

## Physics Lecture 17 - Car Lubrication Part 2 - Wheel Bores

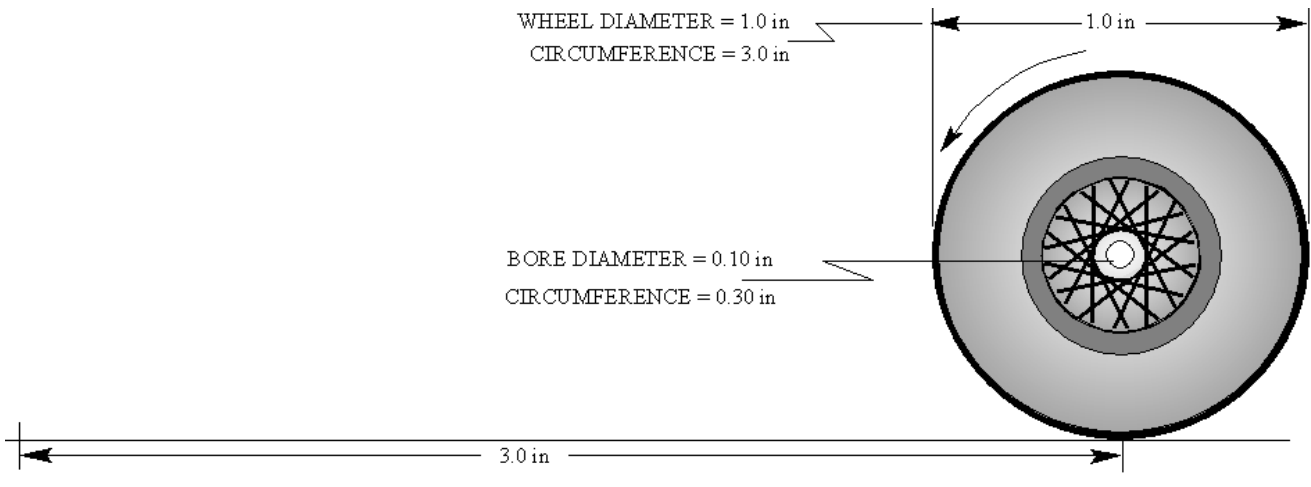
**Introduction** - Now that **Lecture 16** has shown the details of proper axle polishing, it is time to consider the all important wheel bore. Only one fixed line across the bottom of the axle contacts the wheel bore, but when the wheel is rolling, this axle contact line slides around the entire bore surface once per wheel revolution. The condition of the bore surface is the largest single factor in winning or losing a race.



### Car Construction E-Book - Lube Chapter

Let the Cub do as much of the hands-on work as possible and always practice safety first. Work as a team.

#### 15. Bore Friction



**Figure 1** - Showing how far a wheel travels down the track for 1 revolution

- We will start with **Item 15 Bore Friction** to continue on from the last **Item 14** in the previous **Lecture 16**. But read the next bullet for a very important physics item about friction on the bore surface.
- Notice in **Fig. 1** that the diameter of a pinewood derby wheel is about 1.0 inches. So the circumference or distance around the wheel is  $\pi$  (pi) times the diameter. Now pi is approximately 3 so every time a wheel rolls without slipping, skidding, or sliding on the track it travels  $3 \times 1.0 \text{ in} = 3.0 \text{ in}$ . down the track. A typical track is about 32 feet long or  $32 \times 12 = 384$  inches. Thus  $384/3.0 = 128$  means the wheel will rotate 128 times during a race. The circumference or distance around the bore surface is only one-tenth as much as around the wheel tread and is thus only 0.30 in. Now  $0.30 \times 128 = 38.4$  in. So that is the total distance the axle must slide on the wheel bore surface each race. And the sliding friction force times this 38.4 in. distance is the total energy loss your car suffers because of the axle sliding on the bore surface. Thus you can see why the bore surface is so important. This is why small bores go faster because if the bore (and axle) was only half as large as in **Fig 1** it would only slide  $\frac{1}{2} \times 38.4 = 19.2$  in. and only take away  $\frac{1}{2}$  as much energy from your car.

## 16. Bore Polish Setup

- It is now time to polish the wheel bore. There is a video on page 4 but look at and read this material before you get to p 4. It shows more detail than the video. Besides, some reader's computers may not play videos.
- The general setup is shown below in **Fig. 2**. About equal amounts of wheel bore polishing compound and water are mixed to a runny paste (also see the photo in **Fig 3** ). Don't forget to get some 91% rubbing alcohol from the drug store for cleaning the wheel up later.
- Chuck one of the special polishing shafts into a drill of some sort. Here we show a drill press but a hand electric drill fixed in a vise or clamped to a bench top could also work well.
- The wheel should slide freely but firmly up and down the shaft. This is important. Occasionally there will be a wheel encountered with an undersized bore into which the rolled cardboard shaft will not fit . The easiest thing to do is set the wheel aside and get another (the Scout Shop has extra wheel/axle kits). As shown in **Fig. 7** a razor blade can be used (carefully by an adult) to shave just a slight amount of material from the shaft so the bore will slip over it.



**Figure 2** - Getting ready to polish the wheel bore.

## 17. Bore Polish Materials

- The first thing you do after you have all the equipment set up is mix a small amount of water with the wheel bore polish compound to make a runny paste. Items number 1,2,3 and 4 from the [Grab Bag](#) are used here as shown in **Fig. 3**. The 4 shafts are rolled cardboard and come with the polish compound. Do not confuse them with the wooden mini dowels from the Grab Bag.



**Figure 3** - Mix the wheel bore polish compound with a few drops of water to create a runny paste.

## 18. Paint Shaft

- In **Fig 4** it shows painting the shaft with the runny mixture of polish compound and water. Immediately run the wheel bore up and down over the wetted shaft after the drill press has been turned on. Keep shaft wetted. You can also apply the polish paste with the right hand after inserting the shaft, starting the rotation, while holding the wheel with the left hand.

- The shaft will gradually swell in 30 sec to 1 minute from the moisture. This gives a good intimate polishing contact.



**Figure 4** - With shaft chucked in drill, rotate at about 300 rpm while applying bore polish paste with brush.

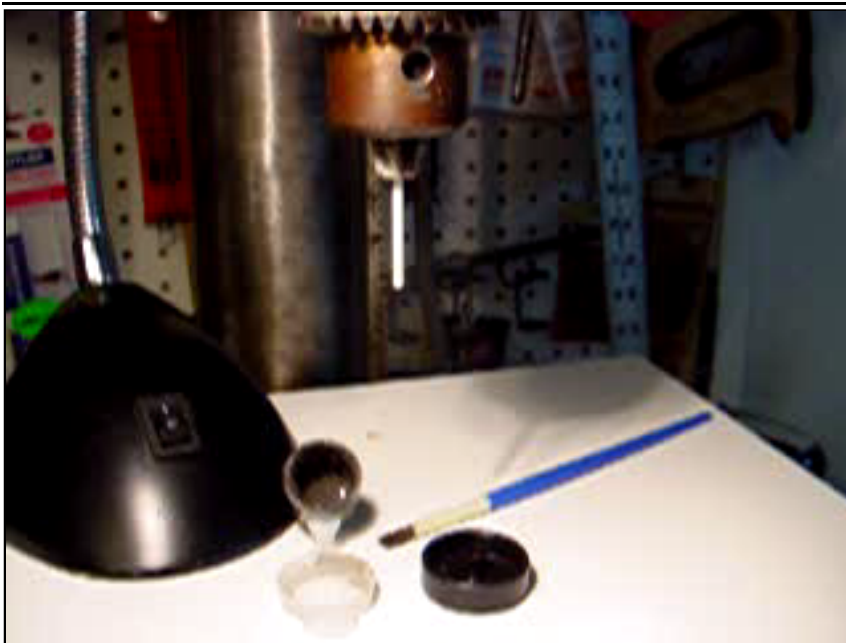
## 19. Spin Shaft in Bore

- Keep the chuck RPM slow, perhaps 300 to 400 rpm.
- You may be able to go up and down only a few times. Be sure and keep the shaft wetted with the runny mixture.
- If the shaft dries out, or if swells too much, it will bind and it will twist off in the wheel bore and it can't be removed without ruining the borehole surface.
- Remember you cannot use the end of shaft more than say 30 or 45 seconds before the watery mixture makes it swell too much and it starts to bind.



- ● You can probably unchuck the white rolled cardboard shaft and switch to the clean end for one or two more polishing runs. Other shafts like toothpicks, small dowels, pipe cleaners, etc are too hard and will ruin the ultra-smooth bore surface coating you are trying to make. Also, a hand electric drill clamped to a workbench will work OK but keep the RPM's down. **Fig. 5** and the **video below** show the procedure.

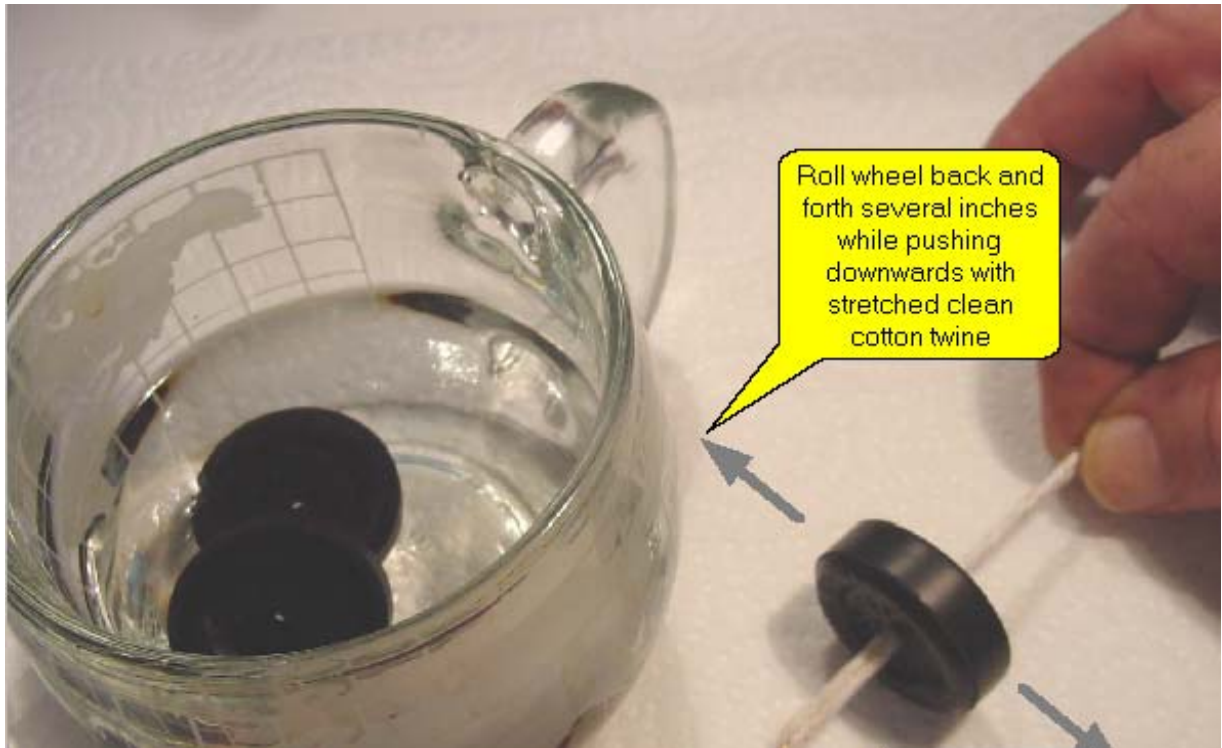
**Figure 5** - Move wheel up and down a few times fairly quickly with left hand. (*see video*). You can also paint the shaft above the wheel with the right hand at the same time. Be sure you keep shaft wet with paste as you move wheel. If shaft is not too tight, flip wheel over and take a quick pass through the other side.



[Click left on image to play video of bore polishing](#)



 20. Clean Bore



**Figure 6** - After IPA rinsing, thread twine through bore and roll back and forth while pressing down to clean bore

- After the bore polish rinse the wheels thoroughly with running water and brush surface of wheel with a toothbrush to remove all the gray colored polishing compound. Do not touch inside bore hole with the toothbrush or pipe cleaner. These could mess up the sensitive polished surface. Shake off excess water but don't dry with a paper towel.
- Then let the wheels sit for a few minutes in 91% IPA (isopropyl alcohol- see cup in **Fig. 6** - this absorbs the water) and then remove them and wipe bore with a clean cotton twine as shown by rolling wheel back and forth around the stretched twine. A fine brass wire (from hobby shop) about 44 gauge (0.012") about 3" long is doubled around the center of the string and mashed flat for threading the string carefully through the bore hole. This twine and brass wire threader are Item 6 in the [Grab Bag](#)
- Especially make sure none of the gray polishing compound is anywhere near the bore hole.

## 21. Shave Shaft

- Now that we have a polished bore, it is time to put a thin but very uniform film of graphite on the bore surface.
- First make sure you have a rolled cardboard shaft, of the same type used for polishing, that will fit into the wheel bore. A shaft is provided in the Super Z Graphite package. Unlike the bore polishing shafts, this one for applying graphite can be used many times.
- If the wheel bore is undersized, or for some reason the cardboard shaft is too large, then shave the shaft slightly smaller using a razor blade as shown in **Fig. 7** (adults only).



**Figure 7** - If a cardboard shaft is slightly too large for the bore, it may be shaved down some with a razor blade (adults only).



## 22. Add Super Z to Bore

- The next step is to fill the bore hole with Super Z graphite as in **Fig. 8**. One of the left fingers is used to cover the bore hole bottom so the graphite doesn't run out.

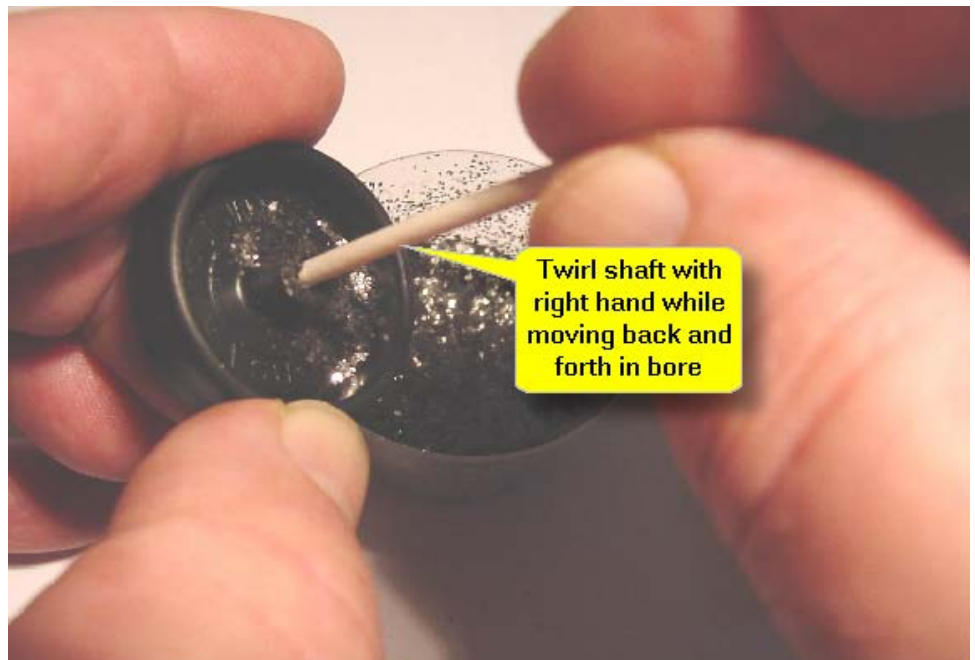


**Figure 8** - Using the brass spatula (Grab Bag Item 9) to dip and pour Super Z Graphite into the bore hole.



## 23. Twirl Shaft

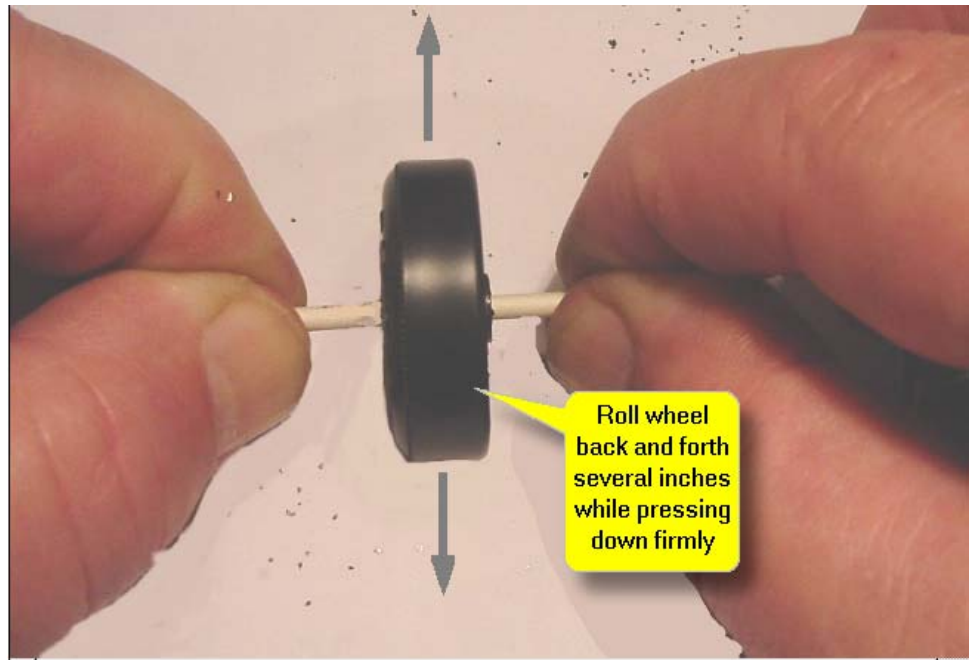
- Next, as in **Fig. 9**, insert the shaft and twirl it as you press the Super Z down some into the bore. The finger is still over the back side of the bore.



**Figure 9** - Insert the shaft in the hole and twirl a few times.

### 24. Roll Wheel

- Then run the shaft all the way through the bore and roll the wheel back and forth on a smooth surface using the shaft as an axle. See **Fig. 10**.
- The roll distance should be several inches and firm downward pressure should be applied.



**Figure 10** - Roll wheel back and forth about 6 - inches while pressing down firmly..

### 25. Shiny Bore

- The wheel bore surface should have a shiny smooth appearance when examined using a magnifying glass as in **Fig. 11**. No bumps, dirt, lint, scratches, or graphite particles should be visible. Especially make sure none of the gray polishing compound is anywhere near the bore hole.

- The shiny bore is hard to see but a good example of a Super Z Graphite coating on the polystyrene surface can be obtained by rubbing the wheel surface on the chamois cloth like **Fig 12**. Use an old wheel and rub the balloon part of the sidewall like shown in **Fig. 11** on a pile of Super Z graphite on the chamois while pressing down hard and twisting. Keep rubbing and your wheel will start to look like slippery polished metal. That's how you want the bore inside surface to look except it's very difficult to see inside the bore hole. It helps to look at a light through it using a strong magnifying glass.



**Figure 11** - Inspect the hub inside for smoothness and finish.

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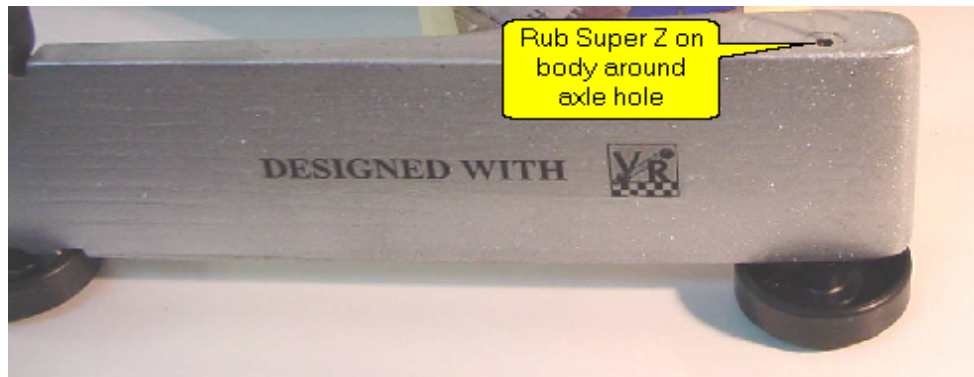


 **26. Lube Hub**

- As a final step rub the wheel hub surface by twisting, etc., with the wheel against Super Z on the application cloth.
- This helps lubricate the surface that may rub against the side of the car body. Also wipe graphite on the car body where the wheel hub touches the body as in **Fig. 13**.
- Do not let graphite get on any other wheel part, **especially the tread surface that rolls on the track**. If it does, the rear wheels may slip side to side on the track surface letting the car "wobble" and lose speed as it goes down the track. Wipe the wheel tread surface with IPA on a damp cloth so it won't be slippery. This is important. You want friction for traction against side to side motion but you don't want friction between the axle and wheel bore surfaces.



**Figure 12** - Rub the inner hub surface on Super Z Graphite.



**Figure 13** - Rub Super Z Graphite on body where wheel hub can rub.

- Rub Super Z graphite on the body just around the axle holes where the wheel hub touches using the application cloth. Then tap body on a hard surface with the hole down so that any graphite flakes that got into the hole will be knocked loose and fall out. If you get graphite in the hole it may make it too slippery to hold an axle firmly so you may need to glue coat inside hole as shown in the **Fig 27** of [Lecture 15](#).
- ● On the next page there is a short video of the wheel bore lube steps as described above.



[Click left on image to play video of bore lubrication](#)

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- This completes **Lecture 17**. Go on to **Lecture 18** to see the finger spin friction test on the axles/wheels you just polished and lubed. With practice and care, the finger spin times can approach the low 30 sec. range. Especially pay attention to the rear wheel's spin times if your car is rear weighted.