Gearbox Assembly 101

By Mark Schutzer 4/13/06

Introduction

If you are planning to re-motor an old brass locomotive you may want to upgrade to a new gearbox at the same time. The early 60's and 70's gearboxes fell into a couple of groups, KTM built gearboxes and non-KTM built gearboxes. As a general rule most of the early non-KTM gearboxes are junk and need to be replaced.

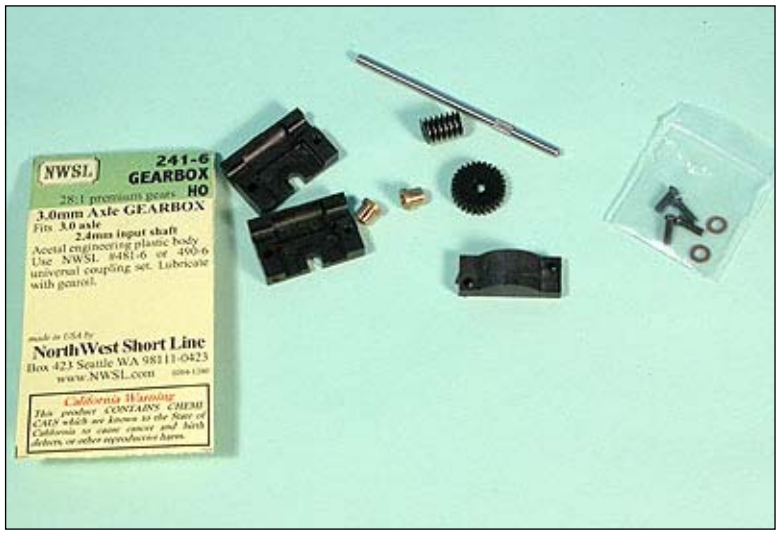
KTM built a quality gearbox and many of these continue to work fine after 30 plus years of service. Even if the gearbox works fine you may want to consider an upgrade to reduce the level of the gearbox noise. The KTM built gearboxes use square cut gears and these tend to be noisier when compared to a new NorthWest Short Line (NWSL) gearbox.

This write up is for those who are considering a gearbox upgrade. I'll show you step by step how to assemble and adjust a gearbox. Gearboxes may seem like they should be simple to put together but in reality there are a few things that need to be adjusted to achieve the best possible performance.

Before Beginning

Let's first begin by looking at the parts that make up a typical gearbox. Most brass steam locomotives use one of two common types of gearboxes. If the worm directly drives the wormgear on the axle the gearbox is called a non-idler type. If the worm first drives an idler gear then the gearbox is referred to as an idler type gearbox. Here are a couple of photos showing the parts from both types of gearboxes.

Here is a photo of a larger 0.4 mod non-idler gearbox.



Here is a photo of a smaller 0.3 mod idler style gearbox. Note the extra idler gear.

As this write-up is primarily about the assembly of the gearboxes I would refer the reader to the NWSL website at: http://NWSL.com for more information on the types and sizes of available gearboxes.

Before beginning be sure to read the instructions that come with the gearbox. The instructions describe all the basic steps of putting the gearbox together and serve as a good starting point.

The assembly of gearbox breaks down into four overall steps:

1. Assemble the worm on the worm shaft.
2. Preparing the gearbox.
3. Install axle gear on drivers.
4. Assemble, lube and test the gearbox.

While this may seen straight forward there are a few more details to each of the steps.

Required Tools

In order to remove and install gears you will need some specialized tooling. Fortunately NWSL sells all the tools that you will need for the job. The new gears are press fit on the shafts using a press such as NWSL's Sensipress. Pulling drivers and gears can be done a couple of ways, using a NWSL puller, or by using the Sensipress with suitable backing plate. A quartering tool such as NWSL's Quarterer or Quarterer 2 is also helpful for reinstalling the drivers in the correct orientation. NWSL "Aligner" blocks help assure the correct alignment of the new wormgear. You will also need a miniature Phillips head screw driver for assembling the gearbox parts.

While these are the only tools that are required, I recommend getting a couple of small metric taps in the sizes of 1.4mm and 2.0mm. You may also occasionally need a 2.4mm hand reamer. I'll discuss the use of these optional tools later on.

Worm and Wormshaft

Checking the worm

Before going any further it is a good idea to check the fit of the worm on the worm shaft. The worm is supposed to be a light to loose press fit on the shaft. As this requires extremely tight manufacturing tolerances you occasional will run into a worm that fits a bit loose and sometimes one will be a bit tight.

To test this I try and fit the worm on the unsplined end of the worm shaft. Using the Senispress I test the fit by pressing the worm on the shaft. If it presses on easily then everything is fine. If the worm is hard to press on and you feel like you are going to bend the wormshaft then stop; the worm will have to be reamed out. After the test, flip the worm over and use the Sensipress to press off the worm gear.

If your worm is too tight you need to fix this before proceeding. An overly tight worm can be easily fixed with a 2.4mm hand reamer. A reamer is a special type of cutting tool that is designed to create a hole of very precise size. If you plan to work on a bunch of gearboxes it's a good idea to have a 2.4mm reamer in your toolbox. As with all the other needed tools the reamer is carried by NWSL.

A reamer is not hard to use, but it does require care to make sure that you do not over enlarge the hole in the worm. To use the reamer mount it in a drill chuck such as the one on a portable drill. You don't need the drill motor, you just need to use the chuck so you have something to hold on the reamer. Then liberally apply cutting oil to the reamer and holding the worm in your hand carefully twist the worm over the reamer and keep twisting the worm until you have worked the reamer all the way through the shaft. You should only be removing a thousandth of an inch or so you should be able to twist the worm over the reamer with hand power only.

If this sounds too adventurous for you then I would suggest that you return the gearbox to the dealer for a replacement worm.

If the worm is a little loose this is not usually a problem as the wormshaft is splined.

Checking the thrust bearing surfaces of the worm

The ends of the worm are a load bearing surface and must be flat and smooth to prevent noise and vibration. Take a close look at both ends of the worm, if they are not perfectly flat you may want to polish them.

Here is a photo showing the end of a worm that is a bit rough.

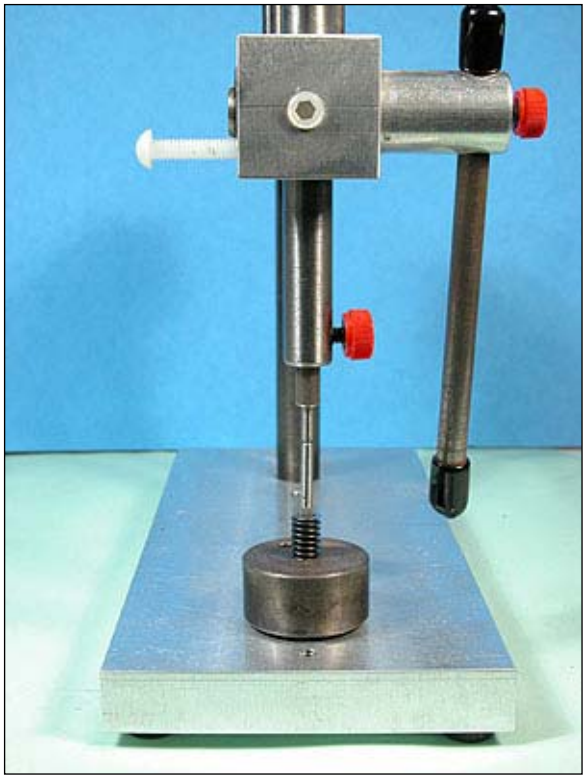
If you have a drill press you can easily polish up the ends of the worm using some 400 grit and 600 grit sandpaper. Just press the worm partially on an extra piece of worm shaft and mount in the drill press chuck. Place a solid surface under the drill press and place the 400 grit sandpaper on top of the surface. Put a little oil on the sandpaper and then start the drill press and bring the worm down until it contacts the sandpaper. Start with the 400 grit and then finish up with the 600 grit. Here's a picture showing the polishing and another one showing the results.

Assembling the worm on the worm shaft

In most applications you will probably need to shorten the length of the worm shaft. A cut off wheel in a Dremel tool works well for this. After cutting use a file or a grinder to chamfer the cut off end of the shaft.

The next step is to press the worm on to the worm shaft. If you are using the supplied worm shaft you want to make sure that the worm is pressed on so that is centered on the splined portion of the shaft.

Here is a photo showing the pressing of the worm on the shaft.



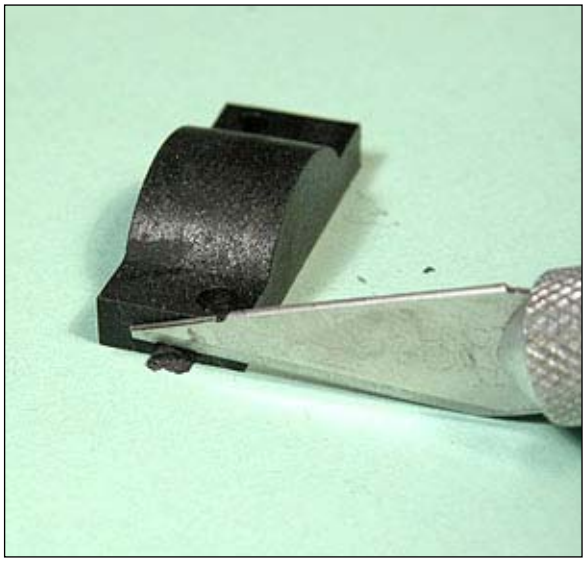
The next step is to slip the bearings on the worm shaft and test the fit in one of the gearbox halves. The bearings should be installed with the larger diameter end facing the worm. There are two thrust washers that are included with the gearbox, these washers are used to eliminate the endplay in the worm. Place the worm and bearing assembly in one half of the gearbox and add thrust washers as necessary to eliminate the endplay to less than a washer thickness. Sometimes you will need more than the two washers that are included.

Here's a picture of the worm assembly with the thrust washers in place.

Preparing the Gearbox

The gearbox housing consists of two halves and a bottom portion that secures the axle in place. On NWSL gearboxes the housing parts are made from Acetyl plastic. Before the parts can be assembled some preparation work needs to be done.

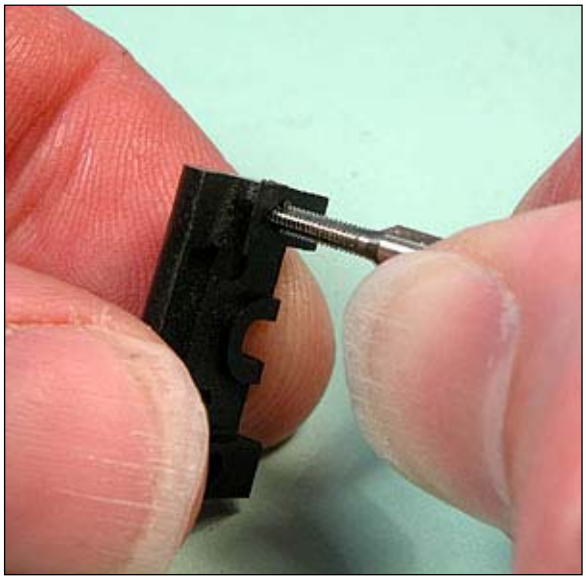
Clean off flashings



The first thing to do is clean up the parts to remove any remaining flashings as shown in the next photo.

Tap screw holes (optional)

The gearbox pieces are all held together with small metric screws, the smaller 0.3 mod gearboxes use 1.4mm screws, and the larger 0.4 mod size use 2.0mm screws. Per the gearbox instructions the screws will self tap themselves into the holes provided. While this does work, it takes a bit of applied force with a screwdriver and it is easy for the bit to slip resulting in a dinged up head on the screw.



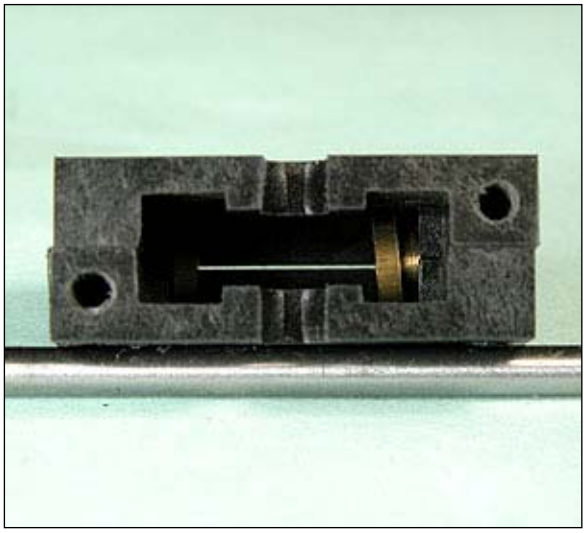
This next step is considered optional but I like to use a tap to thread the holes making the assembly of the screws much easier. As the gearbox is plastic the holes can be tapped very easily by just holding the tap between you fingers as shown in the next photo.

Check the bearing fit in the gearbox

When assembled the worm shaft bearings are supposed to be securely held in place by the two halves of the gearbox. In order for this to work right the bearings need to be a little larger than the space between the gearbox halves. With the smaller 0.3 mod gearboxes this is usually correct, but I have found that the bearings tend to be loose on some of the larger 0.4 mod gearboxes.

To check the bearing fit assemble the two halves of the gearboxes with the bearings in their correct place. As you tighten down the screws, reach inside the bottom of the gearbox using a small jeweler's screwdriver and press the bearings up against gearbox ends. When the gearbox screws are tightened completely the bearings should not move.

After assembly use a small jeweler's screwdriver and from the outside of the gear box, press against the end of each bearing and try to push it out of place. These bearings should be snug and should not move easily.

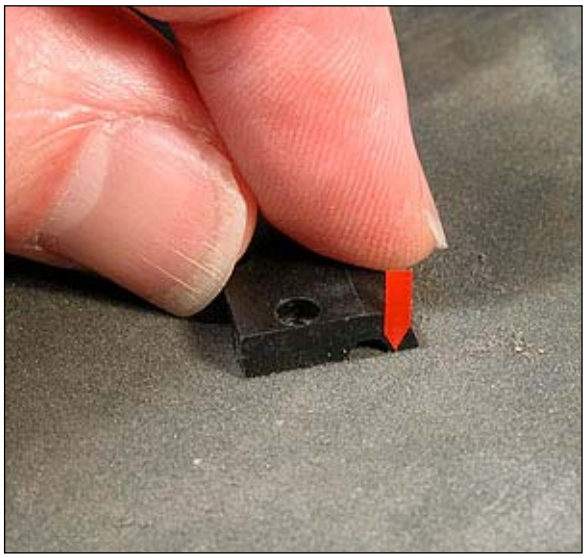


Here is a photo of a 0.4 mod gearbox showing a loose bearing that will not even stay in place.

If the bearings are loose the gearbox needs to be adjusted to correct this. If the bearings are flopping around loose the gearbox will destroy itself as I learned the hard way.

As you can't make the bearings any larger the way to fix this is to put a slight taper on the gearbox sides so that bearings are pinched in between the gearbox halves.

Here is a photo showing one of the gearbox sides on a piece of 220 grit sandpaper. You want to sand a slight taper on the gearbox, so you want to apply pressure to the gearbox top (indicated by the red arrow) and then gently make a few passes across the sandpaper. Make a few passes on each of the gearbox halves, then reassemble and test the fit of the bearings once again.

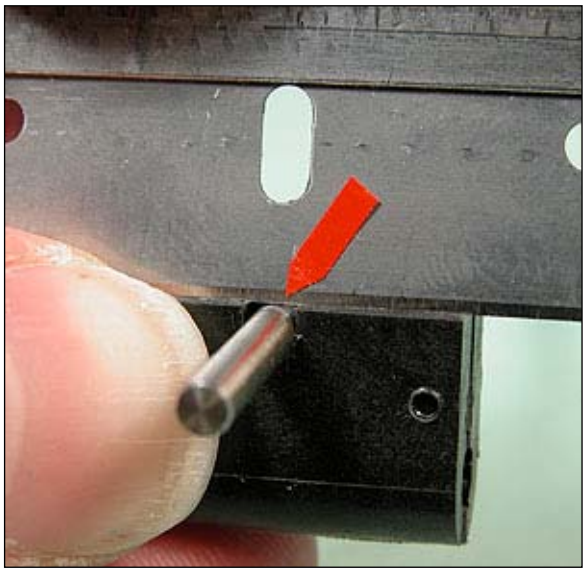


Keep repeating this process until the bearings are held snugly in place. Be sure to go slowly and test often so you don't take off any more material then necessary.

Checking the vertical axle play

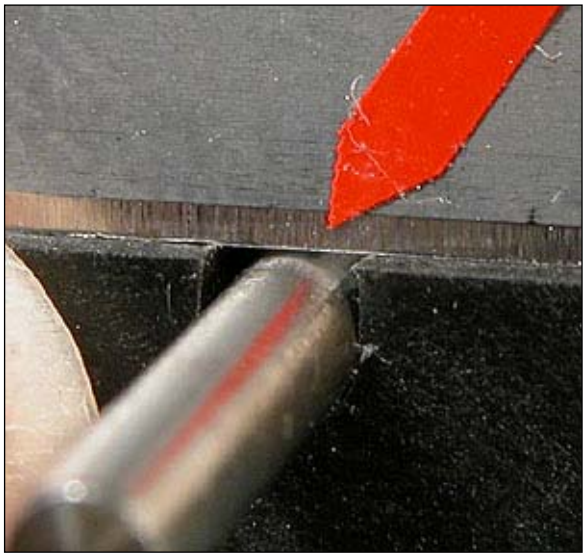
The same gearbox housing is used for both 1/8” diameter and 3mm diameter axles. If your locomotive uses 3mm axles (typical of brass imports) the gearbox will likely have excess vertical play in the axle bearing area.

The easiest way to check for excess play is to use a piece of 3mm shafting and a single edged razor blade to check the clearance between the axle and the bottom plate.



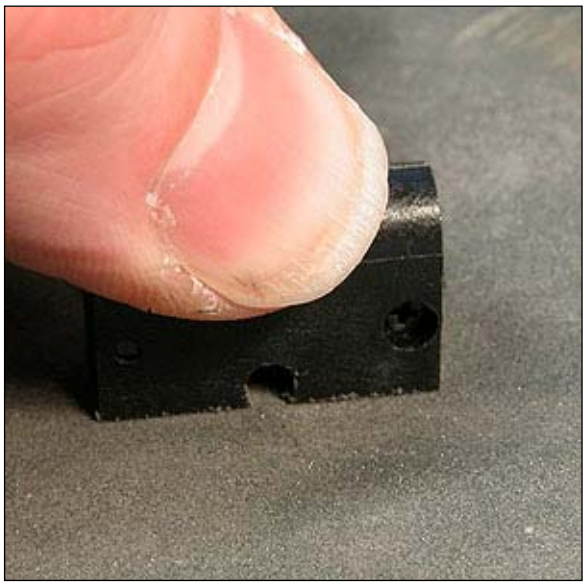
Note the gap between the axle and the bottom surface in the close up photo.

To reduce this gap lightly sand the bottom side of the gearbox with some 220 grit sandpaper as shown in the next photo. Make sure that the gearbox halves are square and aligned with each other before sanding. If you are working on an idler gearbox it’s a good idea to install the idler gear in the gearbox to help align the gearbox sides. Once again easy does it, just make a few light passes and recheck with the axle and razor blade.



If your locomotive has 1/8” axles your axle may be a little tight and may require that you remove a little material from the gearbox bottom cover. See the instruction sheet for more on this case.

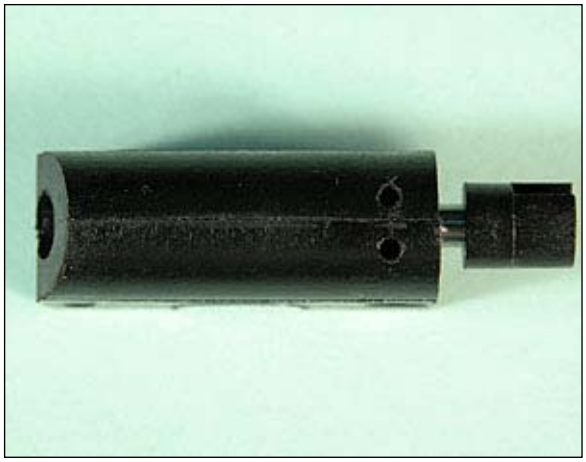
After you finish the adjustments screw on the bottom cover plate and use the piece of axle shaft to verify that the axle spins free and that you have minimal vertical play.



Drill the holes to secure the torque arm (optional)

If you plan to use an overhead torque arm to secure your gearbox it’s time to drill the holes in the top of the gearbox. I typically use 1.4mm screws to secure the torque arm to the gearbox.

I drill two .043” diameter holes near one end of the gearbox as shown in the adjacent photo. For a 0.4 mod gearbox I drill two holes spaced 0.1” apart and 0.1” in from the end of the gearbox. As you will be drilling into a round surface make sure that you use a rigid drill bit such as spade bit or an old dental bit to prevent the hole locations from wandering. After drilling I tap the holes with a 1.4 x 0.4mm tap.



More optional steps

The larger NWSL 0.4 mod gearboxes are a bit wider than the original KTM gearboxes. Due to the wider gearbox the side to side motion of the geared driver may be reduced somewhat.

So just what does this mean? As a locomotive negotiates a curve the drivers shift their side to side position in response to the curve in the track. If the side to side travel of one of the drivers is reduced it may impact the minimum radius that the locomotive can

negotiate. I say may because the pilot or trailing truck often causes problems before the side to side travel of the geared driver becomes the limiting item.

Anyway the point of all this is to point out that if you provide a little clearance on the side of the gearbox you can maintain the original side to side travel of the drivers.

This next photo shows where .010" of clearance has been added in the area of the bearings to maintain the original side to side travel, this step is purely optional.

This photo also shows how I filed off a bit of one of the top corners of the gearbox to allow it to fit under the valve gear hanger. I just want to point out that there is nothing sacred about the size and shape of the gearbox enclosure. If you have to customize and file a bit here and there that's okay as long as you make sure that you don't compromise the workings of the gearbox

Installing the new axle gear

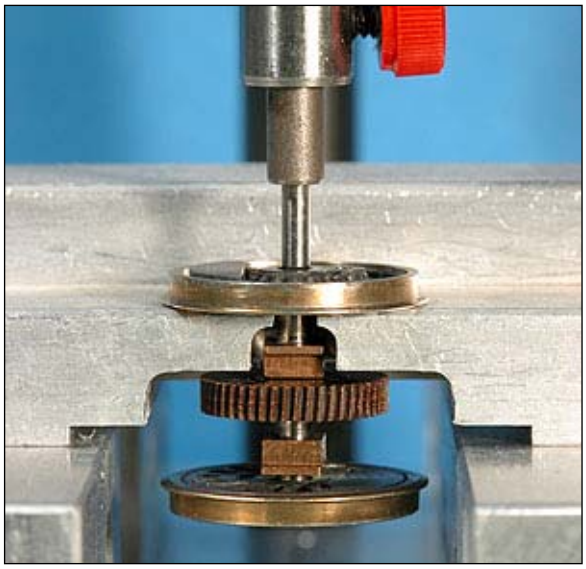
The one thing that frightens most modelers away from changing a gearbox is the thought of having to pull off a driver wheel to replace the axle gear. The good news is that with the right tools replacing the gear can be broken down into a straight forward step by step process.

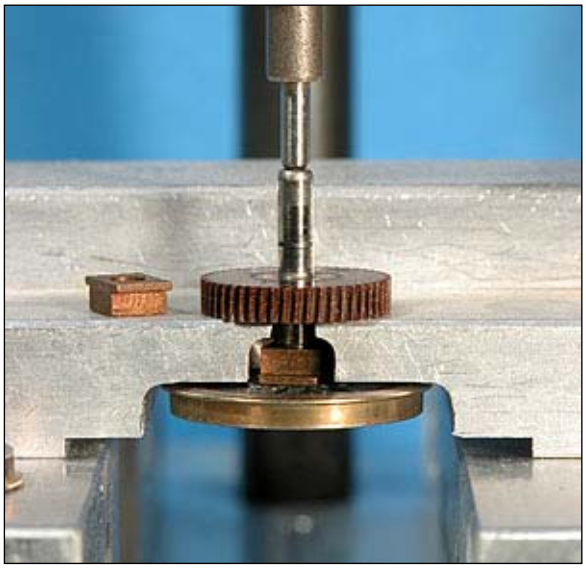
The most important part of this job is making sure that you get everything put back together with the drivers in proper quartering. NWSL makes a couple of tools specifically for quartering, the Quarterer, and the Quarterer 2. These tools are easy to use and designed to hold the drivers at 90 degrees during the pressing operation.

There is also the "pie scribing" method of aligning the driver. If the drivers are correctly quartered you can scribe a couple of lines in the axle that extend into the wheel hub. The two lines should be scribed in pie shape at roughly a 45 degree angle between the lines. When re-installing the driver simply rotate the driver until the scribed lines on the axle line up with the ones on the hub. This way you are sure to get the driver re-installed in its original orientation.

Step 1 – Pull one of the drivers

Use either the “Puller” or the “Sensipress” to remove the non-insulated driver. Here is a photo showing the driver being pressed off.





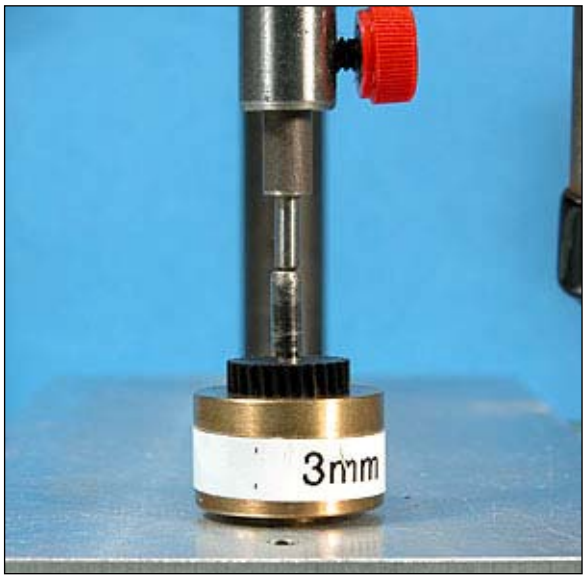
Step 2 – Pull off the old worm gear

Again using either the “Puller” or “Sensipress” remove the old worm gear as shown in this photo.

Step 3 – Press on the new gear

Using an Aligner block slowly press on the new gear. A drop of red Loctite can be added to the shaft to secure the gear if it is at all loose. If you choose to use Loctite just make sure that you keep it away from the bearings.

As you are pressing the gear on stop every so often and measure the location of the gear. You want to make sure that the gear is perfectly centered between the wheels.

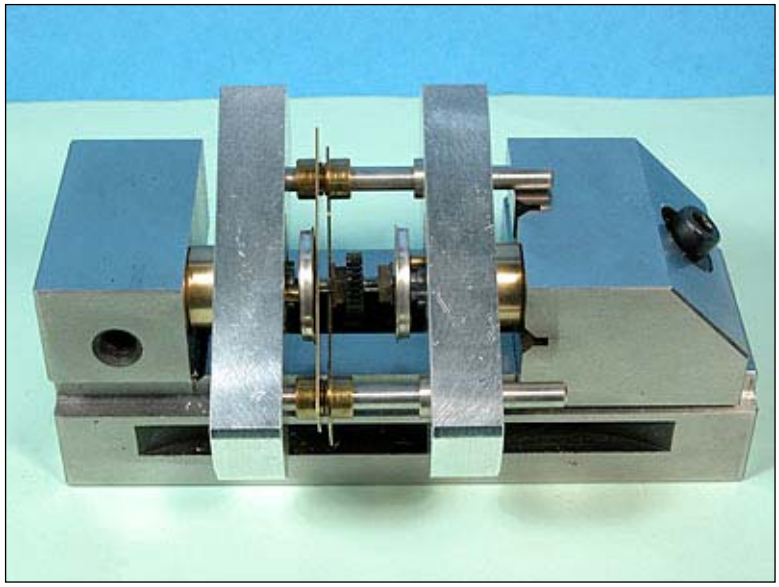


A caliper is helpful in making these measurements. If you use any Loctite be sure to clean off all the excess so that it doesn't get in the bearings.

Step 4 – Reinstall the driver

The next step is to reinstall the driver that you removed earlier. Also don't forget to put the bearing back on the axle before the driver.

If you "pie scribed" the driver prior to removal, carefully align the driver to line up the scribe marks and then press the driver back on using the Sensipress. Be sure to put some support under the mounted driver so you only apply pressure to the center of the mounted driver. Also be sure to use a wheel gauge to properly gauge how far to press on the driver.



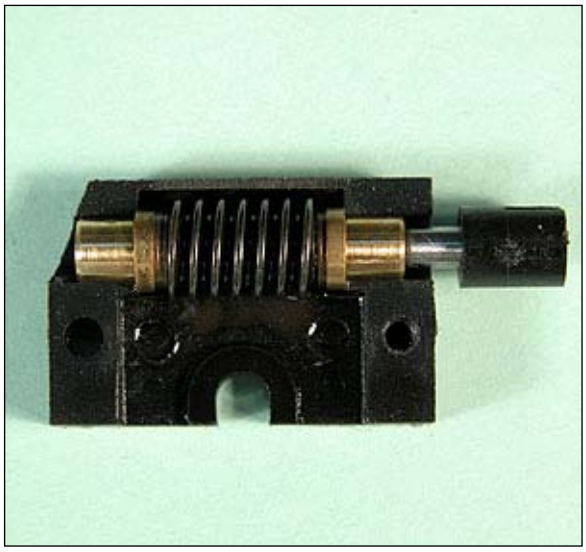
I usually completely requarter all the drivers on the locomotive during a rebuild so I prefer to use a quartering tool to re-install the drivers. Either the Quarterer or the Quarterer 2 will work fine for this. Here's a photo showing the driver set in the Quarterer 2.

I also like to place a drop of red Loctite on the end of the axle before I press the driver back on. The Loctite prevents the driver from slipping in case of a looser fit. Many of the early KTM models just used a tapered axle and often the wheel fit is somewhat loose especially when the drivers are gauged properly. Once again be sure to keep the Loctite away from the bearing areas and wipe off any excess otherwise it will do a very good job of locking up the bearings.

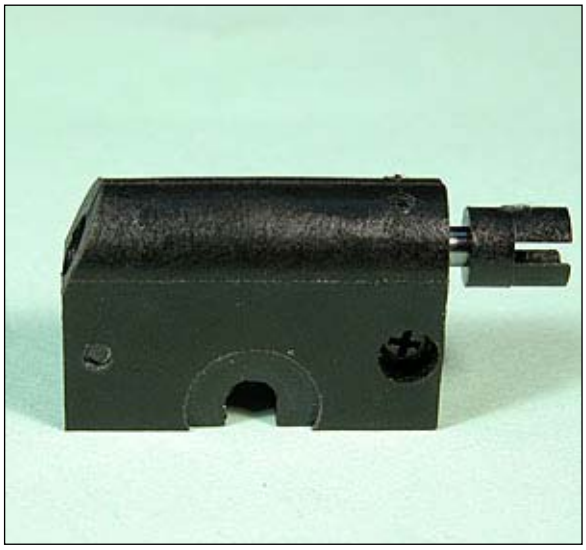
Putting it all together…

Now that everything is prepared it's time to put everything together. Place the assembled worm assembly with the washers and bearings in it place in one of the gearbox sides. Lubricate the bearing surfaces with a light oil such as Labelle #108. Lubricate the worm with a gear oil such as Labelle #102. If your gearbox is an idler type install the idler gear next, once again lubricating the shaft areas with Labelle #108 and the idler gear with Labelle #102.

Now install the other gearbox half and secure it in place with the two screws provided. Make sure the gearbox halves are aligned and square.



Tap lightly on both of the ends of the wormshaft to help seat the bearings in place. Using your fingers rotate the wormshaft and make sure that everything spins nice and free with out any binding. If you feel any binding or stiffness at any point, loosen the two screws and readjust the position of the gearbox halves until the binding is gone.

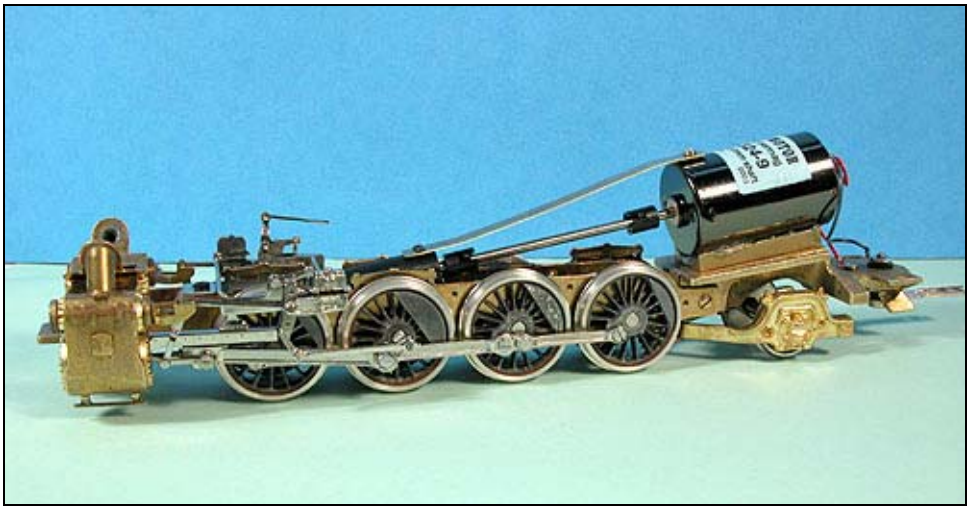


Before installing the gearbox on the driver axle I recommend that you completely reassembly all the drivers, rods, and valve gear mechanisms. Make sure that this all runs freely with out any binds before securing the gearbox assembly to the geared driver. I can't emphasize this step enough, no matter how good your gearbox is it can't make up for a mechanism that is full of binds.

When you are happy with the performance of the driver mechanisms it's time to secure the gearbox to the geared driver. Once again lubricate the axle gear with Labelle #102 and the axle with Labelle #108. As you set the gearbox in place you should feel it snap in place. Turn the locomotive's mechanism over and install the bottom cover plate on the gearbox using the screws provided. Tighten these screws until the bottom cover is snug against the gearbox bottom surface.

Conclusion

Your gearbox upgrade is now complete and it's time to test it out on the track. Here's one final photo showing the example gearbox installed in an Espee Mountain.



I hope that some of this has been helpful in encouraging you to upgrade the gearbox in your old brass steamer. With both gearbox and motor upgrades these fine old models can be turned into your most prized runners.

If you are interested in more information on rebuilding brass please see some of my other rebuilding articles on my website at: http://markschutzer.com