Advanced Photo Etching Tips & Tricks

Every Design Engineer Should Know

Newcut by Fathom is a Chemical Milling House located in upstate New York's Finger Lakes Region between Rochester and Syracuse. Newcut was one of the very first firms in Chemical Milling established in 1970. We have specialized solely in the productive area of Photofabrication and have concentrated on developing cost-effective methods and techniques.

Burr-free parts are provided using low cost tooling with fast turn around from prototype to production. Secondary forming capabilities, heat treating and plating are available.

We make custom parts using metals ranging from aluminum through zirconium and thickness from .0005" to .125" in panels up to 40"X96".

We are also able to etch Aerospace materials including René 41, Inconels series 600 and 700, titanium, etc. Quality Control conforms to AS9100. Engineering idea exchanges are encouraged on developmental work.

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Designing For Photo Chemical Etching //

With every metalworking process, there are certain tips or techniques that a designer should know to gain maximum benefit from that process. This is certainly true with photo chemical machining.

In this brochure we present a few ideas to help you understand the philosophy of design for photo chemical machining. To obtain additional tips and guidelines for practical design, it is important that you communicate with a company that is a reliable manufacturer of photo chemically produced parts. If you consult with Newcut before you complete your design, you will usually find additional ideas to give you maximum benefits from the process.

Here are some practical ideas to keep in mind when designing parts for the PCM process.

Low Cost Tooling

Other processes require elaborate manual and mechanical techniques. Tooling in the photo chemical machining process is computer generated. We can work from your CAD file or our designers can convert your paper drawings, thereby increasing accuracy and reducing tooling costs. Tooling costs can be as little as 1/10th of that required for the processes.

Speed of Delivery

When time means money, the Photo Chemical Machining Process can save your firm dollars through a turn around time quicker than any method. In some instances, parts can be delivered overnight. For large quantities and for more difficult jobs, delivery should never be more than a month away. Other processes require up to 6 months delivery time.

Integrity of Metal Properties

The designer will find that Photo Chemical Machining provides a unique advantage-the internal structure of the metal is unchanged by the process. Furthermore, Photo Chemical Machining does not affect the properties of the metal worked as do some processes which change the hardness, grain structure, or ductility.

Multiplicity of Design

Frequently a designer will need a large panel with a repeated pattern or with several patterns which are small and which require tight tolerances. Patterns can be reproduced photographically time after time with little additional cost. Consult Newcut for special variations of this process.

Burring

Some processes give finished parts a burr which may be detrimental to the functioning of the parts. In the Photo Chemical Machining operation the part configuration is achieved without any surface burr. Newcut can supply parts of any temper metal including aluminum, copper and copper alloys (brass, bronze, beryllium copper, etc.) molybdenum, steels (Cold rolled, spring-tempered, stainless, Swedish, etc.), Titanium and many others in any quantity from 1 to infinity, in any design, in sizes from .040 inch square to 40" x 96", in metal thicknesses from .0005" to .100".

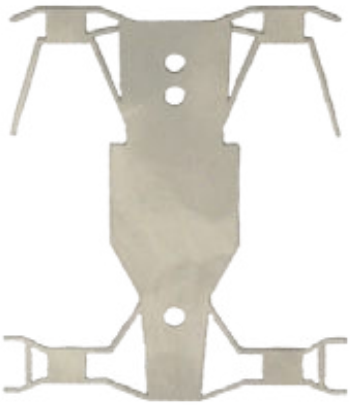
Send Newcut a print, sketch or sample of the part required, the quantity desired, and without obligation, Newcut will promptly forward a quotation. If forming, heat-treating and/or plating is required, Newcut can quote the complete part. Bear in mind that original lowcost tooling can be used for prototype through production runs. If design improvements develop they can be incorporated at minimum expense without scrapping expensive dies. When design problems arise, Newcut's knowledge and facilities are always at your service.

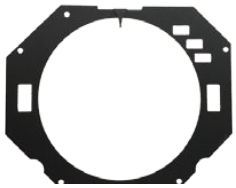
Tooling Modification

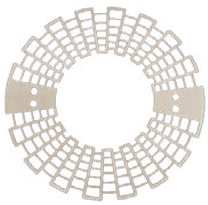
The Photo Chemical Machining Process allows the designer to do practical experiments at a minimum cost. Furthermore, through changes in the manufacturing process, it may be possible to change hole sizes, tab widths, and so forth, without any changes to the tooling. If a design concept is untried, the designer should consult with Newcut to select the layout which will allow the most flexibility for change at the minimum cost.

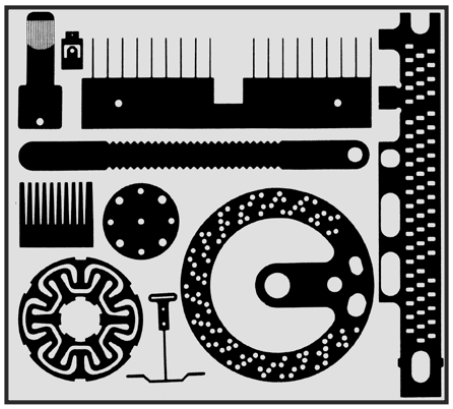
Prototype To Production

Because of the time and cost factors in other processes, prototypes are frequently made by a method different from that used for full production. There are inherent dangers in this. Process variables could result in the production part not corresponding to the prototype and, therefore, not functioning properly. In the Photo Chemical Machining Process, however, this danger does not exist. The process can be used to make one or one million parts. This allows the engineer or designer to carry his concept from prototype to pilot to full production with parts manufactured by the same process.









Dimensions //

Because of the nature of the etching process and the undercutting at the edges of the resist pattern on the surface, all dimensions, tolerances, and configurations are functions of the thickness of the stock being etched, the material, and to a lesser extent, the process variables. In the section on tolerances and materials which follows, tolerances are given for a variety of metals, thicknesses, overall pattern sizes, etc. These are generally applicable to equipment, processes, metals and configurations currently being used. They do not, however, express the ultimate capabilities of photo chemical machining. For dimensions such as slots, corners, etc., there are a few guide lines for designers which express practical limitations as the dimension under consideration approaches the thickness of the metal.

Relationship of Holesize to Metal Thickness

As a general rule, it is normally stated that the diameter of a hole cannot be less than the metal thickness. This relationship, however, does vary as the metal thickness changes. A more exact relationship might be as per the chart:

Metal Thickness (t)	Smallest Hole Diameter (D)
Less than .001”	Must be determined by test run
.001” - .005”	At least metal thickness, with a .003” minimum holesize
.005” or over	At least 110% metal thickness

Relationship of Line Width to Metal Thickness

Generally speaking the width of metal between holes is not a particular problem in photo chemical machining. However, when this space is the remaining surface area in a large field of slots or holes, there are limitations as to how small the metal width between the holes can be. This relationship is as follows:

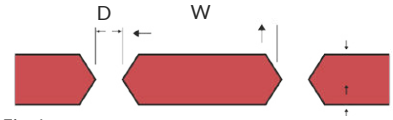
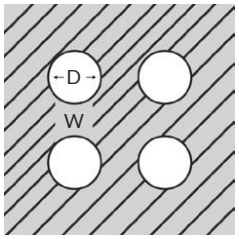


Fig. 1

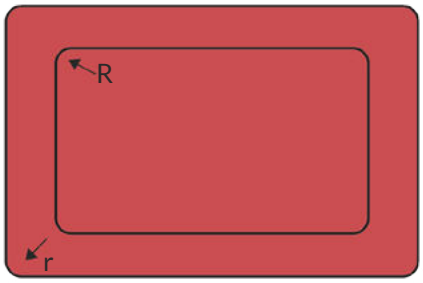
Fig. 2



Metal Thickness (t)	Space Between Holes (w)
Less than .005”	At least metal thickness
Over .005”	At least 1.25 times metal thickness

Relationship of Inside Corner Radius to Metal Thickness

In general, the smallest corner radius is directly proportional to the thickness of the metal i.e., for metal thickness of .002", corner radius would be .002". Under certain circumstances, this radius can be made smaller and Newcut should be contacted when there are requirements for a radius smaller than the metal thickness.



Relationship of Bevel to Metal Thickness

ETCHING ONE SIDE - (Figure 4a)
An etchant attacks the material laterally as well as vertically. The result, therefore, is the condition of etch configuration for a hole which is known as a "bevel". As a rule of thumb, for a material with a thickness (t), the bevel A would be approximately 0.4(t).

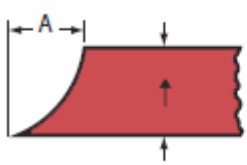


Fig. 4a

ETCHING TWO SIDES - (Figure 4b)
Assuming that the material is being etched equally from two sides, it can be easily seen that the bevel is appreciably reduced. As a general rule, when etching from two sides, the bevel A is approximately 0.2(t).

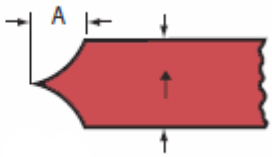


Fig. 4b

Tolerances //

Center-to-Center Dimensions

Generally speaking, for small pieces, it is possible to etch photo chemically machined parts which tend to duplicate the center-to-center dimensions which exist on production artwork. Because of limitations in the area of artwork preparation the following table gives practical center-to-center dimension tolerances for finished parts.

C/C Dimensions (inches)	Tolerances
1.0" or less	+ .0005"
1.0" - 3.0"	+ .0010"
3.0" - 6.0"	+ .0020"
6.0" - 10.0"	+ .0030"

Etched Dimensions

Because of the many parameters involved in determining etching tolerances, it is impossible to give a definite, absolute rule which will cover all circumstances. Some of the more common variables, which will affect the etching tolerances are type of metal being etched, size of panel, equipment being used, and yield required. For purposes of establishing some general rule of thumb, a tolerance of ± 15% of the metal thickness is usually acceptable. The two tables below give tolerances to be expected for varying metal thicknesses and flat sizes. Table 1 is for prototype or short run of parts with not more than one dimension per piece requiring the tolerance shown. Table 2 reflects the tolerances on full production runs.

PROTOTYPE & SHORT RUNS Thickness (t) (inches)							
Approximate Flat Size	**.001”**	**.002”**	**.005”**	**.010”**	**.015”**	**.020”**	**.040”**
2” x 2”	Empirical	±.0005”	±.0007”	±.0010”	±.0015”	±.0020”	±.0040”
8” x 10”	Empirical	±.0007”	±.0010”	±.0015”	±.0020”	±.0030”	±.0050”
12” x 18”	Empirical	±.0010”	±.0015”	±.0020”	±.0030”	±.0040”	±.0060”

PRODUCTION RUNS Thickness (t) (inches)							
Approximate Flat Size	**.001”**	**.002”**	**.005”**	**.010”**	**.015”**	**.020”**	**.040”**
2” x 2”	Empirical	±.0010”	±.0010”	±.0015”	±.0020”	±.0030”	±.0050”
8” x 10”	Empirical	±.0010”	±.0015”	±.0020”	±.0025”	±.0040”	±.0060”
12” x 18”	Empirical	±.0015”	±.0020”	±.0025”	±.0035”	±.0045”	±.0070”

Corner Radii

The photo chemical machining pro cess tends to round off corners. This is sometimes advantageous because it keeps the part from causing scratches or cuts or from catching on other parts. However, if a square corner is desired, there are techniques available to Newcut to obtain them. For example, Fig. 5 shows how serifs can be added to the art work so that when the image is transferred it will reproduce as a sharp corner on the actual part.

Fig. 5

Hole Configurations

Where possible, it is best to keep hole configurations similar within a giv en piece. The reason being that different configur ations tend to etch at different rates. Where different hole sizes are required, the problem can be solved by making sure that you use a common width etch band for making each hole configur ation. Fig. 6 shows a variety of different size holes, but utilizes the same width etch band. The etch band presents the same surface area to the etchant, and therefore etches more uniformly.

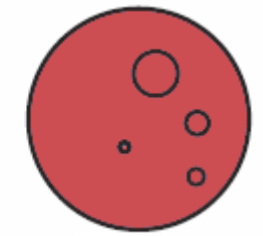


Fig. 6

Tie-Ins or Tabs

Tabbing is normally done by extending one or more lines from the part to the surrounding metal border. Unless specified, these tie-ins are normally made as few and as small as possible consistent with the size and quantity of parts being etched. Newcut feels that tie-ins or tabs should be avoided wherever possible as this defeats one of the major advantages of Chemical Milling. The part that is tabbed is no longer burr free. However, we do understand the necessity for tabbing particularly when the part is very small and a secondary plating has to be performed. If there are any questions concerning tabbing, we suggest you consult Newcut for an Engineering opinion.

Bevel

By the nature of the etching process there will be some degree of slope to the wall of the holes or to the metal edge. This bevel condition is discussed in the section on dimensions. Generally, it is easier for Newcut either to etch equally from both sides or to etch entirely from one. However in a two-side etch the depth may be varied to produce more bevel on one side. Normally, this condition is referred to by the percentage of etch from either side, e.g. 90/10 would be etching 90% from one side, 10% from the other. When such a variation is required, it should be so specified. In as much as this is a difficult oper ation, some latitude should be given Newcut as to percentage of etch from either side.

Fig. 7 50/50

90/10

Line Widths

Because of the bevel characteristic as discussed previously, the width of metal at the surface of the sheet may not necessarily be as big as that which would appear if the part were placed on a light table and viewed from above through a microscope. Normally the width of tabs is determined by a measurement from the widest point which is halfway through the thickness of the metal. As an example, a wire which has a measurement of 0.016 wide may have a surface width of only 0.014. If the width of the metal at the surface is important, it should be so specified on the print. An allowance should be made for the tab itself which will measure a certain amount more.

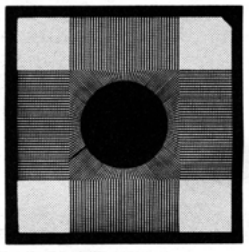


Fig. 8

Unsupported Tabs or Wires

Designs for photo chemical machining should not incorporate tabs or wire which are exceedingly long and unsupported. What length will cause trouble will vary with the type of metal being used, its hardness, thickness, the width of the wire, and the general design of the piece. However if designed too long, tabs can cause distortion problems either in processing or in handling. Their weight may cause them to sag or, if they are very thin, the pressure from spray etching may bend them. When the designer is in doubt, he should consult with Newcut.

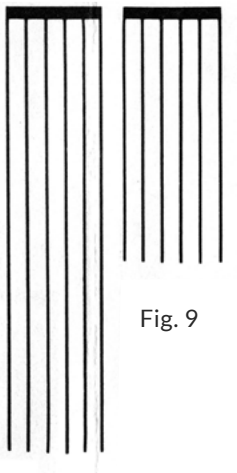


Fig. 9

Materials // Metals

Aluminum
- 1100 Series - 1100, 1145
- 2000 Series - 2024
- 3000 Series - 3003
- 5000 Series - 5052
- 6000 Series - 6061
- 7000 Series - 7075
- Alclad
- Anodized Aluminum

Beryllium Copper
- C172
- C190

Copper & Copper Alloys
- ETP c110
- OFHC c101 or c102
- C7025
- Brass c260
- Phosphor Bronze c510
- Nickel Silver c752 & c770
- c194

Controlled Expansion Alloys
- ASTM F15 Kovar
- Alloy 36 Invar
- Alloy 42, Alloy 48, Alloy 52
- Nispan C

High Temp Alloys
- Inconel 600
- Inconel 718
- Inconel x750
- Hastelloy X
- Molybdenum

Magnetic Alloys
- HyMu 80, HyMu 800
- Hiper 50
- Carpenter 49
- M-19 Silicon Steel

Miscellaneous Alloys
- Beryllium
- Silver
- Fecralloy
- Tin-lead

Nickel Alloys
- Alloy 200, Alloy 201
- Beryllium Nickeli Alloy 360
- Copper Nickel Alloy 715
- Nichrome 80/20

Stainless Steel
- 300 Series - 301, 302, 304, 304L, 316L, 321, 347
- 400 Series - 410, 420, 430, custom 455
- Preciptaion Hardening 17-4, 17-7, 15-5
- Flapper Valve - UHB716, AEB-L, 7C27MO

Steel
- 1008/1010
- 1074/1075
- 1095
- Tool Steel

Titanium
- Grade 1
- Grade 2
- Grade 3