

## Design and Development of Chemical Machining Setup

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**Abstract:** This research deals with the design and development of chemical machining setup. In non-conventional machines, the cutting action is performed by the tool is much costly and can machine materials with some limited criteria. This setup has been developed to get cutting in most of the alloys or metals which have high strength to weight ratio. This attachment we constructed is used to perform machining operation on stainless steel and aluminum work piece with required operating parameters like material removal rate for utilize accurate work. This setup is also used to increase efficiency and productivity of chemical machining by reducing machining time without sacrificing accuracy of the product.

**Keywords:** Chemical machining setup, design, development, non-conventional machining

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### I. Introduction

Chemical machining is a well-known nontraditional machining process is the controlled chemical dissolution of the machined workpiece material by contact with a strong acidic or alkaline chemical reagent. Special coatings called maskants protect areas from which the metal is not to be removed. The process is used to produce pockets and contours and to remove materials from parts having a high strength-to-weight ratio. Primary objective of machining operations is the efficient production of accurate parts. In non-conventional machines, the cutting action is performed by the tool is much costly and can machine materials with some limited criteria. This attachment is developed for to get cutting in most of the alloys or metals which have high strength to weight ratio. This attachment we made is used to perform machining operation on stainless steel and Aluminum workpiece with required operating parameters like material removal rate for utilize accurate work. This attachment is also increase efficiency and productivity of chemical machining by reducing machining time without sacrificing accuracy of the product.

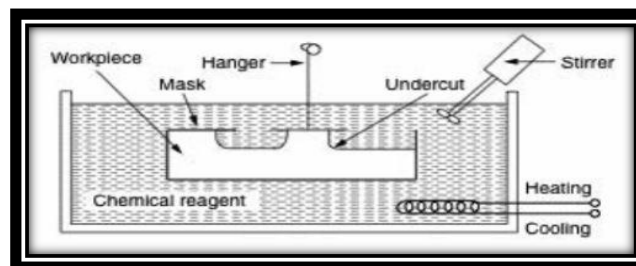


Figure 1: Basic Chemical Machining Setup [1]

### II. Literature Review

El-Awadi et al. (2016) has studied the effect of etchants ferric chloride and nitric acid on its initial concentration and temperature on metal removal rate of stainless steel, copper and aluminum sheets. The results indicated that the maximum values of metal removal rate were achieved at 33% concentration of ferric chloride with  $50 \pm 2^\circ\text{C}$  for all metals, which were  $0.738$ ,  $0.287$  and  $0.224 \text{ mm}^3/\text{min}$  for aluminum, copper and stainless steel respectively [2]. Puthumana et al. (2014) has concluded that surface finish was improved by adding triethanolamine in the etchant solution. Addition of 5-10% triethanolamine improves the surface roughness [3]. Al-Ethari et al. (2013) has analyzed the effect of machining temperature, machining time and cold working on the metal removal rate and the surface finish of chemically machined samples of stainless steel 420 using a mixture of acids as an etchant to find out its effect on the alloy samples of  $(44.5 \times 44.5 \times 3 \text{ mm})$  dimensions and cold rolled alloy samples with the same dimensions were chemically machined with four different machining temperatures and five machining times as machining conditions and concluded that the surface roughness of chemically parts increases with machining temperature and machining time as well as material removal rate was

also increased with increase in machining temperatures [4]. Çakır et al. (2008) had machined aluminum by an eminent chemical etchant, ferric chloride at different etching temperature. The effects of selected chemical etching parameters on depth of etch and surface finish quality were examined & concluded that ferric chloride was very useful chemical etching for aluminum etching [5]. Brinksmeier et al. (2004) has discussed the chemical effects of metalworking fluids on the processes of machining and grinding, including the chemical interactions occurs between the various participating surfaces as well as the effect of the subsequent chemical state of the surface formed is addressed and concluded that the generation of reaction layers on cutting tools can improve wear resistance resulting in overall improvement of the material removal process [6].

### III. Methodology

The main objective of this research was to design and develop the setup which is used to perform the chemical machining process. In addition, a small experiment was performed to ensure working of the setup. The experiments were done at the room temperature (An additional heater can also be attached for high temperature processes). The components were drafted using PTC CreoParametric 3.0. The methodology contains different steps of the process from beginning to the end of the experimentation has shown in the flow chart given below.

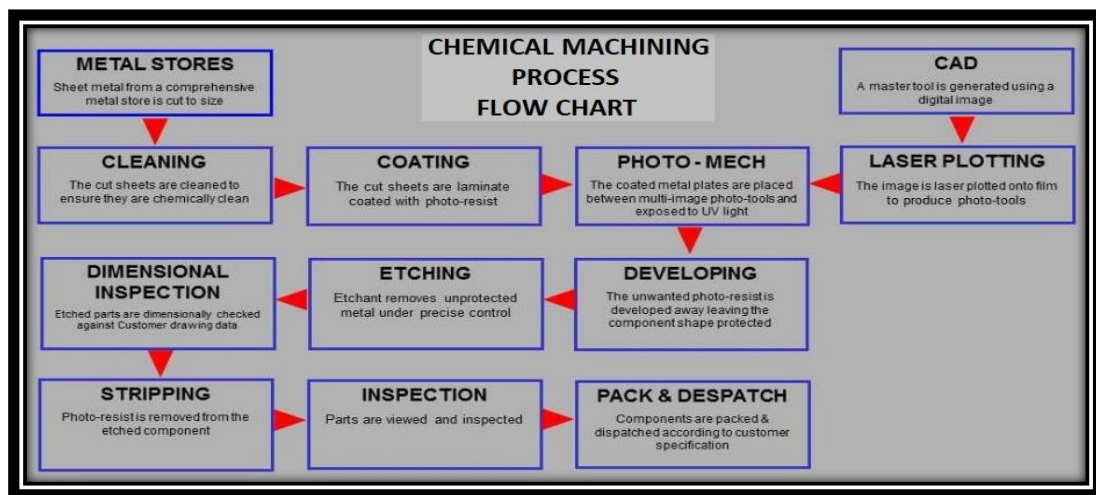


Figure 2: Chemical Etching Process Flow Chart [7]

### IV. Required Components

The components required for chemical machining setup has listed below with brief information.

#### 1) Container

The container used in set up was made of acrylic sheet. The acrylics are esters of acrylic acids, which are they are the products formed by the reaction of an acrylic acid and alcohol. The esters of acrylic acid polymerize readily to form exceptionally clear plastics. These are widely used in applications requiring clear durable surfaces, e.g. in the aircraft and automobile industries. In more common use are surface coatings involving acrylics [8]. Figure 3 shows the dimensions (in mm) of the container.

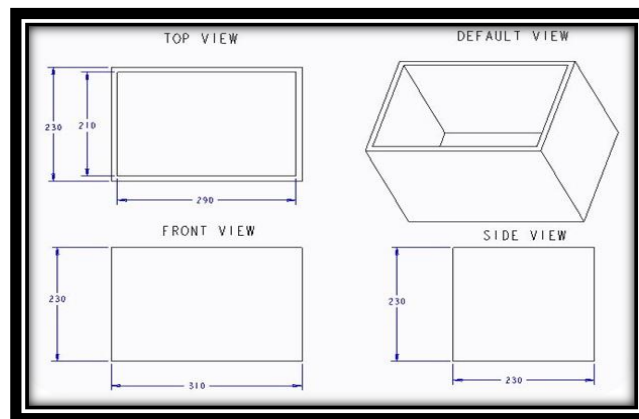
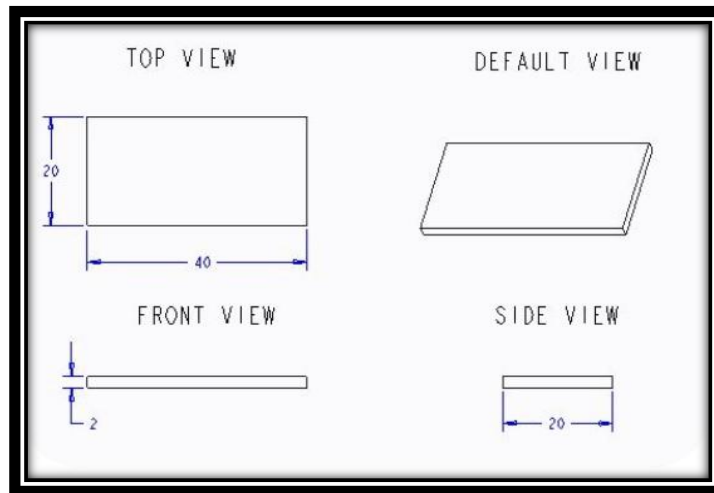


Figure 3: Container Detailed Drawing

**2) Work-piece**

We used aluminum work-piece for chemical machining process because of its low strength and can easy machinability by the chemicals and it can also perform at the temperatures above 300°C. Aluminum is a cheap as well as easily available material. Figure 4 shows the dimensions (in mm) of the work-piece.



**Figure 4:** Work-piece Detailed Drawing

**3) Maskant**

Masking is the process of applying the maskant material to the surface to ensure that only desired areas are etched. Liquid maskants may be applied via dip-masking, in which the part is dipped into an open tank of maskant and then the maskant dried. Maskant may also be applied by flow coating; liquid maskant is flowed over the surface of the part. Certain conductive maskants may also be applied by electrostatic deposition, where electrical charges are applied to particles of maskant as it is sprayed onto the surface of the material. The charge causes the particles of maskant to adhere to the surface [9].

**4) Etchant**

It's a Chemical used to etch design into metal, glass, or other material. We used water, Hydrochloric acid (HCl), Nitric acid (HNO<sub>3</sub>) and Hydrofluoric acid (HF) in chemical machining set up as etchants.

**5) Stirrer**

Stirrer is used to regulate the flow of the etchant. The stirrers are usually small to medium sized impellers. Figure 5 indicates different types of stirrers.



**Figure 5:** Stirrers

### V. Technical Specifications

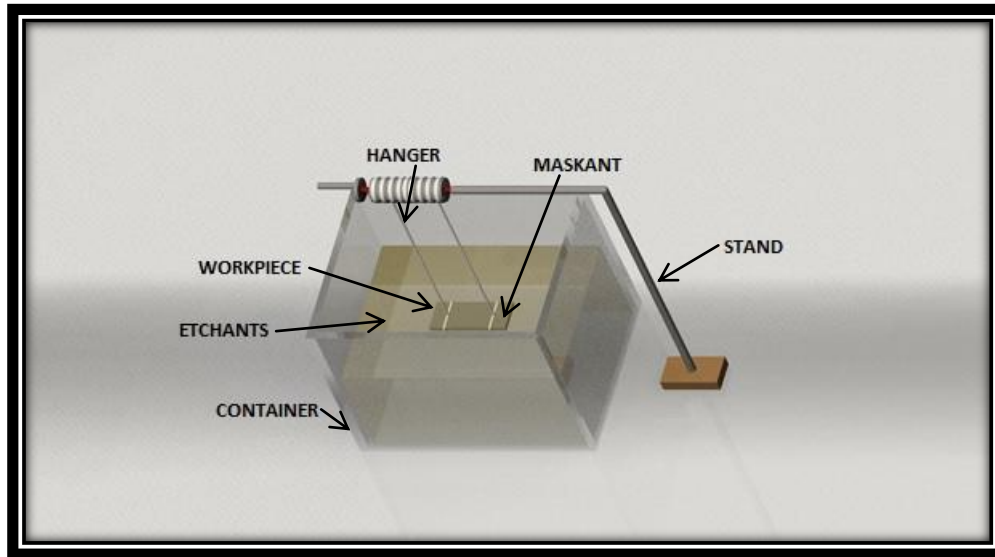
The technical specification of the components used in the experiment has given below in the Table 1.

**Table 1:** Technical Specifications

Sr. No.	Components	Materials	Dimensions (in mm)
1	Container	Acrylic	310×230×230
2	Work-piece	Aluminum	40×20×2
3	Maskant	Butyl Rubber	1.5
4	Etchant	Water, HCL, HF, HNO <sub>3</sub>	-

### VI. Rendered Assembly Of Setup

The rendered assembly of chemical machining setup is shown in Figure 6. The heater and stirrer weren't used in this current setup.



**Figure 6:** Rendered Assembly Setup

### VII. Cost Sheet

The cost expenditure of the components used in this setup is displayed in the Table 2 given below.

**Table 2:** Cost Sheet

Sr. No.	Description	Quantity	Cost (₹/-)
1	Aluminum sheet (For Workpiece)	1 kg	200
2	Formic acid	500 ml	400
3	Nitric acid	500 ml	310
4	Hydrochloric acid	500 ml	300
5	Measuring cylinder	50 ml	350
6	Triethyl amine	500 ml	420
7	Hydrofluoric acid	500 ml	520
8	Acrylic sheet	-	800
9	Hanger	1 Nos.	100
10	Stirrer	1 Nos.	30
-----	-----	<b>Total</b>	<b>3430</b>

### VIII. Conclusions

From this research it could be concluded that the chemical machining setup is one of the simplest non-conventional machining method for small quantity material removal process. The setup was built at the total cost of 3430 ₹/-, which concludes that it was a cost effective setup. This setup could be useful in engineering colleges for demonstration in order to understand the working and concept of chemical machining process.

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