Physics Lecture 22 - Standard Wheel Imperfections

Introduction

The Standard 1999 wheel is shown in **Figure 1**. In this lecture we will give data dealing with bore-to-tread distance deviations, tread flatness, and more on bore size. We can then use the results of the preceding **Lecture 21** to assess the seriousness of such Standard wheel imperfections.

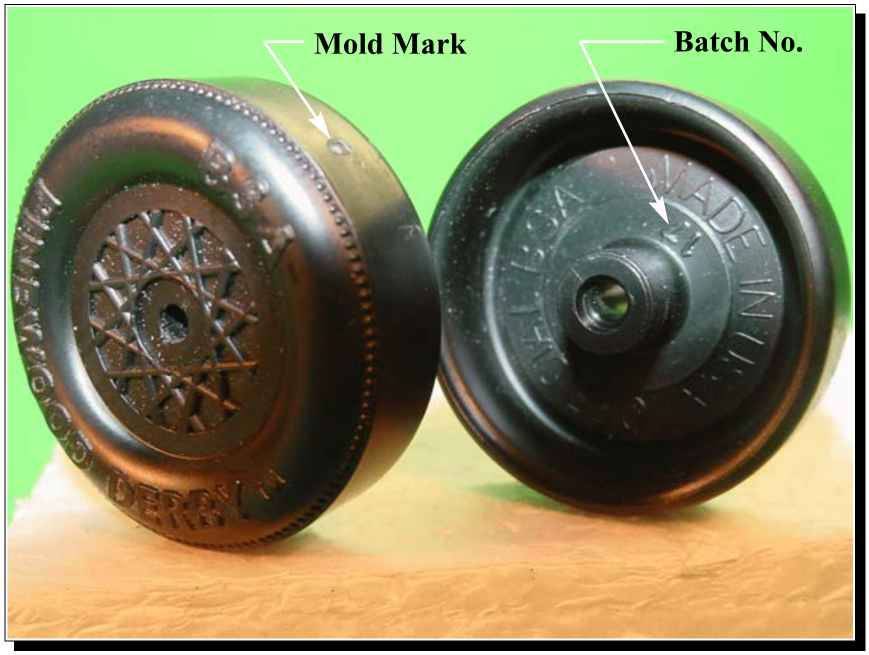

Figure 1 - *The Cub Scout wheel introduced in 1999.*

Measurements

Ideally, a rolling wheel should allow its axle to smoothly follow a uniform track surface at a constant distance above the surface. The axle bottom rests on the top surface of the bore hole, and if the bore circumference and the tread surface circumference are concentric circles of constant diameter, the constant axle to track rolling distance will be met. We will estimate the tread/bore distance as follows. The first thing to do is to find a drill bit shaft that is a snug fit into the bore. We select the axle from a group of "miked" drill bits to make measurements of the bore hole itself as described in detail in **Lecture 12**. Once a good fit is obtained on the inside, the bit shaft is inserted through the bore and then it is secured in a lathe chuck as shown in **Figure 2.** The shaft should be well polished so the wheel can be rotated on the shaft by hand. This will give a truer measure of deviation compared with turning the whole chuck. Often times 3-jawed self-centering chucks have only 0.002 to 0.003" accuracy, and this introduces too much error. There is a 4-jawed chuck that can be adjusted to a fraction of a mil axial accuracy if needed, but this process is tedious and it is much simpler to just carefully rotate the wheel by hand on a fixed shaft. Tread/bore radial distance deviation measurements , commonly called radial runout, are made on the tread surface just inside the inside edge of the wheel and just inside the outside edge of the tread as shown in **Figure 3.** Dial caliper interpolation can give a measurement to the nearest ten-thousandths of an inch. For example, in **Figure 2** the dial indicator is reading 0.0086". The deviations of record are the difference or max-min caliper readings for one revolution. Such deviations could be caused by a circular bore not being concentric with a circular (in plane of measurement) tread. Or the tread could be elliptical with the bore centered at the major/minor axis intersection. In some cases there are irregular (sharp) deviations caused, for example, by a mold mark in the tread center as shown in **Figure 1**. Because the bore is uniformly circular to within a fraction of a mil, and because the tight-fitting "axle" is a constant distance from the caliper body, the deviations measured should closely approximate those found during actual rolling. Radial runout is sometimes simply called "out-of-round", as compared to a side-to-side tread wobble, where distance deviations are called lateral runout.

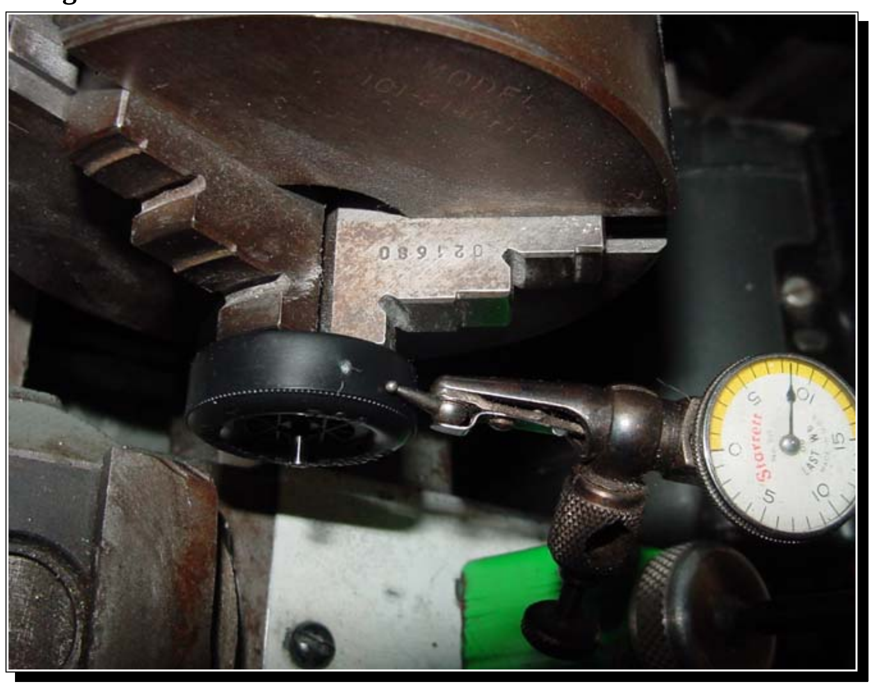

Figure 2 - *Measuring deviations in wheel tread/bore distances.*

Table 1 shows data on 10 wheels which came from 2 separate boxes of 5 each as sold by the Scout shop. The batch number refers to the mold from which the wheel was made. If a box contained more than one of a certain batch number, then A and B, etc., were used as additional identifiers. More wheels will be examined later if time permits. In **Figure 3** one can see the different areas of the wheel that were inspected and measured. An interesting area is the flatness of the tread, a departure from which can be noted for some wheels. If a straight edge is held as shown and a bright light is positioned behind the wheel, a sliver of light can be seen illuminating the space (if any) between the tread and the straight edge. The smallest concave "sag" in the tread that could be observed is estimated as 0.0001". According to **Lecture 6**, if the tread is not totally flat then there is less contact adhesion and rolling resistance between the tread and the track surface leading to faster race times for such wheels.

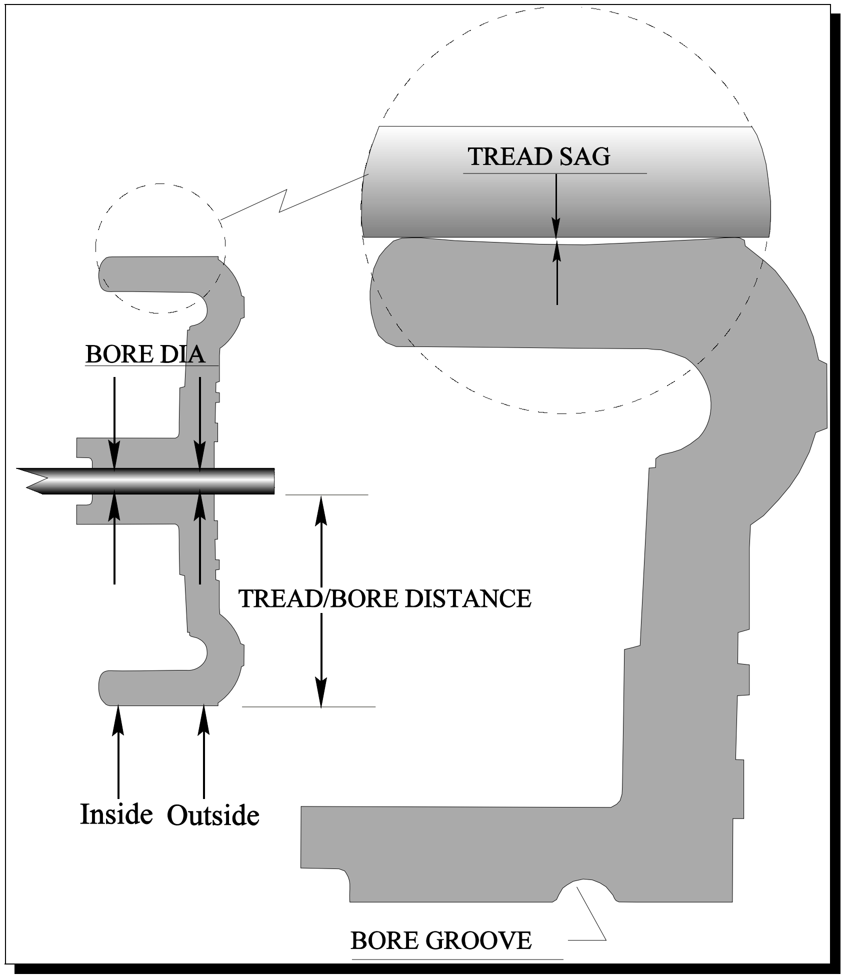

Figure 3 - *Wheel measurements.*

Regarding the bore groove, this appears sometimes as a result of molding details and does not seem to favor certain batches. Such grooves can hold solid particles, such as graphite, and this forces the wheel bore/axle surface to be a graphite crusher which unwisely uses energy.

For a judgement on how serious wheel tread/bore distance deviations and mold mark bumps are at the finish line, refer to the graphs in **Lecture 21.** There it shows, for example, that a 0.005" high mold mark like on wheel 1 B in **Table 1** could cost you ½ inch at the finish line on a 32 ft track.

Table 1 - *Wheel measurement data for 2 boxes of 5 ea (distances in inches).*

Batch	Bore Diameter		Tread/Bore Radial Deviation		Tread		Wt (g)	Bore Groove ?
	Inside	Outside	Inside	Outside	Sag	Mold Mark		
16	0.0982	0.0978	0.010	0.010	0.0002	0.002	3.661	No
1 A	0.0982	0.0978	0.013	0.015	0.0002	0.002	3.580	No
17	0.0968	0.0958	0.003	0.004	0.0001	0.003	3.560	No
13	0.0982	0.0976	0.009	0.010	0.0002	0.001	3.579	No
1 B	0.0982	0.0978	0.010	0.010	0.0002	0.005	3.658	No
18	0.0980	0.0978	0.008	0.006	0.0006	0.002	3.610	Yes
15	0.0971	0.0971	0.006	0.006	0.0002	0.002	3.661	Yes
5 A	0.0978	0.0978	0.008	0.008	0.0001	0.003	3.571	No
5 B	0.0980	0.0978	0.008	0.008	0.002	0.002	3.577	No
8	0.0980	0.0976	0.009	0.008	0.002	0.002	3.527	Yes