Making Reed Valves Using Electro-chemical Etching

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The most common form of reed valve used on small pulsejet engines is the petal-valve. They are given this name because they look like the petals of a flower.

Cutting such a shape from thin (usually 0.006") spring steel can be very problematic.

While scissors and shears work fine for cutting straight lines, it is almost impossible to cut the curves and thin slits needed to create a petal valve.

Even if one were careful and lucky enough to produce a petal valve using such tools, the resulting valve would almost certainly have areas where the metal was bent or where there were overcuts that would encourage the rapid formation of cracks and premature failure.

So just how can you create the relatively complex shape of a petal valve using commonly available equipment?

The answer is to use **electrochemical etching**.

By painting both sides of the reed valve material and then scratching the shape of the valve into that paint, it becomes possible to etch the exposed metal so that the valve virtually falls out of the sheet from which it has been made.

Acid Etching

At first glance it might seem that we could simply drop a suitably painted and scratched sheet of valve material into a container of acid and the exposed metal would be eaten away to do the job – but that's not a particularly good idea for several reasons:

1. Acid is corrosive – and few of us have a pint or two of sulfuric, nitric or hydrochloric acid laying about the workshop.
2. Acid etching has the undesirable effect of rapidly under-cutting any exposed edge. This means that as well as eating directly into the exposed metal, the acid would start etching away under the paint. As a result, our finished reed valve would probably end up with very thin and ragged edges that would be prone to burning and splitting.

Electrochemical Etching

By comparison, the electrochemical etching method requires nothing more than a battery, some wire, a bowl and common household salt in solution with water.

What's more, electrochemical etching suffers far less from the under-cutting tendencies associated with acid etching.

Here are the steps involved in etching a reed valve using this technique:

Preparation

Let me say right now that preparation is everything. If you skip on this step then you will end up regretting it later.

The metal from which your reed valve will be etched must be absolutely clean with no traces of rust or grease as these will cause the paint to lift and allow etching to occur in all the wrong places.

It's also important that the metal is slightly roughened so that the paint can adhere properly. A perfectly polished service will give the paint nothing to hold on to and it will come off in big flakes.

For absolutely the best results you should scrub the reed valve material with a soap-impregnated wire-wool pad. This will remove all traces of grease and (if your arms are up to it) any rust spots.

Now rinse in very hot water, taking care to hold the metal only by the edges – oily fingerprints will ruin your hard work.

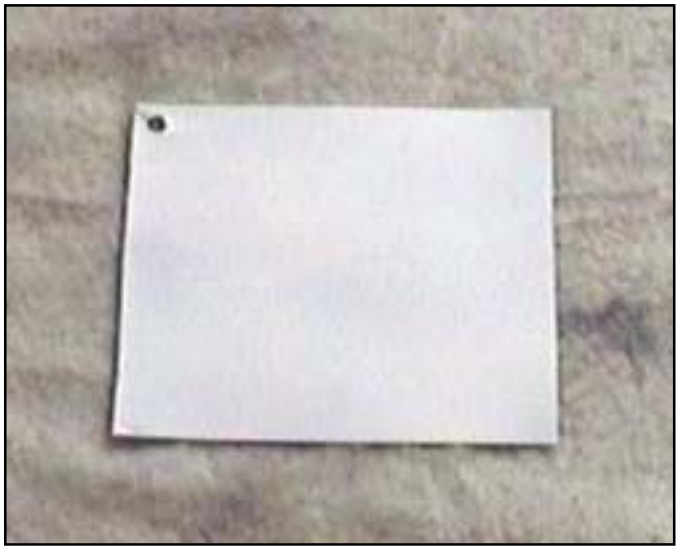
You can now give the metal an acid-etch if you have some dilute sulfuric acid available. This is done by dipping the bare metal into a very dilute solution (battery acid can be diluted by 4 parts of water). Place the metal in the solution and you should see small bubbles start forming. Lift it out at regular intervals and when it's turned a dull gray color you can rinse it under hot running water again.

This acid-etch will provide the best surface for paint to adhere to – but if you don't have any sulfuric acid then don't worry – you can give both sides of the metal a light sanding with 1200 grade wet-and-dry sandpaper. This will provide a similar surface roughness to help paint adhesion.

Painting

The type of paint and the manner in which it's applied will also be a critical factor in the success of the etching operation.

Don't use a cheap spray-can enamel – it probably won't stick well enough, even if you've roughened the surface.



What's needed is an automotive undercoat. These paints are designed to be sprayed directly onto bare metal and can be obtained in spray-can form from your local paint store or auto accessories outlet. If you can, use white undercoat – it makes the job of getting a nice even coat much easier than when using the traditional gray.

Make sure you get an even and thorough coating of paint on the metal. I actually find it easier to lay the metal on a sheet of newspaper and spray it while it's flat. This avoids creating paint runs if you over-do it slightly. Of course it means that you have to wait for one side to dry before you can turn it over and do the other – but automotive primers tend to be very fast-drying anyway.

Once the first coat is dry, give it another thorough all-over coat.

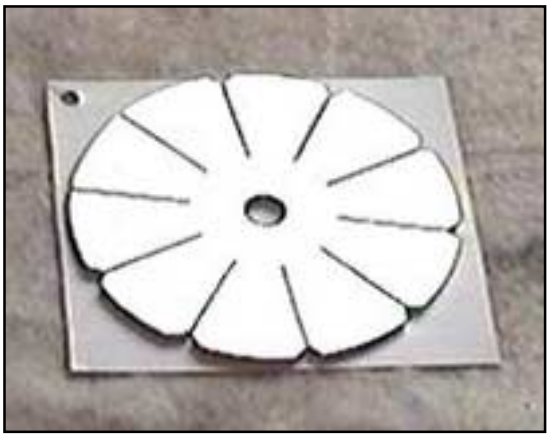
Don't be tempted to make do with a single coat. Even though it may look as if you've covered all the metal, experience has shown that there will probably be some very tiny pinholes that will cause similar holes to appear in your reed valve. A second coat is good insurance against this type of thing happening.

Another reason you want at least two coats is because as you near the end of the etching process, it's only the paint that will hold everything together. Insufficient paint means that the valve will start breaking away from the rest of the metal prematurely and this can cause the paint to rip away from a surface you don't want etched – with disastrous results.

Let the paint dry at least overnight if you can. Even though these paints are fast-drying, the very bottom layer tends to remain slightly plastic for several hours and this can cause the lines you scribe later to close-over.

Marking Out

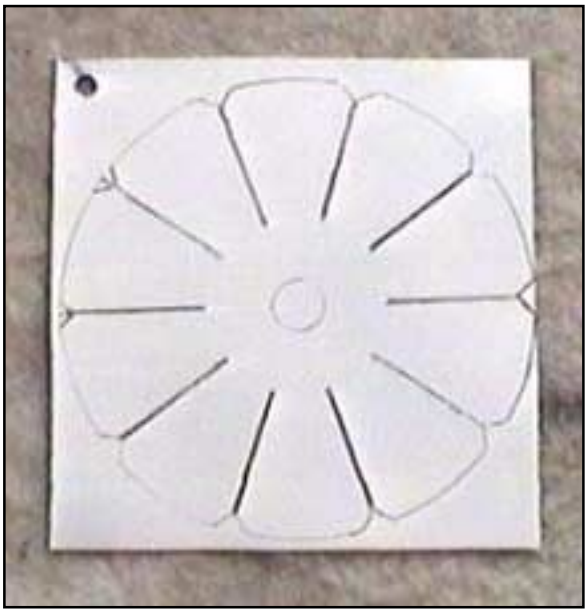
Now that you have a nice piece of reed valve material, totally covered in a good solid layer of paint, you need to scribe the lines that represent the outline of your reed valve.



NOTE: You only scribe one side! The undisturbed layer of paint on the back-side of the plate will hold everything together as the metal under the scribed lines is etched away.

You can draw and scribe the pattern of your reed valve directly onto the piece of metal you've prepared – but it's a better idea to make a template that you can trace around.

The reasons for this are obvious: If you make a mistake while drawing the pattern onto your painted material then your work to date will have been wasted.



I've made a template from 1mm (0.040") stainless steel and I simply press this against the prepared reed valve material and scribe around the edges with a sharp modeling knife. Don't forget to also scribe the hole in the middle!

If you have an existing reed valve in good condition then you can use that as the template for scribing your pattern.

When you've finished scribing, the shiny steel underneath the paint should be visible at the bottom of the scribe lines.

Check to make sure that all your lines join where they should – a line that doesn't quite join up will leave a bridge of metal that will make complicate removal of the valve from the sheet of prepared metal.

Etching

You'll need a plastic or glass bowl or container that is large enough to fully submerse your valve material while it's stood on edge. As you can see here, I've used an old yogurt container but you can grab your mother or wife's Tupperware if she's not looking and it would do just as well.

Now mix up a solution of common table salt and water. About a tablespoon per pint will do the trick – the strength of the solution isn't that critical. You'll need enough to fill your container to the desired level.

Hint: the salt will dissolve more easily if you use warm water.

Now find yourself a piece of stainless (preferred) or regular steel that will act as a cathode plate in the solution. It should be about the same area as your blank sheet of reed valve material – although, once again, this isn't too critical.

Next, you'll need a source of 6-12V DC. This can be a lead acid car or motorcycle battery or, if you have one, a variable voltage/current power supply.

Connect that plate to the NEGATIVE terminal of your battery or power supply and place it on once side of your container, immersed in the salt solution.

Place your painted and scribed piece of reed valve material in the salt solution on the other side of your container – making sure that the scribed side faces the cathode plate.

Make absolutely sure that the two pieces of metal can not accidentally touch together if they move. One good way to do this is to place a sponge in the middle. This will absorb the salt solution and allow the current to flow but stops the two plates from meeting.

Connect the reed valve material to the POSITIVE terminal of your power supply. You may want to include a resistor (8 ohms is about optimum) in this lead to limit the current flow if you're using a small container as I have here. If you don't have an 10 watt, 8 ohm resistor, you can use a 10W-20W 12V light bulb instead.

Once you connect things up, you should see bubbles begin to rise from the cathode plate as in the picture.

At this stage the salt solution will still be clear.

Depending on a number of factors, it may take between 10 minutes and an hour to etch your valve. Once the process gets underway, a rather awful looking green or brown sludge will begin to form on top of the solution. This is the iron that has been removed from the scribed lines.

Things will go more quickly and the results will be better if you give the reed valve plate a bit of a shake now and then. This dislodges the crud that forms on the scribed lines so that a fresh salt solution can reach the bare metal and continue etching.

If you remove the plate from the solution you'll see that the formerly shiny metal under the scribed lines has turned black.

Eventually the scribed lines will etch right through and when you remove the plate from the solution you'll see the paint on the back surface exposed.

If you hold the plate up to a lamp at this stage you can see exactly where the etching is complete because the light will shine right through as in this picture.

Post-etching Steps

Once you get to this stage you can disconnect all the wires and carefully push the reed valve out of the plate. There will probably still be some areas where the etching is not quite complete but the metal at these points will now be so thin that it will break away very easily.

Don't worry if the edges seem a little ragged – this is normal.

Now wash off the paint with suitable thinners. Another benefit of the automotive primer is that it washes off very easily with lacquer thinners.

Now you'll have a new valve – but chances are that the edges will still be ragged as mentioned above.

In order to avoid premature cracking of the valve it pays to file or sand those ragged edges to make them smooth(er).

In theory, you can further reduce the risk of cracking by putting the valve in your oven at about 200 deg F for an hour or so. What this will do is bake out any hydrogen that might have entered the structure of the reed valve material as a result of the etching. Hydrogen in the molecular structure causes what is known as "hydrogen embrittlement" and that makes steel far more prone to cracking. For what it's worth – I don't bother. Let's face it – the valves are going to get hot enough anyway once you fire up your engine.

Here at FAB Jets, (http://aardvark.co.nz/pjet) we also perform one more additional step to create our own exceptionally robust valves. This is a proprietary triple-plating operation unique to FAB Jets that creates a valve which is not only very hard and heat-resistant, but which is also incredibly ductile and resistant to cracking.

Note: This document is part of the Pulsejets CDROM available for purchase from FAB Jets for US$39 through the secure website at:
https://www06.tierranet.com/shockhorrorprobe.com/cart/pulsejets/

If you want more information on pulsejet engines, their design, history, uses and construction, then this CD is an invaluable resource.

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