

Mill Engine from Bar Stock

By Thor Hansen

After making a few slide valve engine with a trunk guide I decided to try and make a mill type engine with bar crosshead slides and a cylinder fabricated from gunmetal. With the stock I had available I could make a cylinder with approximately 19mm bore and 28mm stroke, that might be a bit short for a mill engine.

Many thanks to Graham Meek for his advice and encouragement.

Materials

The mild steel used I found in my scrap box or in a skip nearby, some mild steel rods, the free-cutting stainless steel, M3 threaded rod and nuts and the brass and gunmetal were purchased.

Flywheel

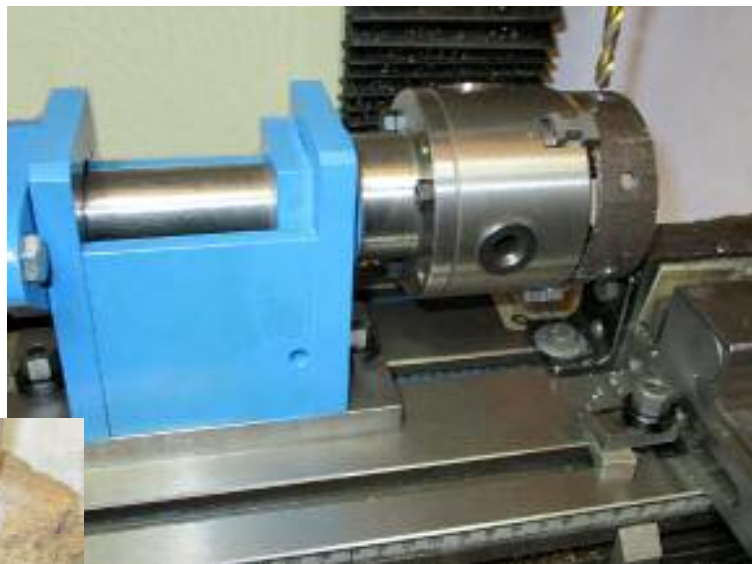
I started with the flywheel since I found a short piece of 3 in. steel tube in a skip nearby and another thick-walled piece with an outer diameter of 90mm. The inner diameter of the thick-walled piece was less than 3 in. so I could turn the two pieces so one fitted inside the other.



I started by drilling six 6.1mm holes 60 deg. apart in the 3 in. steel tube using my home made indexer – right photo.

The holes were first spotted using a centre drill before an ordinary twist drill was used to drill the holes.

The hub was made from a piece of 20mm black mild steel turned down to around



19mm and a 7.9mm hole drilled through and then reamed to 8mm.

The work was then transferred to my indexer and six 5mm holes drilled 60 deg. apart almost into the 8mm hole and then tapped M6.

I used a length of 6mm bright mild steel rod for the spokes, the rod was cut into 35mm long pieces and one end threaded M6 for a short distance. The left photo shows the wheel after silver soldering and also the jig used to make sure the hub ended up in the

centre.

The wheel was then mounted on a between centres mandrel in the lathe and the wheel turned to run true – right photo.

I used a long bolt as a lathe dog to drive the wheel, this worked fairly well as long as I took light cuts.



The "tyre" was mounted in the 4-jaw and centred and the inside diameter turned to a light push fit on the wheel. I didn't take the last cuts entirely through, but left a small (about 1mm) ridge at the end closest to the chuck, this will prevent the wheel from falling trough when gluing the parts together.

I drilled three 2.5mm holes 120 deg. apart in the wheel and used a short piece from a broken 2.5mm drill to spot these holes on the inside of the "tyre" so I could use the same broken drill in my Dremel tool and drill a shallow depression. The 2.5mm holes were tapped M3 for some grub screws, I used a scribe to make some witness marks that lined up the tapped holes with the marks in the tyre.



I applied epoxy to the two mating parts and pushed the two parts together and let the epoxy cure on top of my hot water tank.

After the glue had cured the flywheel was mounted on the same mandrel between centres and finish turned. The right photo shows the finished wheel (the inside got a coat of black paint).



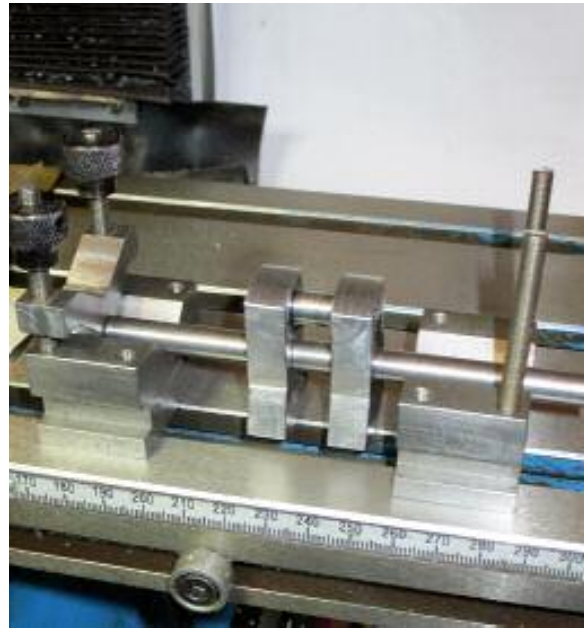
Crankshaft

The Crankshaft was built up from a piece of 8mm diameter bright mild steel rod and I found a couple of pieces of mild steel I could use to make the webs.

The two webs were glued together and the centres for the Crankshaft and Crankpins marked. I drilled the two holes and reamed them to 8mm.

The webs were milled to size and using the hole in the centre I could mount a web in the lathe chuck and turn the outside.

The pieces were cleaned and I used anaerobic glue to glue the pieces together – right photo. The Crankshaft is resting on two V-blocks while the glue cures.



I decided to pin the webs to the Crankshaft and Crankpin. The two V-blocks were used to clamp the work and 4 holes drilled for the 2mm pins – left photo. When I inserted the pins I first put a drop of anaerobic glue in the hole.

The finished Crankshaft is shown below.



Bearing Blocks

I found a couple of pieces of mild steel in my box of scrap that I could use for the Bearing Blocks. First I milled the underside and marked out the position of the M3 tapped holes that will be used to clamp the Bearing Blocks to the Base. The holes are 18mm apart so I used the dials on the milling machine handle to get the correct distance.

I made a small jig to mount the Bearing Blocks on, the jig could then be mounted on an angle-plate



mounted on the lathe faceplate. On the front Bearing Block I had marked out the centre of the hole for the Bearing Bush and the hole for the bush could then be drilled and reamed.

I don't run my small engines for long periods of time so I just used two pieces of brass tube for the two bushes that are a light press fit in the Bearing Blocks – right photo.



The left photo shows how I milled the corners of the Bearing Blocks at 45 deg.



Base

The Base was made from a piece of aluminium 3mm thick. The work was clamped to the milling machine table with some scrap steel pieces as spacers to lift the work well clear of the table. I then used an end mill to mill one short side to dimension – right photo. I could then move one clamp and mill that side to dimension, so then move the clamp again and mill until all sides were milled.

The sides were chamfered the same way.



The next job was to mill a hole in the base for the webs of the Crankshaft – right photo.



The position of the Bearing Blocks were marked out and four 3mm holes drilled, the holes were countersunk on the underside of the Base.

I also drilled a 2.5mm hole in each corner and tapped M3, these tapped holes are used to clamp the Base to a wooden box.

The right photo shows the Base with the Bearing Blocks (and Crankshaft and Flywheel) mounted.



Cylinder Cover

I decided to combine the Cylinder Cover (with gland for the Piston Rod) and standard. I didn't have a large enough brass block, so I made the largest part from mild steel and silver soldered (brazed) a few brass parts to the steel part.

I started with the steel part and milled it to dimensions – right photo.

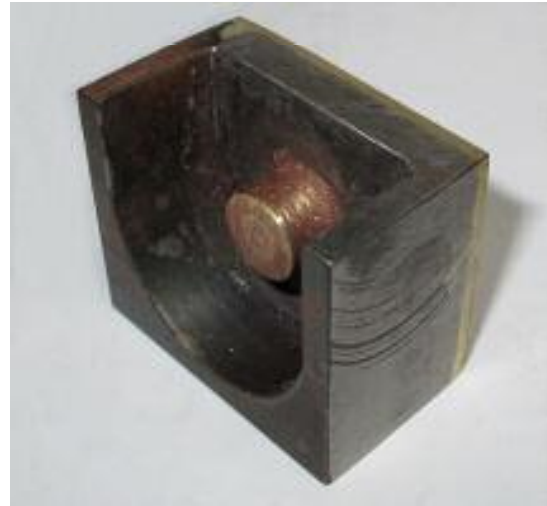


I wanted the Piston Rod Gland recessed in the standard so I used a 30mm face mill to mill the recess – left photo.

I then drilled a 10mm hole in the centre of the milled recess.

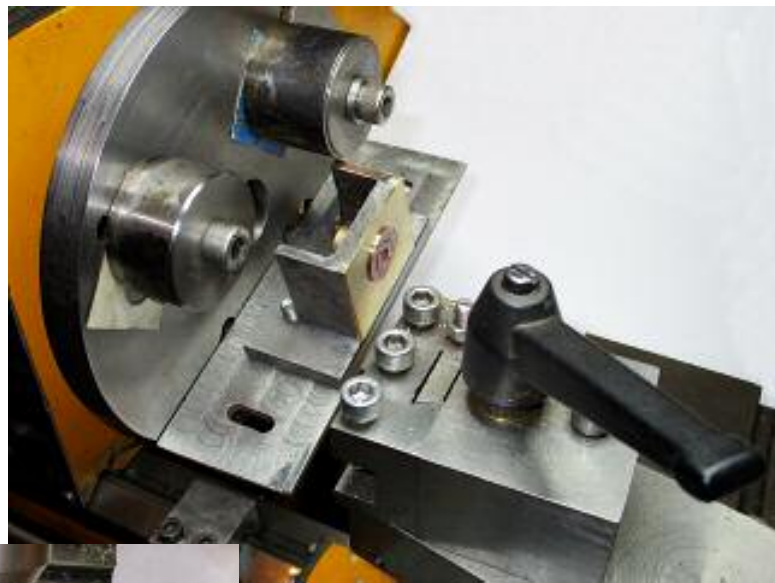
I cut off a suitable piece of 1.5mm brass sheet and a piece of brass rod and silver soldered (brazed) the parts together.

The right photo shows the part after silver soldering and pickling in citric acid.



I used the dials on my milling machine to drill four 2.5mm holes on the under side of the cover and mounted it on a sub-plate that I clamped to an angle plate on the lathe faceplate – right photo.

I could now face the end that will face the cylinder and turn a 19mm spigot and drill a 3.8mm hole through the brass rod and ream it to 4mm.



The work was then mounted on my home made rotary table with the 4mm reamed hole at the centre of the rotary table. The work is a couple of millimetres above the table surface.

Then 6 holes spaced 60 deg. apart were centre drilled on a 26mm PCD using a long centre drill – left photo. I just marked the position of the 6 holes, then used a 3mm drill and drill through.

The Cover was mounted on a piece of angle iron on my rotary table and the top half milled round – right photo.



I also milled the "side walls" of the cover – left photo.

Cylinder

The Cylinder was fabricated from a piece of 32mm dia. leaded gunmetal and I silver soldered (brazed) another piece of gunmetal to the turned cylinder.

The gunmetal rod was first centred in the 4-jaw and the end faced, then the piece was turned around and the other end faced and centre drilled. The cylinder was slightly over length as this stage. The work could then be moved further out and supported by a tailstock centre – right photo. Part of the cylinder was turned down to a diameter of 25mm – as seen in the right photo.



The portface was made from another piece of leaded gunmetal, first the piece was squared up in the milling machine. I then used a milling vise clamped on its side to hold the work while using a 20mm slot drill to mill a curve on the side that will face the cylinder – right photo that also shows the cylinder.



I then used my boring head to bring the curve to fit the cylinder – left photo.



The two parts were then fluxed and silver soldered (brazed together) – right photo.

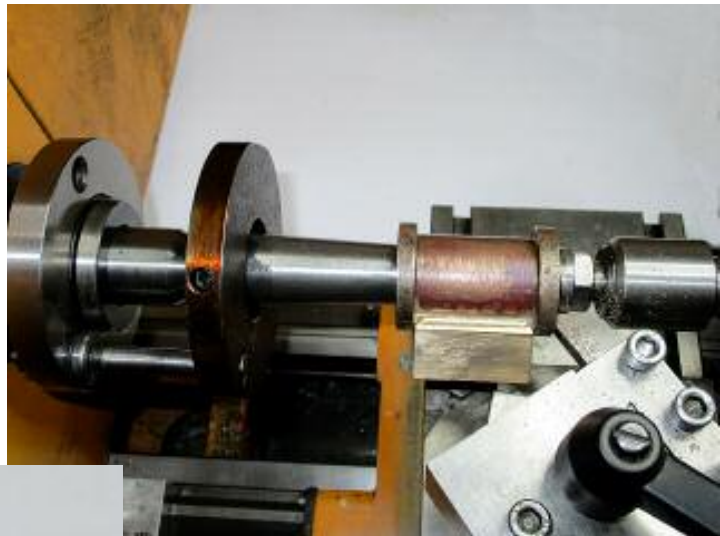
The work was then mounted in my indexer on the milling machine table and the portface finish milled – right photo.



The work was then mounted in the 4-jaw and I could use the previously drilled centre hole to centre the work on the cylinder part. I drilled through the cylinder and finished with a boring bar – right photo.



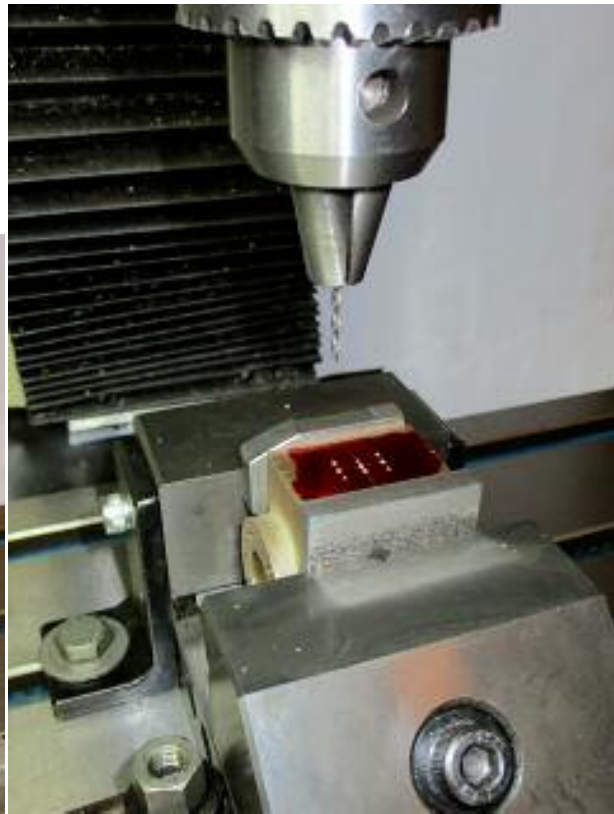
The work was then mounted on an expanding mandrel since I had a sleeve that fit the cylinder bore. This way I could finish turn each end of the cylinder – right photo.



A friend sandblasted the cylinder for me – left photo.

I used the Cylinder Cover to spot and then drill and tap (M3) six holes in the Cylinder flange.

The cylinder was then mounted with the portface up in the vise on the milling machine, and I used the hand dials to mark out the position of the three ports – right photo. I then drilled a hole in each



port to make it easier for the tiny slot drills I used to mill the ports – left photo.

I also turned the work 90 deg. and drilled a hole from the outside and into the exhaust port.

I used my tilting vise to drill the 2mm steam passages from the end of the Cylinder and into the steam ports – right photo.

Before drilling I used a small slot drill to mill a flat to make it easier to start the drill.

I had marked out the bottom of the port on the side of the portblock so I could measure how deep to drill (you don't want to drill through the steam port and into the exhaust port).

I also made a Cylinder Cover for the other cylinder end.



Steam Chest

I fabricated the steam chest from pieces of brass. To try and prevent the pieces from moving during the brazing process I drilled a few small blind holes and put short pieces of brass rod into the holes – right photo.



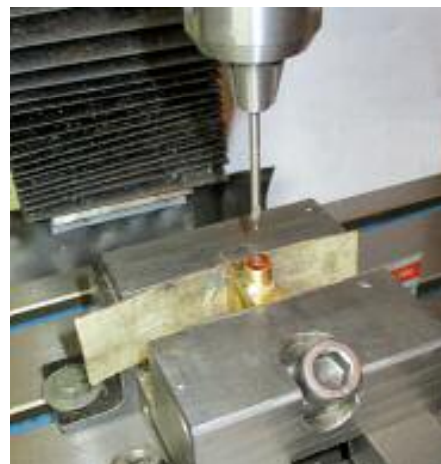
The left photo shows the parts fluxed and ready to be silver soldered (brazed) together. In spite of the pins used some parts did move slightly.

The right photo shows the Steam Chest and cover after pickling and use of emery cloth.



The Steam Chest was transferred to the milling machine and the position of the various holes marked. The left photo shows the drilling of four 3mm holes – one in each corner.

I used a long centre drill to mark the position at the 2.5mm dia. blind hole at the rear of the Steam Chest – right photo. This will give the Valve Rod some extra support



The Steam Chest could then be used to mark out the position of the four 2.5mm holes in the Portface of the Cylinder, the 2.5mm holes were then tapped M3 – right photo.

The same procedure was used for the cover except I used a 3mm drill.



Slide Valve

The Slide Valve was made from free-cutting stainless steel (303). The stainless steel rod was clamped in a square ER-32 Stevenson block so I could mill the protruding part rectangular – right photo. I also drilled two 3mm holes at right angles, these will make the bottom of the slots for the Valve Rod and nut rounded.

The work was then transferred to my lathe and a light facing cut taken. I then used a slot drill to mill the recess in the valve, the corners were dealt with later.



Then the rectangular piece was parted off and transferred to the milling machine to finish the recess – left photo.

The work was then turned around in the vise and the slots for the Valve Rod and Valve nut milled – right photo.



The left photo shows the Valve and nut.

Conrod and Big End Bearing

The Conrod was fabricated from a piece of 5mm dia. mild steel rod and a piece of mild steel. The two parts were silver soldered (brazed) together. After pickling in citric acid the Conrod was dipped in a Sodium Bicarbonate solution to neutralise the acid. The end of the rod with the mild steel piece brazed on will be the Big End, the other end of the rod was heated and hammered flat. After the work had cooled I milled the sides flat – right photo. I just measured the length from the Crosshead to the Crankpin and added about 5mm when cutting the 5mm rod.

This end of the Conrod was now a bit over length so I drilled a small centre hole and mounted it in my lathe. I mounted my Boring Head in the lathe tailstock and placed a small revolving centre just off centre so I could turn the main part of the Conrod with a slight taper (largest diameter at the big end) – right photo. The part with the centre hole was removed when shortening the rod to correct length and threading M4.



The Big End bearing was made from two pieces of gunmetal left over from the portblock. I milled the two flats that will be joined and drilled two 3 mm holes through and clamped them together – right photo.



The centre was marked and drilled and reamed to 8mm – left photo.

The bearing was then mounted on a mandrel with a diameter slightly over 8mm so when the two screws were tightened the bearing was firmly clamped on the mandrel and I could turn the sides so the bearing would fit on the Crankpin – right photo.



Valve Rod

The Valve Rod was made from 3mm free-cutting stainless steel (303). One end was turned down to 2.5mm to fit in the blind hole in the Steam Chest and I used a tailstock dieholder when threading the M3 thread – right photo.

The other end was threaded M3 the same way for about 4mm.



Piston

The piston was turned from a piece of free-cutting stainless steel (303). I used a narrow parting tool to cut two packing grooves – right photo.

The Piston rod was also made from 4mm dia. free-cutting stainless steel (303) and threaded M4 at each end.



Crosshead and guides

The Crosshead guides were made from pieces of Cast Iron from old car disc brakes. The material was fine grained and easy to machine.

The guide supports were parted off from a 6mm mild steel rod, before parting off I drilled a 3mm hole in the rod.



The Crosshead was made from a piece of mild steel milled to dimensions and a 3.3mm hole drilled in the end facing the Cylinder, the hole was tapped M4 to connect with the Piston Rod. At the other end of the Crosshead a slot was milled for the Conrod end, and a 2.5mm cross-hole drilled. The hole was opened up to 3mm for most of its length, the last part was tapped M3. A 3mm brass rod was threaded at the end and used to connect the Conrod to the Crosshead. Since the guide supports were slightly short I had to shim the bottom guides with some pieces of stiff paper.



Eccentric

I used some Cast Iron for the Eccentric Sheave and fabricated the Eccentric Strap from a short piece of mild steel tube and a piece of mild steel silver soldered (brazed) together right photo.

The hole for the Crankshaft was drilled 2.6mm



off centre and reamed to 8mm. A 3.3mm hole was drilled radially and tapped M4 for a grub screw.

The Eccentric Strap's protruding end was drilled 2.5mm and tapped M3 and a 3mm mild steel rod was used for the Eccentric Rod.

Here's a photo of the finished engine.

