Aerodynamic Effects on Pinewood Derby Car Performance

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Abstract

The conventional wisdom in building pinewood derby cars states that the sleekest, most aerodynamic car will be the fastest. The objective of this study was to test if this notion is correct and, in doing so, to identify the critical aerodynamic factors. A number of cars were raced in competition and also tested in the TCU wind tunnel to obtain data on the aerodynamic drag at various speeds. This data was then used to calculate dimensionless drag coefficients and was subsequently used to determine whether aerodynamic drag correlated to car performance in the race standings.

Motivation

Each year, students and teachers construct cars for the annual Pi Day Pinewood Derby car race. A wide range of designs and strategies are used in designing the cars. Most try and make a sleek racecar style derby car, whereas others see this as unnecessary and simply race the uncut block of wood. After viewing many races, the question of whether or not aerodynamics plays a roll in the performance of the car came up. Therefore, the goal of this research was to determine if there is a distinct correlation between derby car body design and performance.

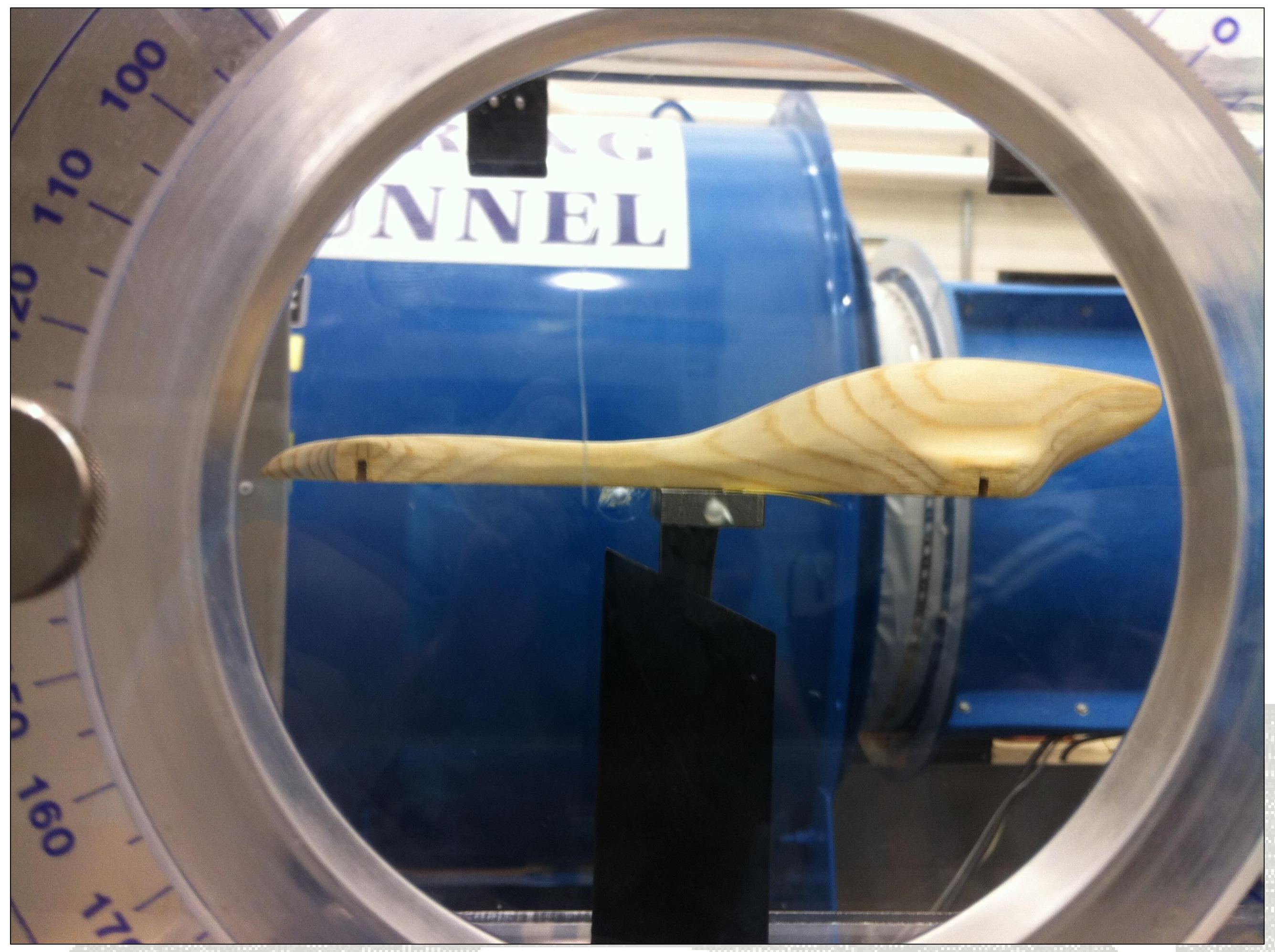
Approach

A number of cars were tested in TCU's state-of-the-art wind tunnel under a variety of conditions. The group gathered data for the drag force three times for each car: with fat wheels, with skinny wheels, and with no wheels. A number of control objects were also tested in the tunnel for comparison, including an original derby block of wood, the platform rail by itself, a golf ball, and a similarly shaped sphere. The resulting drag forces at each velocity were used in a fluid motion equation (seen below) to determine dimensionless drag coefficients. These values were compared against Reynolds Numbers, which were calculated dimensionless quantities used to describe the airflow. Next, the cars were raced on a wooden track to evaluate their individual speeds and thus performance. Using the calculated drag coefficient along with this performance data, the group was able to accurately compare the different designs with their respective performance.

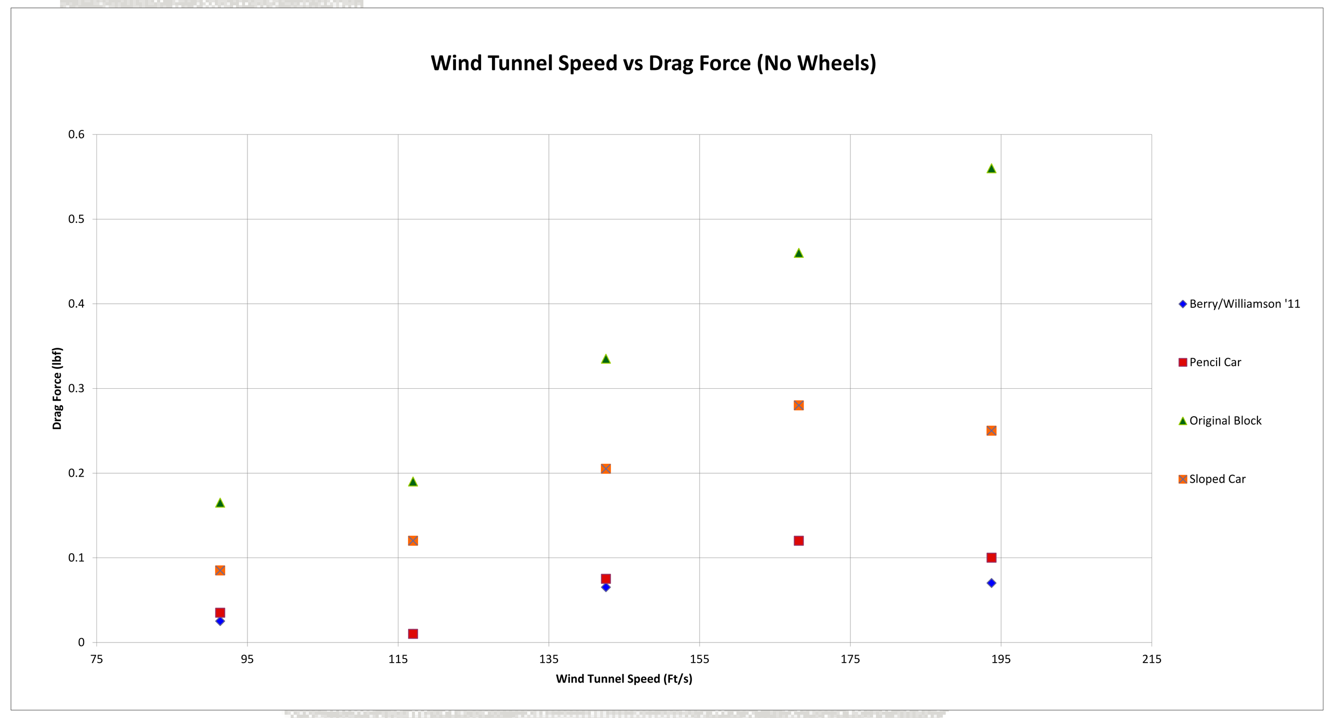
$$C_D = \frac{measured\ drag\ force}{dynamic\ pressure\ \times\ projected\ area}$$

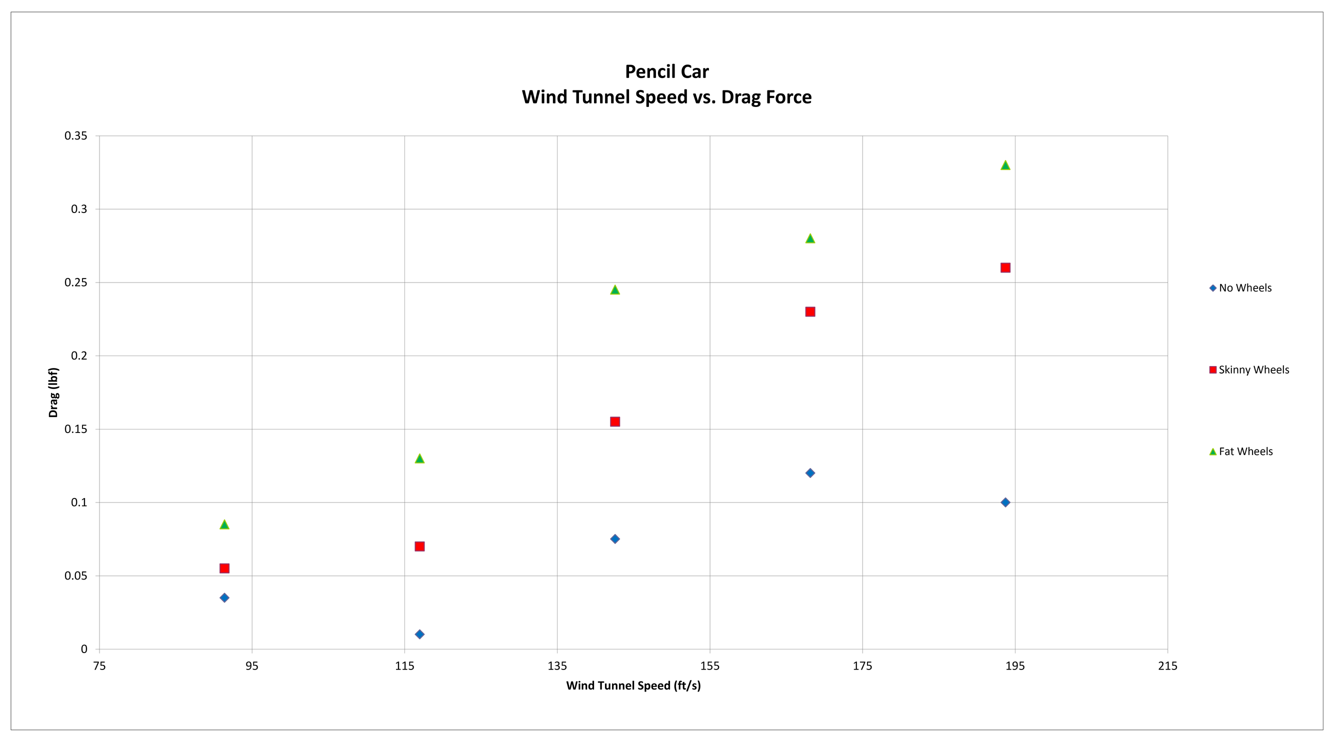
Race Times

Place	Car	Full Run (sec)	Flat Section (sec)
1	Berry/Williamson '11	2.32	0.93
2	Pencil	2.49	1.10
3	Block	2.54	1.18
4	Sloped	2.84	1.28



Results





Discussion

The results and experiment in general revealed many things about the wind tunnel and the pinewood derby cars' performance. Due to instrumentation sensitivity, the data at lower velocities did not provide results as clear as at the higher velocities, which could have impacted the analysis since the cars were raced at lower speeds. Also, track friction is thought to be an important factor affecting the cars' race times, but it was not considered in our study of aerodynamic effects. However, in the end the measured data appears to correlate well with the race results, and showed a number of interesting correlations between drag and performance, including:

- **Aerodynamics has a major impact on the speeds of pinewood derby cars, as shown by the cars with the least drag forces placing best**
- **Switching from the fat wheels to the skinny wheels is an effective way to reduce overall aerodynamic drag**
- **A well-designed car can have less drag than a golf ball**
- **The dimples on a golf ball make it more aerodynamics than similar spheres; further research could test a car design with similar dimples**