PRECISION MACHINE SPINDLE REBUILDING
Educational Video Series

Part 4: Machine Spindle Break-in Procedure

For all the videos in this Educational Video Series, please visit:
http://www.activeatom.com/education-spindle-rebuilding-videos.php

0. Introduction
00:00:19 in video Part 4

Now that the spindle assembly procedure has been completed, we are now ready to perform the *break-in* procedure which is also known as the *run-in* or *running-in* procedure.

a) Spindle 100% Assembled & Functional

At this stage of the procedure, the spindle should be 100% assembled. Also when rotating the spindle by hand, it should feel silky smooth without any binding in rotation or the feel of any bumps or obstructions. If there are any problems with the rotation of the spindle, you need to go back and investigate the issue(s) before proceeding with this break-in procedure.

Also keep in mind that there will be some resistance in spindle rotation due to the preload of the bearings which is completely normal. This type of resistance should be consistent throughout the full rotation of the spindle. If there are areas where the resistance increases or decreases, then this is what we refer to as a binding issue which is not normal and needs to be resolved. This problem is usually due to the bearings or a spindle part that is not properly installed or seated.

b) Preparing for the Break-in Procedure
00:05:11

Nice talk leading up to the break-in procedure as we attempt to lighten up on the precision guidelines shared in regards to these spindles, the bearing break-in times and RPM's. We do share that while you have to perform these procedures for angular contact bearings, we actually perform these procedures on all machine spindle rebuilds.

1. Tools Required
00:07:55 in video Part 4 Section 1

a) Temperature Meter

A Temperature Meter with a Type K Thermocouple is recommended by the bearing manufactures for obtaining an accurate temperature of the bearings.. We actually recommend the use of 2 of these meters or a meter that has 2 Thermocouple inputs so that a temperature reading can be taken at both ends of the spindle at the same time throughout this break-in procedure. As described further in this document, you can use the palm of your hand in lieu of a temperature meter if absolutely necessary but we do not recommend this.

The meters we share from Tektronix were purchased many years ago and are no longer offered so your meters will vary from ours but the results should be the same if you purchase a quality meter. The Magnetic tape that we show in the video and use, is a soft material which holds the very accurate Type K Thermocouples and provide the most accurate reading while not causing damage to the surface and finishes. We also share why you need two thermocouples for the best results. There are also temperature meters available that contain 2 thermocouple inputs so that you don't have to purchase 2 separate meters.

b) Test Indicator & Magnetic Stand
00:14:40

A high quality test indicator with a resolution of either 0.001 mm or 0.000050" is shared in video Part 3 as well. Remember, we need to take measurements of a spindle that leaves the factory with a guaranteed accuracy of 0.000050" T.I.R. (Total Indicator Runout) or roughly a little more than 1 Micron (0.001 mm). The test indicator also needs to be mounted to a small magnetic base which will be mounted on the lathe bed for taking measurements of the spindle.

c) RPM Meter
00:15:28

An RPM Meter is absolutely required for this break-in procedure as the spindle RPM must be set at precise speed intervals. This is a type of meter where you place a piece of reflective tape on the spindle and then aim the RPM Meter at this area when the spindle is rotating, and it will display the spindle speed in RPM.

d) Lathe Setup
00:17:12

Although it's possible to temporary configure a test setup for performing this break-in procedure, we recommend installing the spindle onto the machine it belongs to and here is why.

We mention in the video that a person that rebuilds spindles for a living will own a machine spindle test bed with meters as a break-in station but somebody that is performing this spindle rebuilding procedure such as yourself, you will not have such a test bed so the next best thing is installing the spindle on the machine that it belongs to.

For this break-in procedures, we will be mounting the Levin Headstock onto the lathe bed which will give us a solid platform for performing this break-in procedure and will also allow us to take accurate measurements of the spindle.

2. About the Break-In Procedure

00:19:27 Part 4 Section 2

a) Why do We Need to Perform the Break-in Procedure?

A common misconception of this spindle break-in procedure is that the bearings themselves need to be broken in but mechanically, the bearings as provided by the manufacture are ready to be used at full speed and load immediately once they are installed on the spindle. It is the lubrication (grease) that is used in the bearings that needs to be broken-in.

There are 2 reasons why we need to perform this break-in procedure.

- The results you see during the break-in procedure will allow us to determine if there are any problems with the spindle as we only want to put a healthy spindle back into service.

- Distribute the excess grease out of the way of the rolling elements (ball bearings & bearing cage) otherwise the bearings will experience over heating due to a condition called grease churning. This will cause bearing failure or shorten the bearing life.

b) How are Spindle Problems detected during the Break-in Procedure?

During the spindle break-in procedure, you are focusing mainly on the temperature of the spindle bearings which is our main indicator for determining that the spindle is ready to be put into operation. At minimum, we recommend that you use a temperature meter with a Type K Thermocouple for monitoring the temperature of the bearings but because there are usually bearings at each end of the spindle, we recommend that you use 2 temperature meters or a meter with 2 thermocouple inputs so you can best monitor both ends of the spindle individually. If you don't have a temperature meter and cannot acquire one, you can use your palm placed on the spindle housing to monitor the temperature but keep in mind that this is not preferred or recommended and should only be used as a last resort.

The bearing manufactures recommend that if possible, the temperature readings be taken at the bearing outer race for obtaining the most accurate bearing temperature but in our experience, we have never worked on a spindle type where we could do it in this manner. So we have always placed the thermocouple on the spindle housing as close as possible to the bearing outer race which has always worked fine for us.

During the break-in procedure, you will be monitoring the bearing temperature and paying special attention to any abnormal spikes in temperature. We do not want to see this temperature reaching over 140 F (60 C) during the break-in procedure and would like to see this temperature not reaching over 122 F (50 C) at the completion of the break-in procedure.

In addition to focusing on abnormal spikes in temperature, you also don't want to see a condition where the bearings are not heating up. This condition is usually an indication that the angular contact bearings are not fully preloaded which can be caused by a loose spindle nut or one of the bearings not seated properly. The spindle nut doesn't have to be very tight, just snug enough to ensure that the bearing inner races are being held together on the spindle. Remember that the preload on the bearings are ground into the bearing races by the bearing manufacture so you don't need to over tighten the spindle nut.

c) What does the Break-in Procedure do?

The sole purpose for performing the break-in procedure is to distribute the grease throughout the bearing evenly so that they are no areas in the bearing raceways with significant grease. The most common cause for high temperature of the bearings is excessive amount of grease in the raceways which causes high heat due to churning. Churning is a condition where the bearing rolling elements (ball bearings & bearing cage) are running into the grease vigorously and can even cause the ball bearings to skid inside the raceways. If this break-in procedure is not performed properly or not at all, this can result in the bearing temperature exceeding the recommended operating temperature which can greatly shorten bearing life or worst, cause sudden spindle failure. In the video, we also talk about centrifugal forces and grease flow in this process.

d) Active Atom Break-in Procedure

The Active Atom break-in procedure is a very detailed procedure that we created ourselves over the years after doing many spindle rebuilds. If you research the break-in procedures from the bearing and machine manufactures, you will find that each break-in procedure is different and in some cases, vastly different. Like most people, we followed the break-in procedures from various manufactures but over time as we gained experience doing this, we customized the break-in procedure to what we felt worked best. Some break-in procedures are quick and simple which we feel ramps up the spindle RPM's too quickly and thus, encouraging temperature spikes to occur too easily. We also question the life of the spindle bearings when following these type of break-in procedures.

As you will notice with our break-in procedure, we start slowly with the spindle RPM's and gradually increase the speed where temperature spikes are greatly reduced. We also feel that this increases the overall life of the bearings as it allows the bearing grease to slowly move outside of the bearing races and not throwing it out of reach of the moving bearing parts.

3. Preparation & Spindle Measurements

00:29:35 in video Part 4 section 3

a) Mounting Headstock

The first step to performing this break-in procedure is to install the headstock on the lathe bed. You will need to mount the headstock as if you are putting this machine back into operation so that means fusing a belt between the headstock pulley and motor pulley, and the motor control powered and ready to be turned on for motor operation.

But do not turn the motor on yet!

The fusing of the belt is not shown in the video but if you would like to see how we perform this procedure, we demonstrate it in our Shop Adventures 13 video on our Active Atom YouTube channel at the following link.

https://www.youtube.com/watch?v=M5k-RbVNsC4

b) Taking Spindle Measurements

Before we start this break-in procedure on this spindle, we want to take some baseline spindle measurements to see where we are at after the spindle assembly but before performing any operations including the break-in procedures on it.

We will be taking 3 runout measurements on the spindle. In Part 3, we took runout measurements of the spindle on the surface plate and now want to take new measurements with the spindle now in its assembled operational state.

- We first want to take a measurement of the spindle collet seat. If the collet seat is in good condition and was properly ground in the past, you should get a good measurement. What is considered a good measurement is dependent on the condition of the spindle and related parts but worst case, the measurement should still be fairly close to factory specifications for T.I.R. (Total Indicator Runout).

- We then take a measurement of the outside spindle head surface. This measurement reading actually becomes more critical if the collet seat measurement reading is not satisfactory (not close to factory specifications). If the collet seat measurement is not satisfactory but the spindle head surface measurement is good, a collet spindle regrind which we show in video Part 5 will likely bring the spindle close to or within factory specifications.

- For our third measurement, we want to move the headstock down the lathe bed so we can measure the read end of the outside spindle surface. This measurement is not critical and mainly done for completeness. The factory does not perform this measurement.

c) Setup Temperature Meters

00:37:25

Now with the headstock mounted, secure the thermocouples to the spindle housing. If only 1 thermocouple is being used, secure it near the area where the angular contact bearings are located otherwise if the angular contact bearings are separated with the use of spacers such as with the Levin Accessory Spindle, secure the thermocouple between the 2 angular contact bearings. If 2 thermocouples are being used, secure each thermocouple close to the bearing locations at each end of the spindle. For the Levin Headstocks, 1 thermocouple should be secured close to the pair of angular contact bearings at the front of the spindle and the other thermocouple should be secured close to the deep grove bearing at the rear of the spindle.

d) Performing the Break-In Procedure

00:44:33 in video Part 4 Section 4

Our motor controller on the Levin lathe you see in the video is configured with a startup delay of 2 seconds which means that it takes 2 seconds for the motor to reach the selected RPM speed. This is important because you don't want your spindle to immediately ramp up to the selected RPM speed.

If your motor controller does not have this delay where it immediately ramps up to the selected RPM speed, you will need to gradually ramp up to the RPM speed each time you perform a test cycle. You might just want to hit the run switch and be at the selected RPM immediately but it is very important for this break-in procedure that you ramp up slowly by using your RPM meter and gradually climb to your required RPM speed for each test cycle of the break-in procedure.

The break-in procedure below runs the spindle starting at a slow speed and then gradually increases the speed while you are monitoring and charting the temperatures of the spindle bearings to ensure that there is no significant rises or spikes in temperature.

Cautionary Note:
If any significant rise in temperature is detected during a break-in cycle procedure, don't panic. Simply stop the spindle and allow it to cool to room temperature. You then want to step down to the prior Step and re-run that Step cycle again as if you are doing it for the first time.

For example, let's say you are Step 2 (50% RPM – Short Cycle) and you notice a temperature spike exceeding 140 F (60C). Immediately stop the spindle and let it cool to room temperature. Once the spindle has cooled, go back to Step 1 (25% RPM – Short Cycle) and re-run the entire Step cycle as if you are running it for the first time. This should resolve your excessive temperature problem but if it doesn't, we recommend going back again 1 more time but after 2 attempts of re-running the test cycle and not resolving this high temperature issue, you will need to diagnose the spindle which may involve disassembling it. A common cause for this issue may be too much grease or the bearings not seated properly.

e) Prepare Spindle for Break-in Procedure

For this spindle test, we will be powering the spindle and bearings for the first time. But before we do that, now is the time to place a small piece of reflective tape on the spindle if you have not already done so, which will be used with the RPM Meter for taking RPM speed readings.

When a speed percentage is specified in the following break-in procedure, this percentage refers to the actual motor speed and not the markings on the motor controller speed knob, which can be very inaccurate and is why we use an RPM Meter.

For example, if your maximum spindle speed is 2,500 RPM and the break-in procedure calls out a speed of 10%, use the RPM Meter and slowly increase the spindle speed to exactly 250 RPM regardless of what the motor speed knob indicates.

VERY IMPORTANT: *before you power on the motor controller, confirm that the speed knob is set to 0% (idle) as we do not want to accidentally run the motor at a high speed.*

Before proceeding with the next step, we highly recommend that you download our Break-in Procedure Form and use this form for performing your break-in procedure. This form can be downloaded under the Documentation section for this video series on our website at the following website link.

http://www.activeatom.com/education-spindle-rebuilding-docs.php

f) PRE-STEP 1: Manual Spindle Rotation

As already performed at the end of the spindle assembly procedure, the spindle should be rotated by hand to confirm that the rotation feels silky smooth and without any obstructions being felt which would be caused by the bearing(s) being contaminated with dust, grit, lint, hair, etc.. Also ensure that there is no binding felt during the spindle rotation which is usually caused by the bearings or a spindle part not assembled or seated correctly.

The spindle must past this feel test before continuing with the next step.

g) PRE-STEP 2: Motor Speed: 5% - Spindle Prep for Break-In

Turn on the motor controller and starting at idle, slowly raise the spindle RPM to 5% of maximum speed and run at this speed for 10 minutes. The purpose of this operation is to gently align the grease within the bearings and to ensure that there are no mechanical spindle problems that could cause damage at higher RPM's.

h) Start Break-in Procedure

- **STEP 1: Motor Speed: 25% - Short Cycles**

  Power the motor controller and set speed to 25% of Maximum Spindle Speed.

  - Let it run at this speed for 20 Seconds and then let it rest for 1 Minute. Repeat this 2 times.
  - Let it run at this speed for 40 Seconds and then let it rest for 1 Minute. Repeat this 2 times.
  - Let it run at this speed for 1 Minute and then let it rest for 2 Minutes. Repeat this 2 times.

- **STEP 2: Motor Speed: 50% - Short Cycles**

  Power the motor controller and set speed to 50% of Maximum Spindle Speed.

  - Let it run at this speed for 20 Seconds and then let it rest for 1 Minute. Repeat this 2 times.
  - Let it run at this speed for 40 Seconds and then let it rest for 1 Minute. Repeat this 2 times.
  - Let it run at this speed for 1 Minute and then let it rest for 2 Minutes. Repeat this 2 times.

- **STEP 3: Motor Speed: 50% - Long Cycle**

  Power the motor controller and set speed to 50% of Maximum Spindle Speed.

  - Let it run at this speed for 15 Minutes while monitoring the spindle temperature that it does not exceed 122 F (50 C). If the temperature exceeds this maximum temperature, stop the spindle and let it sit until it cools to room temperature. Then go back to the prior Step (50% - Short Cycles) and start at this step over again.

  - Before proceeding to the next step, let the spindle rest (idle) for 5 Minutes.

- **STEP 4: Motor Speed: 75% - Short Cycles**

  Power the motor controller and set speed to 75% of Maximum Spindle Speed.

  - Let it run at this speed for 20 Seconds and then let it rest for 1 Minute. Repeat this 2 times.
  - Let it run at this speed for 40 Seconds and then let it rest for 1 Minute. Repeat this 2 times.
  - Let it run at this speed for 1 Minute and then let it rest for 2 Minutes. Repeat this 2 times.

- **STEP 5: Motor Speed: 100% - Short Cycles**

  Power the motor controller and set speed to 100% of Maximum Spindle Speed.

  - Let it run at this speed for 20 Seconds and then let it rest for 1 Minute. Repeat this 2 times.
  - Let it run at this speed for 40 Seconds and then let it rest for 1 Minute. Repeat this 3 times.
  - Let it run at this speed for 1 Minute and then let it rest for 2 Minutes. Repeat this 5 times.

  **Notice that the run times have increased for this step at 100% motor speed.*

- **STEP 6: Motor Speed: 100% - Long Cycle**

  - For the Final Test, now let the spindle run for 1 Hour at 100% Maximum Spindle Speed. Monitor the temperature of the bearings to ensure that they do not reach over 140 F (60 C). If the temperature exceeds this maximum temperature, stop the spindle and let it sit until it cools to room temperature. Then go back to the prior Step (100% - Short Cycles) and start at this step over again.

5. Final Thoughts

00:54:04 in video Part 4 Section 6

In the video, we discuss the spindle bearings ideal equilibrium temperature and just some general conversation to understand in depth what we all just went through here. It is a good chat and yes, some additional information and discoveries are shared.

We also discuss our Spindle Break-in Procedure Form so you can fill in the blanks to record your temperature readings as you perform the break-in procedure. And as mentioned earlier, we highly recommend that you download this Break-in Procedure Form which can be downloaded under the Documentation section for this video series on our website at the following website link.

http://www.activeatom.com/education-spindle-rebuilding-docs.php