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CHEMICAL MACHINING PROCESS - A REVIEW

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A B S T R A C T

Chemical Machining (CHM) is a non-conventional machining process, which is used to machine hard brittle materials. The objective of this paper is a literature survey related to the chemical machining process. In this machining process, the chemical energy of the etchant is used to remove the excess materials from the workpiece; materials will be removed through the chemical dissolution process. In the literature, it is identified that so many factors influence the process of chemical machinings such as concentrate of etchant, the temperature of the etchant, masking methods, types of the masking and etchants. It is also identified that these process parameters influence the material removal rate (MRR) and surface finish.

1. INTRODUCTION

To produce geometrically complex and precision components nowadays non-traditional machining is more economical (Benedict, 1987; McGeough, 1988), chemical machining is one among them. The chemical machining process is the removal of material from the workpiece using chemical reactions CHM is employed for metal removal purposes by the dissolution of acidic or alkaline solution and this solution is called etchant (Puthumana & Anusree, 2014; Pawar et al., 2021). CHM is used in industrial applications such as micro-electric systems and semiconductor industries (Liang & Shih, 2016).

2. LITERATURE REVIEW

El-Awadi et al. (2016) has studied the effect of etchants ferric chloride ($Fecl_3$) and nitric acid (Hno_3) at the starting concentration and temperature on the rate of metal removal of stainless steel, Cu and Al sheets. According to the results, it shows that the at most (highest) values of rate of metal removal were accomplished at 33% concentration of ferric chloride ($Fecl_3$) with all metals containing $50+2^0C$ or $50-2^0C$ for all metals, which were 0.738, 0.287, and 0.224mm^3/min for aluminium (Al), copper (Cu), and stainless steel respectively.

Al-Ethari et al. (2013) and Rajurkar (1994), throughout his studies he came up with the set of machine temperature effects, machining time and removal rate of metal in which a metal shaped at a fairly low temperature where strength and hardness of steel can be increased(cold working) chemical machine samples under surface finish are stainless steel using a mixture of acids as an etchant to figure out samples of alloy's effect (44.5*44.5*3mm) dimensions and metal being rolled into sheets while cold, results in smooth and hard finishing. This kind of alloy samples with the same dimensions

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with four different machining temperatures were chemically machined and conditions of machining of five machining times and concluded that the chemical part's surface roughness increases with machining temperature and machining time as well as the rate of removal of material were also increased with increase in machining temperatures.

2.1 Process Parameters of Chemical Machining Process

The process parameters of the CHM system should be controlled optimally, to achieve effective high precision, so many factors influence the process of chemical machining's such as concentrate of etchant, the temperature of the etchant, masking methods, types of the masking and etchants (Çakir et al.,2007; Langworthy, 1994; Pawar et al., 2021). This influences the machining criteria that is Material removal rate, Surface finish and Accuracy these factors are evaluated to control the CHM process optimally CHM performance is controlled and achieved by the parameters that are mentioned below.

2.2 Etchant in chemical machining

Etchants are acid or alkaline solutions that continue within a control range of chemical composition and temperature. For a suitable etchant, the workpiece material should be removed sprayed or immersed. Etchants influence the factors of the chemical machining of all materials. Due to the workpiece material, there are various etchants available and the possible etchants should have properties as follows, high etch rate, better surface finish, least undercut, economic regeneration, etched material regaining, simple control of the process, personal safety maintenance.

Table 1. Properties of concentration etchant, etching temperatures for other materials in chemical machining (Dini et al.,1984; Hofy 2005)

Material	Chemical etchant	Concentration etchant	Etching Temperature (^{0}C)	Etch rate (mm/min)
Copper (Cu) and alloys	$Fecl_3$ $CuCl_2$ Alkaline etchants	42^0 Be 35^0 Be --	49 54 50	2 1 --
Aluminium (Al) and alloys	$Fecl_3$	$12\text{-}18^0$ Be	49	.013-.025
Steel	$Fecl_3$	42^0 Be	54	0.025
Titanium (Ti)	HF	--	--	1
Glass	HF $HF+HNO_3$	-- --	--	--
Nickel (Ni)	$Fecl_3$	42^0 Be	49	0.13-0.38
Silicon	HNO_3+ $HF+H_2O$	--	38-49	Very slow

Different etchants are corrosive chemicals used in etching that are commercially accessible or the needed etchant can be prepared. One of the most widely used etchants in chemical machining is ferric chloride ($Fecl_3$). Iron (Fe) based alloys, as well as Copper (Cu) and its alloys aluminium (Al) etc., mainly goes under etching cupric chloride ($cucl_3$) are generally registered for copper (Cu) based alloys in most of the electronic industries because due to fast etchant different kinds of regeneration systems are available. The manufacturing of electronic components is established by alkaline etchants such as printed circuit boards (Tehrani & Imanian, 2004).

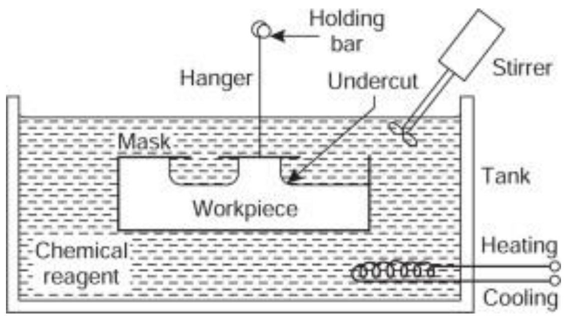

Figure 1. Typical chemical machining setup (Hofy 2005; Çakir et al.,2007)

2.3 Masking process in chemical machining

Masking materials are known as maskant by this chemical etchant acting on the surface of the workpiece can be protected in other words, the chemical action of etchant a portion of workpiece need not be removed from the material this is known as maskants. In maskants material generally used materials are based on polymer or rubber different maskant application methods can be used such as dip, brush, spray, roller and electro-coating as well as adhesive tapes.

Dimension has to be precise for higher machine parts, when the mask is sprayed on the workpiece using silkscreen would always give a good result. When a thin mask is sprayed on the workpiece causes major problems such as not tolerating when handled roughly or when exposed to the etchant for a long time. The uses of photoresist masks which are generally taken into account in the photochemical machining operation, with high accuracy, multipart etching can be repeated easily, and his of moderation. various workpiece material where maskant material is possibly used are given in following Table 2.

Table2. Masking materials (Dini et al.,1984; Hofy 2005)

Workpiece materials	Masking materials
Magnesium(Mg)	Polymer
Titanium(Ti)	Polymer
Silicon(Si)	Polymer
Aluminium(Al) and alloys	Polymer, Butyl rubber, neoprene
Iron(Fe) based alloys	Polymer, Polyvinylchloride, Polyetilien butyl rubber
Copper(Cu) and alloys	Polymer
Nickel(Ni)	Neoprene

2.4 Masking Methods in chemical machining

Maskant materials comprise neoprene, polyvinylchloride, polyethene and other polymers. Masking can be attained by the following three methods (El-Hofy et al., 2005; Nanjundeswaraswamy, 2021).

1. Cut and Peel: chemically resistant material is applied to the workpiece by dipping, spraying, scribing knife is used to remove hardened maskant. These are used in the applications of large work parts production where accuracy is not a critical factor. Maximum tolerance can be achieved.

2. Photographic Resist: This method is used to perform masking. This masking material consists of photosensitive chemicals. Maskantis were removed through photographic developing techniques. this process is usually applied in which small parts were produced with high quantities and nearest tolerance are required

3. Screen Resist: In this method, the maskant are inserted by the means of the silk screening method. This screen resists method applications are used between the other two masking methods in terms of accuracy, part size and production quantities.

2.5 Material Removal Rate

MRR plays an important role in evaluating the efficiency of a non-traditional machining process. MRR depends on the design pattern which we are about to produce. Acid and corrosive chemical used in electing removes the metal quickly and tend to have many side effects which result in a reduction in surface finish, and increased undercutting. while greater the etchant temperature, there is a bond between the maskant and the workpiece which will be attacked. This might have higher stress due to higher heating, which can have an impact on the strength of the material. If the MRR is not controlled this may lead to causing problems that can affect the surface finish and accuracy. The material removal rate and etch rate, tolerance are shown in the Table 3.

Table 3. Material Removal Rate

Material	Etch Rate mm/min	Tolerance mm
Aluminium	0.025	+/-0.025
Magnesium alloys	0.033	+/-0.025
Stainless steel	0.13	+/-0.025
Titanium alloys	0.13	+/-0.09

2.6 Surface Finish

CHM can proudly give a surface finish value same where around 0.4µm by rotation of tool/work. Any tool face defect produces a replica on the workpiece. Tool surface should be waxed. The finish is better o harder materials. Cobalt alloys give a mirror-like finish while copper and aluminium give a matte finish. For optimal surface finish the electrode design, maximum feed rate and improving additives of surface finish are chosen (Kumar et al., 2018; Patel et al., 2012). Less voltage reduces the equilibrium gap of machining as a result we get quite a great(improved) surface finish and tolerance control. we can observe better surface finish and tolerance. Low electrolyte temperature gives a better surface finish.

While contouring most metals, waviness and defects of the initial surface are not greatly alloyed, out to a certain extent it can be smoothened. the process used to create objects of the fixed cross-sectional profile, forging and castings are lower at the end quality The surface finish might be close to 5µm. Al alloys show fine surface for 1.6µm. To avoid Hydrogen complement in steel, SS steel, Cu alloys and Ni alloys, should be taken care of. By heating, the workpiece 120^0c for 1 to 4hours will help in overcoming, when hydrogen embrittlement occurs. The CHM process produced by the surface are stress-free and show no thermal effects

3. CONCLUSION

the process of CHM has very low induction when tallied with other various kinds of processes as there could be no establishment of burr, the metal workpiece contact is not required and there are some disadvantages also that is, environmental impact by the usage of etchants this price of cost is very high and the chances of the operator getting harmed are quite high. However, the process is slow and cannot be used to produce large quantities. Hence all the process has to be considered. To select this process MRR is important and that depends on the rate of metal being removed. the selection and important is the effect of surface finish and accuracy A different automation is cooperated to achieve a finer rate of MRR. A change in acid or corrosive chemical in etching can increase or improve the properties of the metal.

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