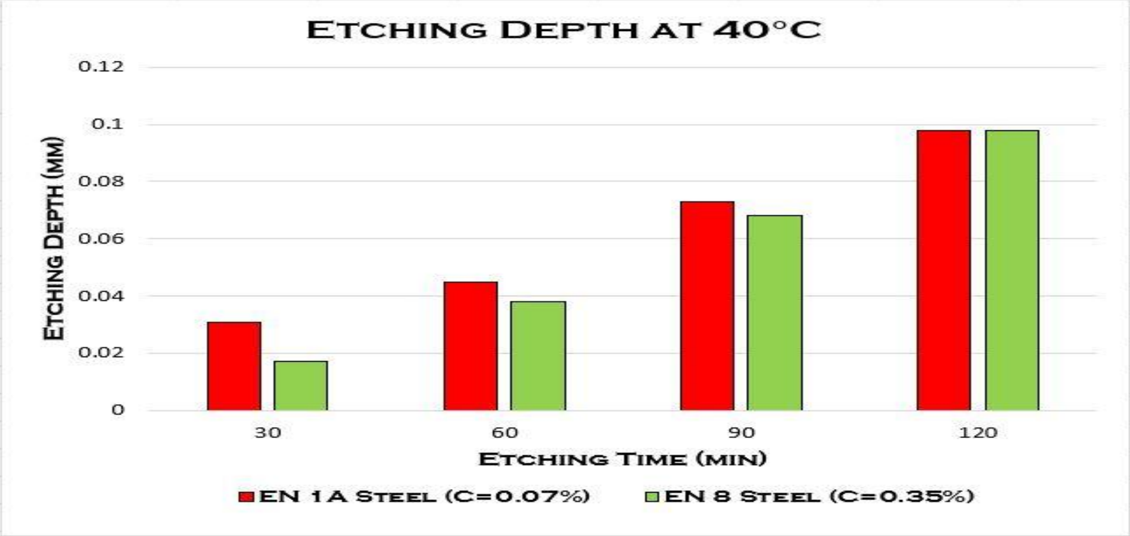

Fig.5 Etching depth at 40 °C

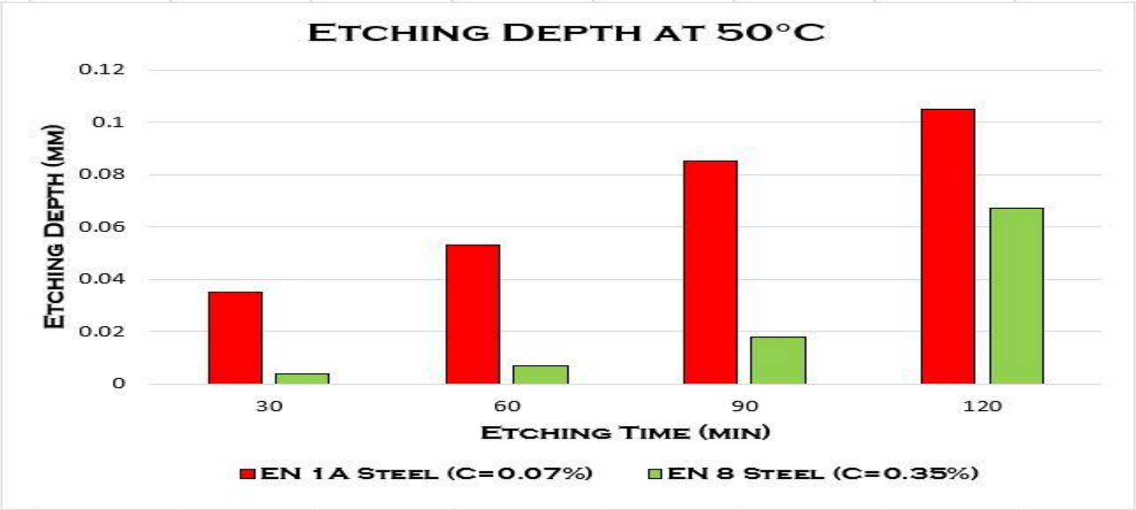

Fig.6 Etching depth at 50 °C

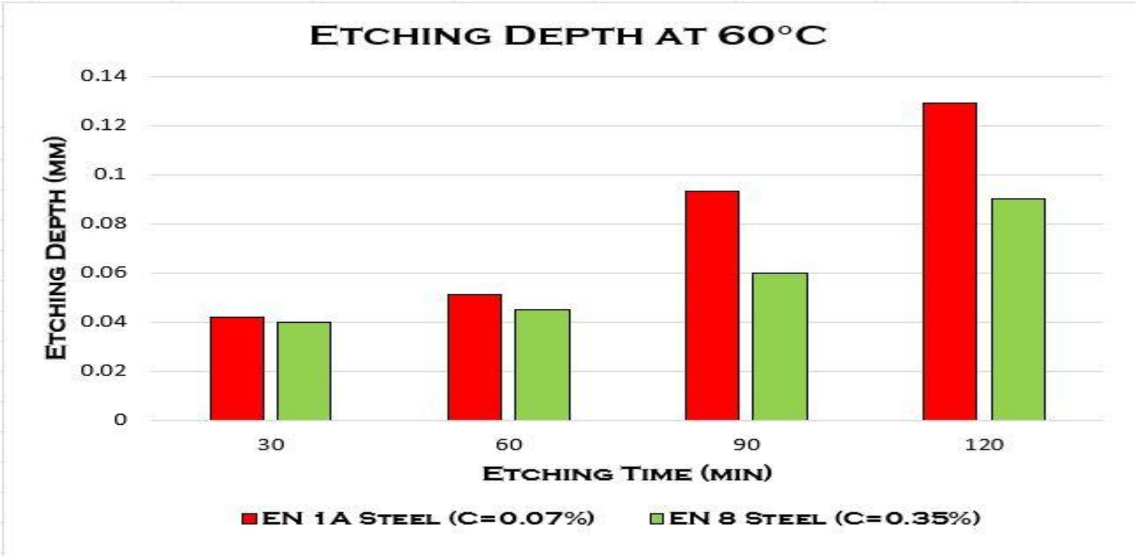

Fig.7 Etching depth at 60 °C

B. Effect of Temperature and Etching Time on Surface Roughness

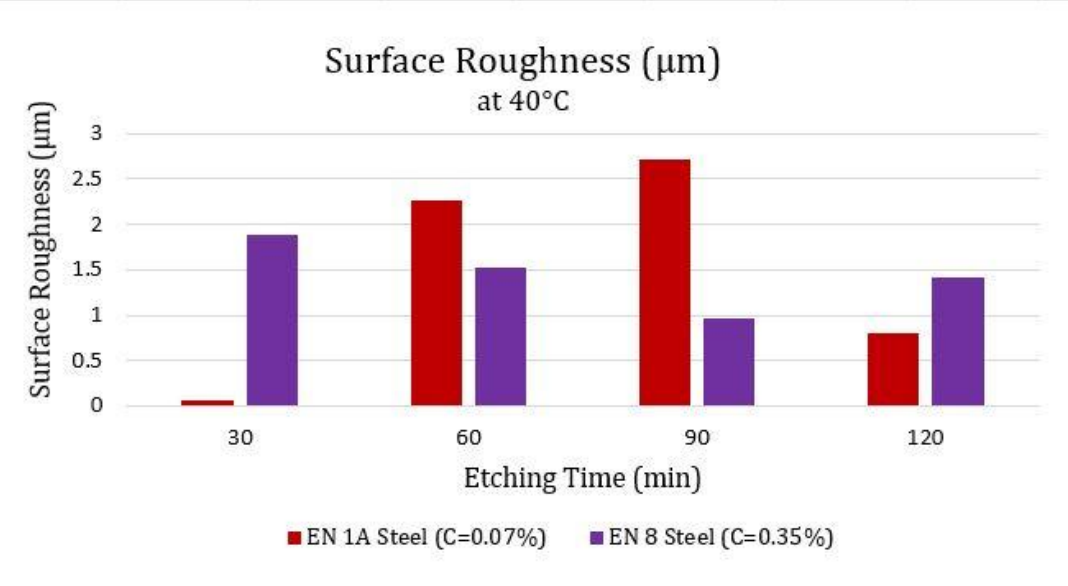

Fig 8. Effect of temp and time on Surface Roughness at 40 °C

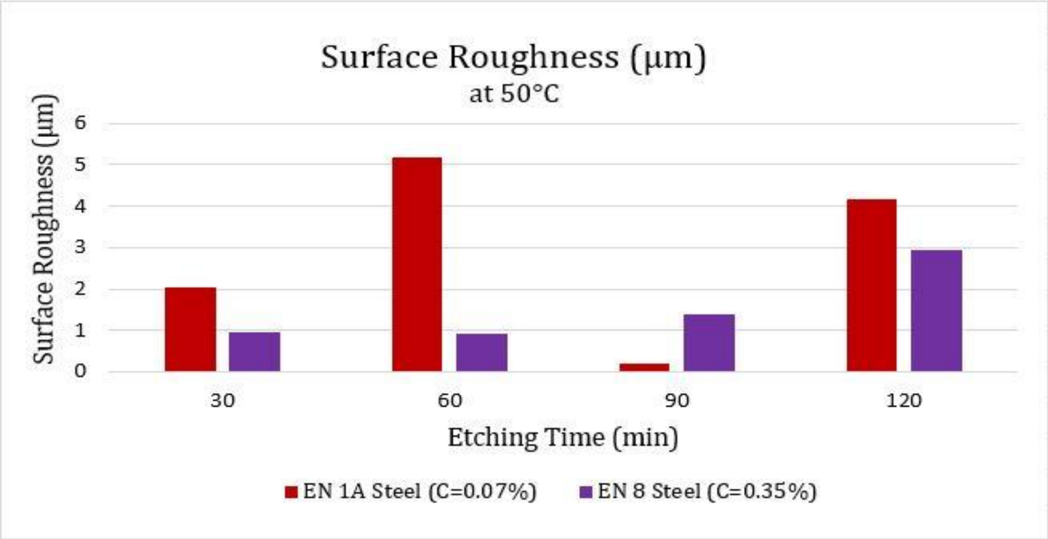

Fig 9. Effect of temp and time on Surface Roughness at 50 °C

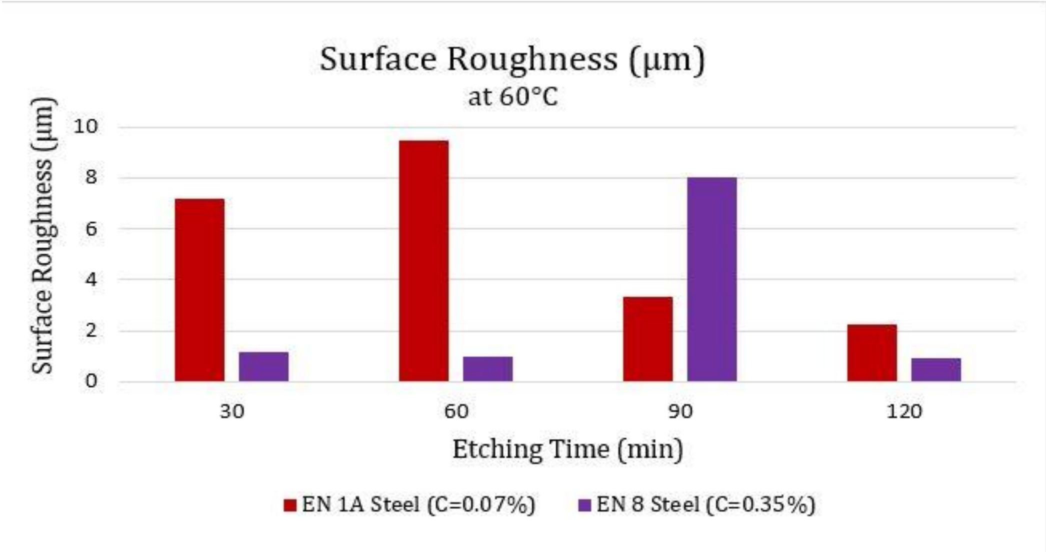

Fig 10. Effect of temp and time on Surface Roughness at 60 °C

V. Conclusion

The current research looks into the depth of etching at different temperatures and times.The etching time and cutting depth were investigated..According to the findings of this study, the following decisions were made. Process parameters were kept constant in this study, and the impact of reaction parameters was investigated by varying etching time and temperature. Etching depth is directly proportional to the energy of light emitted by the photo tool and photoresist thickness. According to OEC values it was observedthat for material EN 1A (C=0.07%) etching temp 60^0C and etching time 120 min is optimal condition and for EN 8 (C=0.35%) Material 50^0Cand 120 Min is Optimal condition.

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