David Massey | Metal Improvement Company

Shot Peening Meets the Pinewood Derby

A Brief Investigation into the Effects of Shot Peening on Sliding Friction Between Metal and Plastic

ACCORDING TO *READER'S DIGEST*, The Pinewood Derby is an essential rite of Spring. For those not familiar, the Pinewood Derby is an event run by the Boy Scouts of America (BSA), typically at the Cub Scout level. Like other Cub Scout packs nationwide, Pack 46 in Morrisville, Pennsylvania has its derby every April at a local church.

In the derby, small model cars made from pine roll down a ramp to a horizontal racing surface. The maximum footprint of the cars is limited to seven inches long by two and three-quarter inches wide. Weight is limited to five ounces. The wheels must be BSA-approved wheels and are all of the same hardness. The plastic wheels ride on a metal axle. Sanding and polishing the axles prior to installation is encouraged.

The potential energy from the height at the top of the ramp is converted to kinetic energy at the finish line. Friction and drag steal this kinetic energy throughout the race. So it is no surprise that children (and more than a few parents) spend their time reducing friction and drag as much as possible.

Shot peening, the process of bombarding a surface with spherical media, has long been known to prevent failure due to high cycle fatigue. Other benefits include enhanced appearance, surface work hardening and resistance to stress corrosion cracking. It is also known to reduce sliding friction. Changing the smooth surface to a dimpled surface reduces the amount of surface area in contact with whatever is sliding over it. Using spherical media gives rounded peaks to the peaks and valleys, so the metal axle doesn't dig into the plastic wheel. The question was: could shot peening reduce the sliding friction enough to make a difference in a Pinewood Derby race?

David Massey's son's car is typical of a Pinewood Derby car: it's made of pine and is seven-inches long and two and three-quarter inches wide. The big difference is that the axles were shot peened to reduce sliding friction between the metal axle and plastic wheel.

The answer was yes.

In preparation for the derby, my son and I worked with two other father-and-son teams to optimize the Pinewood Derby race car. One of the fathers built a test track in his basement, complete with digital timing. Each team designed experiments to determine the impacts of different variables such as weight distribution, wind resistance, and in our case, axle condition. Not only did the boys learn about physics and the scientific method, but they also got to optimize their cars. While I wasn't able to let my son do any of the actual shot peening due to safety restrictions, we went over what was done and why in exhaustive detail. The following are the results of the shot peening.

Table 1: Course time in seconds

	Untreated	Polished	Polished and Shot Peened	% Improvement
Car A	2.118		2.095	1.09%
Car B		2.125	2.109	0.75%

As noted in the table, when a car's axles were taken from an untreated condition to a polished and shot-peened condition, the car was 0.023 seconds quicker. Each time is an average of three runs on one car, so this experiment is somewhat limited. To isolate whether this was an effect of the shot peening or the polishing, a second test was run with polished axles versus polished and shot peened axles. The car was still 0.016 seconds faster through the course. To give an idea of scale, cars typically ran 2-2.5 seconds. The margin of victory on race day was 0.0025 seconds; roughly one-tenth of the improvement provided by shot peening. By a long way, shot peening provided a great benefit to the Pinewood Derby car.

Most NASCAR teams would pay dearly for a 1% improvement.

So was it enough?

Sadly, no.

We won in our twelve-person den of Bear Cub Scouts by 0.0035 seconds. We lost in the overall pack by 0.0025 seconds to the Cubmaster's son.

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