Re-boring a Polly – *Mike Brown*

At the end of the 2011 running season my Polly was having a lot of trouble with lubrication. I was so fed up that I just shoved the Polly into the van, and then into a far dark corner of the workshop in disgust. Eventually I made a new lubricator over the winter (see previous article). The first run out of the 2012 season was at Llanberris Slate Museum. Steaming up went well, but as I opened the regulator there was a spray of rusty water which went everywhere (including over me). I instantly realised that in my haste to bury the Polly at the end of the season, I had forgotten to squirt some oil into the cylinders and to open the drain cocks. This would not have been so bad if a senior member of the club had not been watching and had shot me a look of shear disgust! I could really have crawled into a hole. Anyway having cleaned up, the Polly ran well for the rest of the event and I tried to forget all about it. However at Hen Blas, things went well on the first day, but on steaming up on the second day all I got when opening the regulator was a lot of steam and no appreciable motion. It soon became clear that there was terminal blow past the pistons.

It was quite a few months before I could find workshop time to find the problem, but eventually the Polly went up on the turnover stand. When the end covers came of the cylinders a sorry sight awaited. There was a clear "tide mark" about 1/3 of the way up the cylinder walls (see fig 1). Below this there were clear signs of corrosion. So what had happened was that the cylinders had filled up with condensation and had then sat all winter rusting away. I should not exaggerate this, the depth of corrosion was probably no more than a few thou, but the surface was roughened. The Polly uses O rings. These have put up with considerable abuse when the lubricator was not working, but running over a rust roughened surface was too much for them

Fig 1

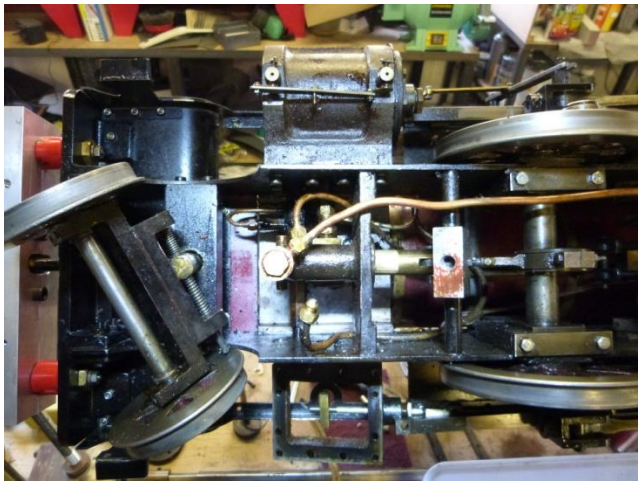

Fig 2

At first I thought that it was not going to be possible to remove the cylinders without taking off the boiler (see fig 2), but that prospect spurred me on and I eventually decided that it might be possible. Sure enough, after a titanic struggle with nuts and bolts near impossible to reach, I had the cylinders on the bench (see fig 3).

Now came the difficult decision, what to do to cure the problem. I could just use a cylinder hone to smooth out the surface. This should work as the cylinders do not have to be round for new O rings to seal, they should easily accommodate a few thou "ovality". This did, however, seem to be a "cheat" and I then thought of re-boring the cylinders. This would work, just a few thou off and maybe I could get away with the same pistons (although technically new slightly larger matching ones would be better). However I reasoned that both of these solutions would leave open the option for the same problem to re-occur. It then occurred to me that a better option would be to sleeve the cylinders with something that will not rust. As it happened, I had a suitable length of Calphos 90 (free cutting phosphor bronze) on the shelf, so that was decision made.

I have a 4 jaw chuck big enough to hold the cylinders, but the problem was how to centre them for boring. Normally I would just use a lever dial gauge on the bore, but now the bore is no longer round all the way. In the end I used a plug. This had one end turned to the dia of the bore with a flange that I could fix to the existing holes in the cylinder (see fig 4).

The plug was fitted and the first cylinder centred as shown in fig 5. Boring the cylinder was now a straight forward task as shown in fig 6.

Fig 3

Fig 4

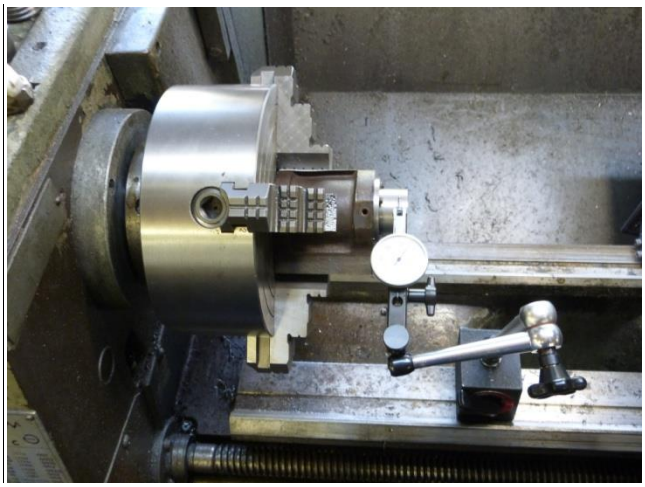

Fig 5

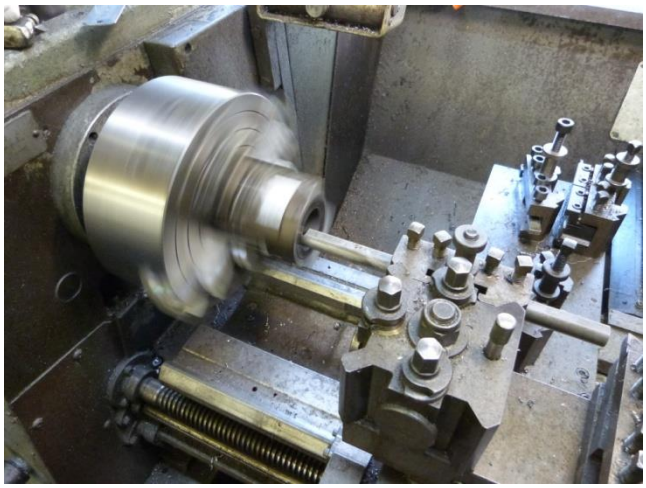

Fig 6

I was not sure how thick to make the bronze sleeve, but I settled on a 2mm wall thickness as providing enough mechanical strength to handle, while not being too thick and so getting too close to other things such as the end cap bolt holes. However at this thickness I was concerned that I might "breakthrough" into the transfer ports when boring. On reflection I decided that this would not matter as the sleeve itself would "heal" any holes and I pressed ahead with the boring. Sure enough there was a small breakthrough (see figs 7 and 8) but as hoped this did not cause any problems.

Fig 7

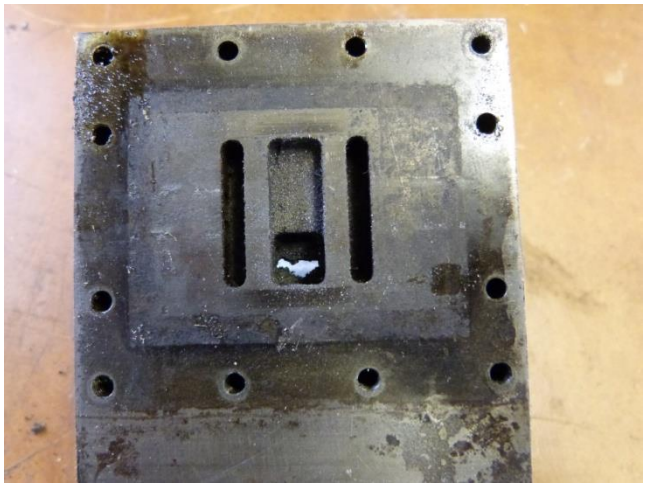

Fig 8

The next job was to make the liners. This was a simple turning and boring job, but how big? The bore size was obvious, but what about the OD. This depended on how the liners were to be fixed to the cylinders, I could go for a press fit, but in the end I decided to glue the liners in. I found some high temperature adhesive on the internet, Permabond 920. This stuff claims to have a working temperature of 250 deg C, more than enough (I hope). Once fitted the liners will not be able to move anyway as they will be held in place by the end plates (at least that is the theory). I made the liners to be a good sliding fit into the bores. Having made the liners I made a simple hone out of a large lump of aluminium (see figs 9 and 10). The splits in the end section of the aluminium expand as the tapered bolt was screwed in. I used some 500 grit lapping paste and set the lathe speed to about 100 RPM. After about 15 minutes of changing the sleeves over, turning them around, recharging the abrasive and gradually nipping up the bolt I finally had a nice smooth matt finish to the bores. (In theory - a surface with very fine abrasive marks is better than a polished smooth surface as the micro groves retain oil – in theory!)

Fig 9

Fig 10

A finished cylinder and a finished liner can be seen in fig 11. Actually, before I inserted the liners I took the opportunity to cut notches in the liners to align with the steam passages as I thought it would be easier than when they were bonded in (big mistake).

Fig 11

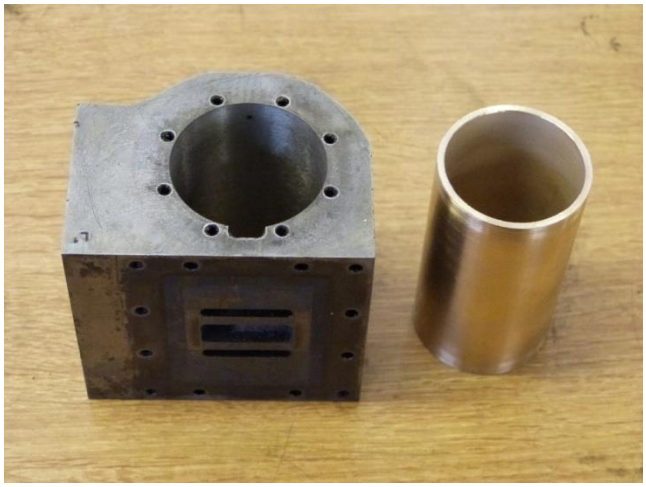

Fig 12

Now to stick the two together. I smeared a liner with adhesive and dropped it into place – perfect. In a couple of seconds it was bonded tight. That should have warned me. Onto the second, more glue smeared and in went the liner only to catch and jam half way down – tried to pull it out – no way! It was then that I realised the glue was actually a cyanoacrylate* (super glue) as opposed to an anaerobic glue (like loctite*), it even says instant glue on the label (if only I could read).

The setting time is just seconds, hence my problem. To get the liner out I had to heat it up to over 250 deg C (carefully avoiding overheating), pull out the liner clean it and the cylinder up and start again. Unfortunately it took 4 more goes before I finally got it right. It's very tricky guiding the liner in to exactly the right orientation, fairly quickly and with no early stopping. The first one must have been beginners luck. In hindsight if I had not cut the notches in the liner things would have been much easier. Still this is how we learn!

A finished liner in place can be seen in fig 13 and the cylinder back in place about be reunited with the piston can be seen in fig 14.

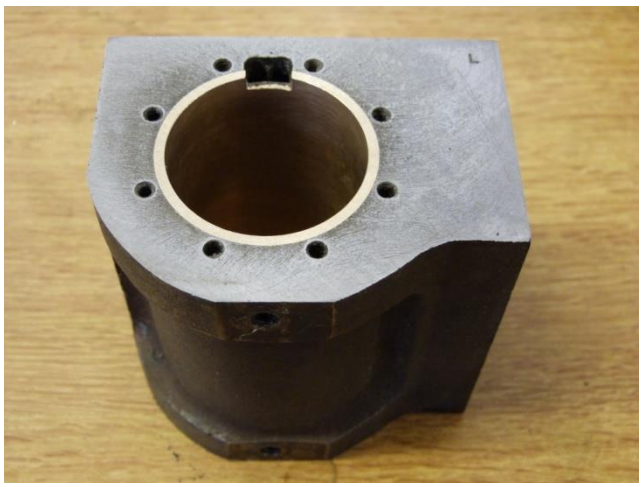

Fig 13

Fig 14

I will let you know how the liners work out in due course.

Some Boring Observations – *Mike Brown*

This article (sort of) follows on from the last one (or at least there is a link). I have recently managed to find some time to get back to building my Hunslett. The most recent job has been machining the cylinders (something I started over 6 months ago!). They have been tricky because there is so little spare on the

castings. Anyway, I clamped each cylinder in turn to a large faceplate for boring (see fig 1). After boring I proceeded to hone them as per the previous article (see fig 2).

Fig 1

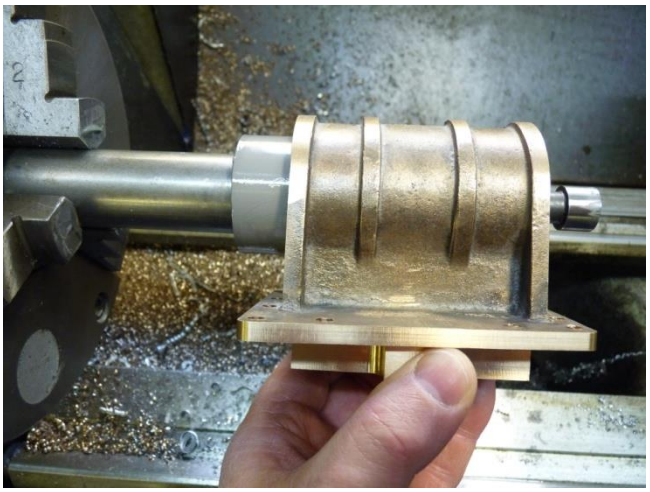

Fig 2

I then noticed a couple of things that may be of interest to others. As I monitored progress an unusual pattern started to appear in the bores (see fig 3 below).

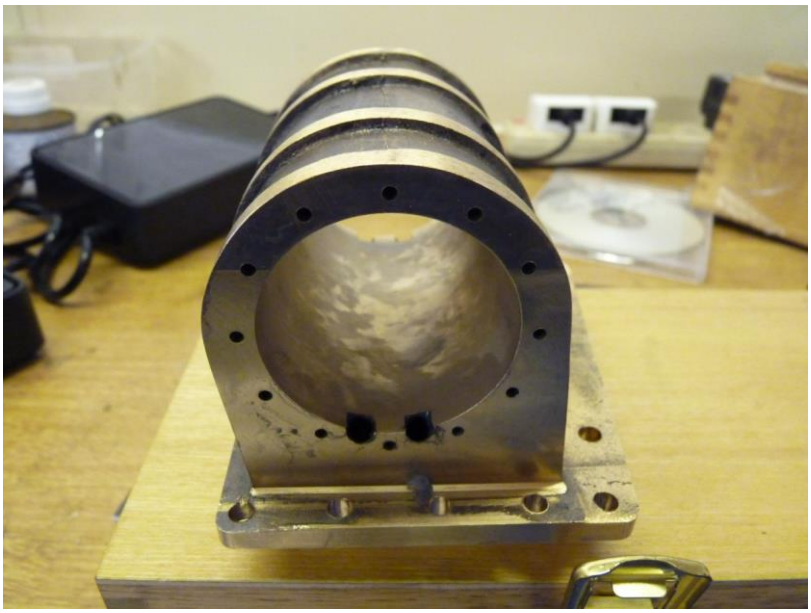

Fig 3

The pattern had a random mottled effect and was more noticeable on the tops and bottoms of the cylinders, rather than on the sides. After a little head scratching I came up with the following explanation. As the cylinders are honed, the honing starts to take off the high spots first (leaving a dull fine matt finish). So why the mottling? I think that this is caused by the crystalline structure of the metal; it is a casting after all, so it is reasonable to expect crystals to form as the metal solidifies. Each crystal will be aligned differently and will have slightly different machining properties. Thus some crystals will be machined slightly deeper than others as the boring bar deflects, hence the mottling. So what about the pattern being more pronounced top and bottom of the cylinder. Easy explanation, if you look at how I was clamping the cylinder to machine it, you will see that the effect will be to squash the cylinder slightly. Thus when the clamp is removed the

cylinder will spring back causing the bore to become oval top to bottom; thus when honing, the sides of the cylinder will be smoothed out first.

I must say that I am surprised by these effects. First, I am amazed that the crystalline structure has enough effect on machining to be seen. Second, I am also amazed that the clamping force was enough to cause a significant effect on the shape of the cylinder (I did not do up the nuts that tight!) To get this in context though, after boring (and before honing) I set up the cylinders vertically in the mill to do some machining on the ends. I used my trusty centre finder to locate the thing. This has a dial gauge that is set to run true to the bore. When setting up, the deflection of the gauge was no more than 0.01mm (less than half a thou), so we are not talking about huge amounts here. Yet more lessons for the future.