The effect of Carbon Fiber wheels vs. Aluminum wheels on high efficiency vehicles

As we move forward in our effort to become a more efficient and sustainable society, one of the big issues we have to face is transportation. Transportation in our society plays a vital role on ensuring not only that people are able to move to where they want to be, but furthermore is the backbone of our society. Transportation of goods and products enables us to live the lifestyles that we choose to and make the world “smaller”. Today transportation is based on fossil non-renewable fuels and in recent years more and more of the nation’s energy has been devoted to transportation. According to the US Energy Information administration, in 2006 transportation on its own accounted for 28.5% of all the energy used nationwide [1]. Therefore given the huge cost that transportation has on our society, through innovation and technology improvement we need to find more efficient ways to transport goods and people.

Approximately 80.5% of all the energy used for transportation in the US was spent on local highways and roadways. Therefore if we want to reduce fuel consumption we should focus on improving our efficiency on ground transportation. There are several ways in which this can be accomplished, from improving engine gas mileage to developing new better highway networks that optimize transport. One of the most important things to taken into account is that much of that Energy is wasted in the form of heat that occurs from the friction between our vehicles' wheels and the road. The energy wasted in this way vary depending on the specific car or truck and working conditions but on average the energy lost in this way account for up to 15% of the energy in the fuel tank [2]. The energy wasted in this way is determined by what we call: Rolling Resistance.

Rolling Resistance or rolling friction or drag is the force that opposes the motion when a body (such as a wheel on the road) rolls on a surface. There are many causes for this energy loss but the main causes are that not all the energy needed for deformation is recovered when the pressure is removed and the slippage that occurs between the body and the ground.

The rolling resistance is proportional to the Normal force that reacts every body’s weight. The proportionality constant is what we define as: “rolling resistance coefficient” (C\text{rr}).
Therefore in order to reduce the Force caused by Rolling resistance and with it the Energy dissipated there are 2 approaches we can take. One would be to reduce the weight of the vehicle in order to reduce “N”, and the other would be to reduce “Crr”.

Thanks to the purchase of Carbon Fiber wheels for NUsolar we are able to obtain experimental data from our new solar powered car SC6 and compare the results obtained when using Carbon Fiber wheels versus the results obtained when using Aluminum wheels in order to determine the actual impact of energy consumption. The impact of the carbon fiber wheels is not only influenced by the reduction of weight in the wheel itself, but the fact that it enables the team to use super-efficient Bridgestone Ecopia Solar Race tires instead of Pirelli Moped tires which reduce the rolling coefficient significantly.

Since SC6 has not been finished yet we can only evaluate the theoretical impact of the carbon fiber wheels on the rolling resistance and the energy dissipated. In order to do so we will assume all variables to be fixed other than the weight of the car (which includes the weight of the wheels) and the rolling resistant coefficient which is affected by the wheels and tires.

<table>
<thead>
<tr>
<th>TYPE OF WHEEL</th>
<th>Rolling Resistance coefficient of tires used.</th>
<th>Weight of wheel</th>
<th>Weight of all wheels in car</th>
<th>Projected total weight of car without driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>GH Craft CFW-S14-94B</td>
<td>0.0025 – 0.0045</td>
<td>2.42 lbs</td>
<td>7.26 lbs</td>
<td>395 lbs</td>
</tr>
<tr>
<td>NGM Aluminum 14in wheel</td>
<td>0.007 – 0.014</td>
<td>4.19 lbs</td>
<td>12.57 lbs</td>
<td>400 lbs</td>
</tr>
</tbody>
</table>

Table 1: Data comparing Carbon fiber wheels & Aluminum wheels. [3][4]

As we can see from the data above, by substituting our current aluminum wheels to carbon fiber wheels there is a significant improvement in both the weight of the car and the rolling resistance coefficient of the tires we are able to use. The improvement in the Rolling Resistance Coefficient is of 65% going from 0.01 to 0.0035 (using average values). The improvement in the overall weight of the car is of 1.5% going from 400lbs to 395lbs. Therefore since the energy dissipated is proportional to the rolling resistance we can see that by simply changing our wheels from aluminum rims to carbon fiber rims the overall estimated improvement in energy dissipation through the tires is of 65%.
Once our newest car SC6 gets finished we will be able to use real data collected from the driving the car and we will be able to compare it to our theoretical improvement in rolling resistance. We will also have more precise data for the weight of our vehicle and we will be able to evaluate what is the overall impact on efficiency is given the improvement in rolling resistance.
References:


