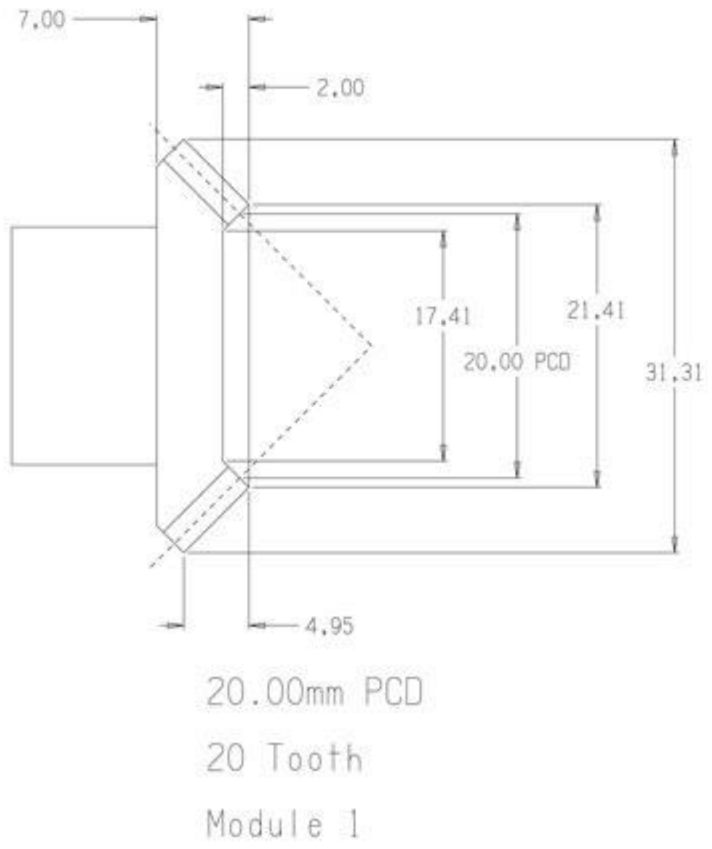
HOW TO CUT MITRE AND BEVEL GEARS

By Paul Swift

This article came about by my need to cut a pair of mitre gears for a future project that I have planned. I made a trial pair in aluminium, having made several mistakes until getting it worked out.
I have to mention from the outset that I found the book Gears And Gear Cutting by Ivan Law an invaluable source of information, and can recommend it to anyone wanting to cut their own gears.



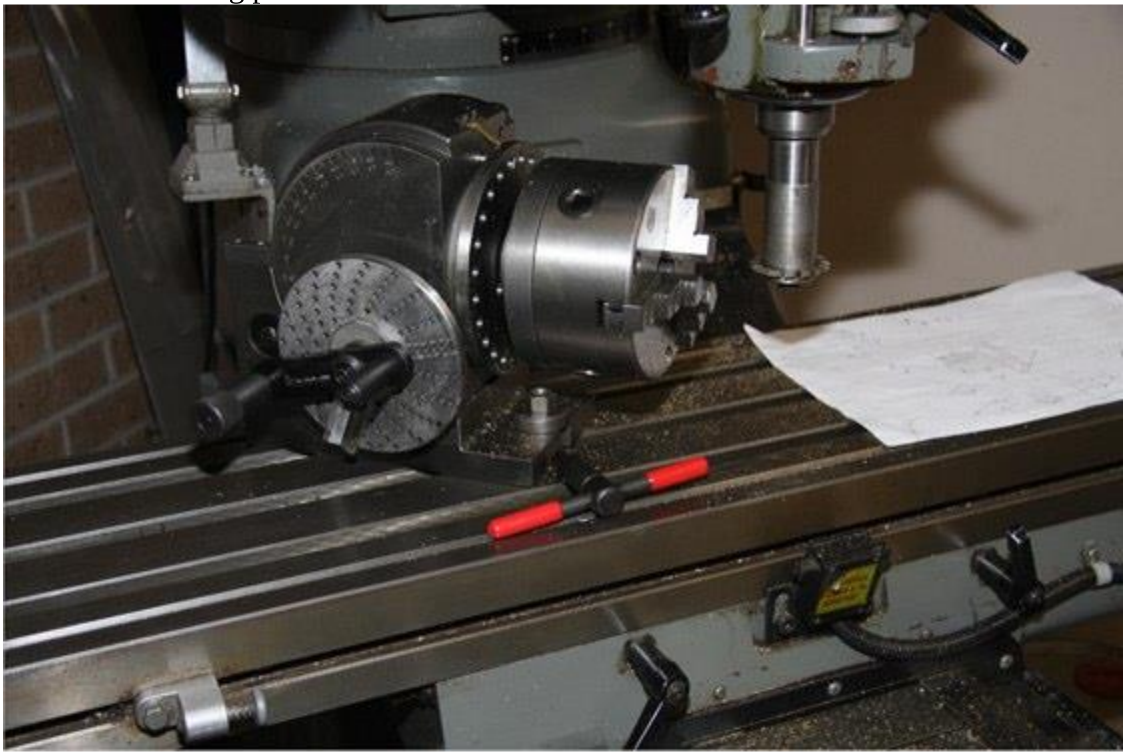

The mitre gears to be cut are Module 1, 20 tooth, 20mm Pitch Circle Diameter. The first thing to do was draw up the gears to find out the sizes required. Rather than go into a detailed explanation as to how the sizes are achieved, I have included a drawing of the finished part.

You will see on the drawing where the 20mm PCD is, from here the addendum and dedendum (the upper and lower parts of the tooth form) are added, and the rest is drawn around these.

Now that I know the sizes to turn the blanks to, work can begin. I chose to make the blanks using 2 pieces and soldering them together. This saved me wasting material, I had some brass that was suitable for the shank and some larger diameter for the gears.
I left the shanks longer than necessary in order to give me some room to hold them when cutting the teeth. A small shoulder was turned on the shank, and a hole was bored in the gear blanks, about 0.10mm oversize. This will allow the solder to flow, normal lead solder will be used.

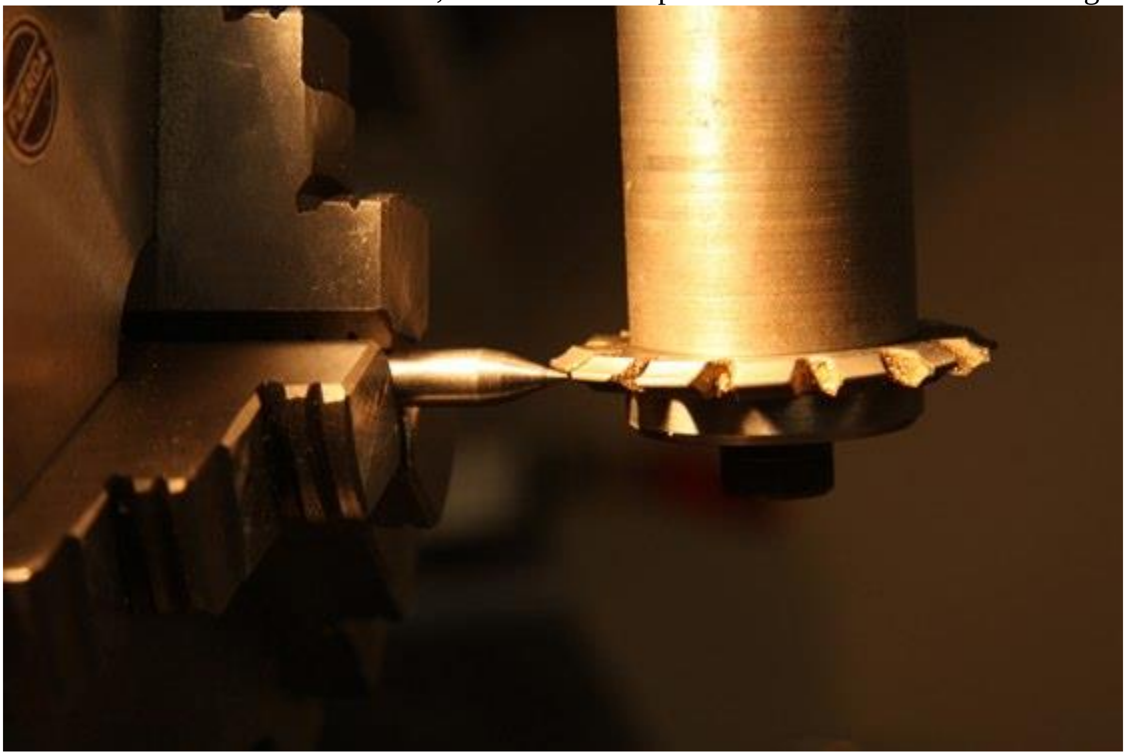
The shanks were stood on end and the larger piece sat on the end held by the turned step. These were gently heated from underneath the large diameter and resin cored solder applied from the top. When the solder flows down towards the shank, remove the heat. The parts were allowed to cool and then machined to size.

First part of the setup to cut the teeth is to mount the dividing head at the required angle to suit the gears being cut. The mitre gears intersect at 90deg, making each gear 45 deg, so the dividing head was set at 45 deg. A rotary table standing up on edge can also be used, as long as a set of dividing plates are available.



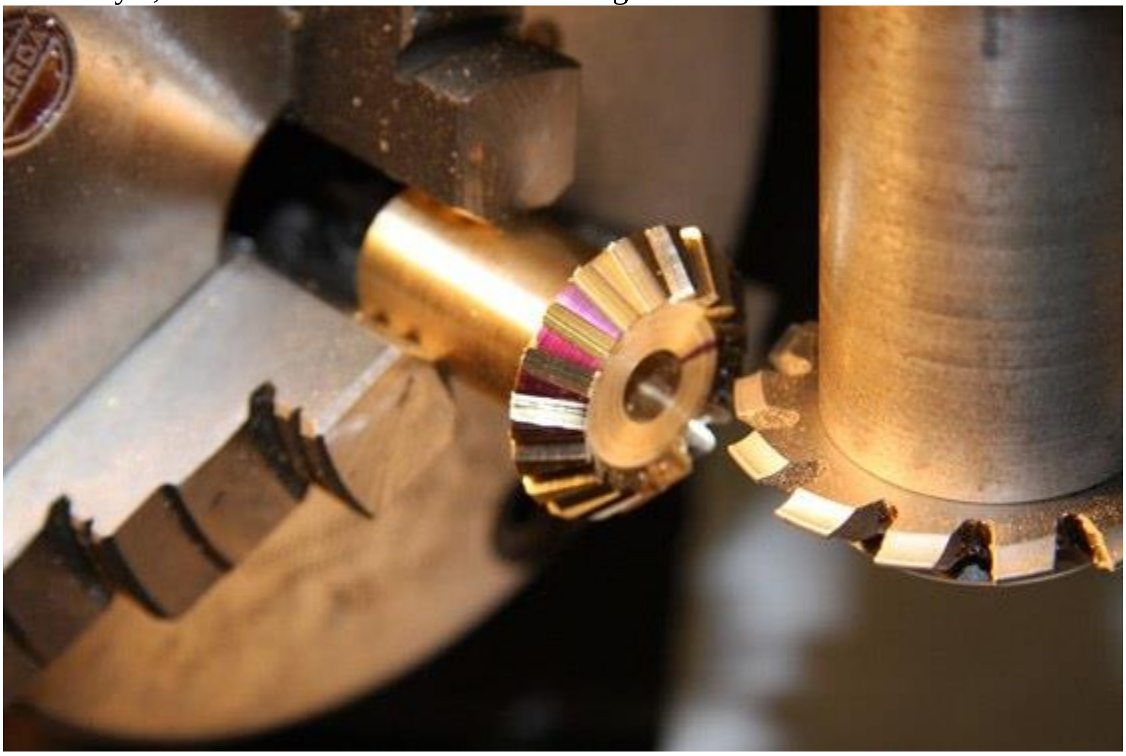
The next step is to choose the cutter to be used, I use normal spur gear cutters. If I was cutting a spur gear with 20 teeth, the cutter chosen would be a No.3, but in the case of mitre gears, a cutter to suit a larger number of teeth is chosen. This is because we use the PCD at the larger

end of the gear to calculate the cutter required. In this case I used a No.5 cutter.
Chapter 7 in Ivan Law's book details how to calculate this.
The cutter is mounted on an arbor, and then lined up on the centre line of the dividing head.



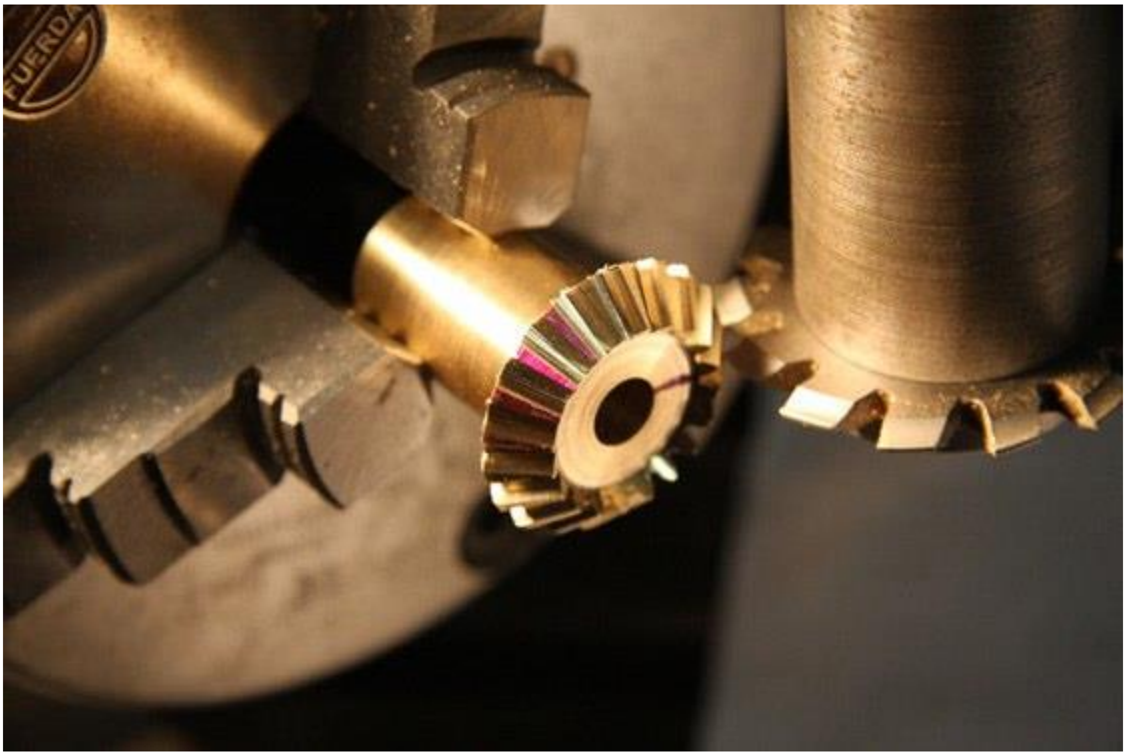
The index pin is set in a dividing plate with an even number of holes, this suits my dividing head which has a ratio of 40:1. This means that with 20 teeth, each tooth will be 2 full turns of the handle. The first cut is made to full depth.

The next tooth is indexed by turning the handle 2 full turns and re-engaging the index pin in the chosen starting hole, the next tooth is then cut. This is repeated until all 20 teeth have been cut. In the photo below, you can see the shape of the top of the tooth. We are not finished yet, as we have to do some more cutting.



After the first cut, we have a parallel gap with tapered teeth. These will not engage with each other because of the difference. What I need to achieve is a tapered gap and tapered tooth that will mesh along the complete tooth profile.
To achieve this, it is necessary to first use a marker pen to mark the tooth that is on the centre line of the dividing head. I now back up 1/4 of a turn of the dividing head, in this case I am using a 20 hole plate, so I back up 10 holes. This is why it is important to choose a plate that has an even number of holes.
Now that I have rotated the gear 1/4 of a turn, the cutter no longer aligns with the tooth form. I then adjust the table height until the cutter is once again in line with the tooth form that I earlier marked (on its smallest diameter end). The cutter is set to full depth again and run through the tooth gap, it will remove nothing front the front, but progressively more from the back, making a tapered gap. The gear is indexed around until all 20 teeth have been cut.
Now, I have to be careful and return the dividing head to its original setting when I cut the first teeth. I now rotate forward a 1/4 turn of the dividing head and again realign the cutter with the marked tooth. I then run the cutter through the gap again, removing nothing from the front, but progressively more from the back. This is repeated until all 20 teeth have been cut.
What I now have is a gear form that has a tapered gap and tapered tooth that will mesh correctly.

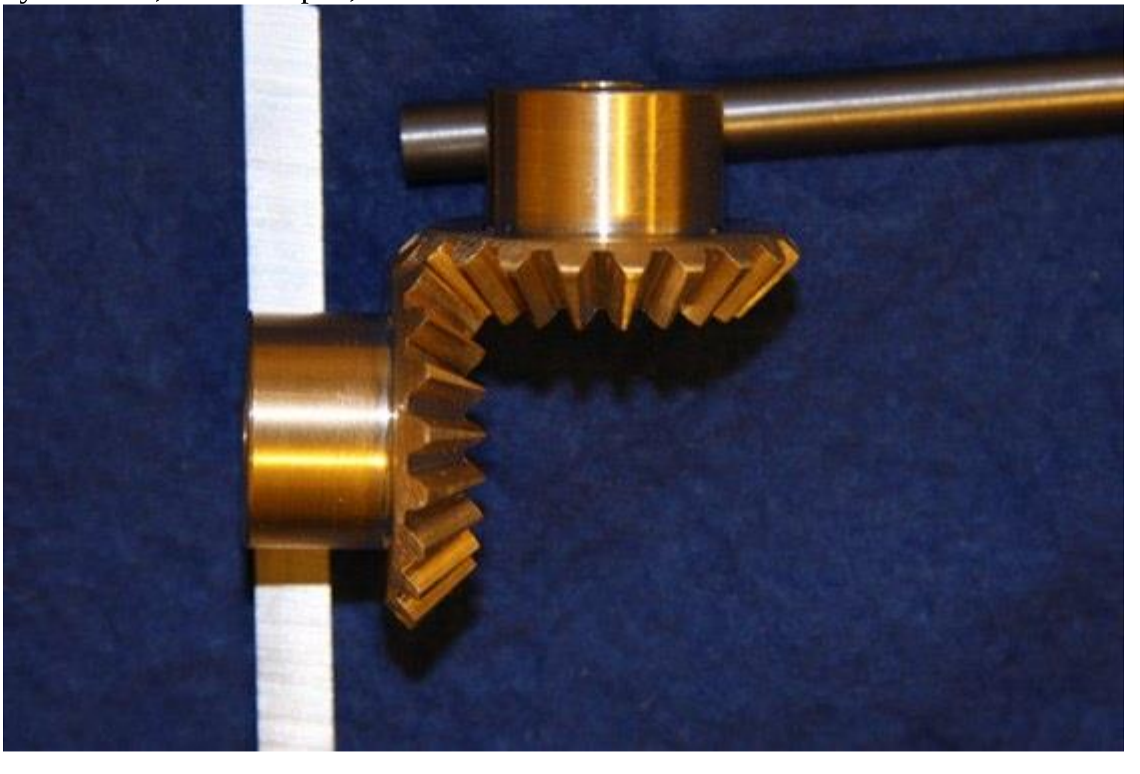
In the photo below, you will notice the reduced shape of the top of the tooth compared to the first cut.



The photo below shows the teeth meshing at the small end of the gear.

The photo below shows the teeth meshing at the large end of the gear.

And here we have a photo of the gears intersecting at 90 degrees. The shanks have been trimmed down to the length required and burrs removed from the teeth using an abrasive nylon brush, held and spun, in the lathe chuck.



The above procedure is applied also to cutting bevel gears, allowing for the different angles involved.