Airtab®

Base Pressure Drag on Trailers

In January 1997, the U.S. Department of Energy (DOE) began a study on Heavy Vehicle Aerodynamic Drag. This is a multi-year study that aims to reduce fossil fuel consumption by heavy trucks (class 8) through the reduction of aerodynamic drag coefficients. According to the Argonne National Laboratory, Class 8 trucks alone consume 18 Billion gallons of fuel each year.

Although tractor manufacturers continue to reduce forebody aerodynamic drag by streamlining their products, little attention has been given to the base drag (suction) at the rear of trailers.

To understand the relationship between forebody aerodynamic improvements and the trailer rear, let's examine this statement from a 1999 NASA report regarding forebody drag at the front of a tractor, and the effects on afterbody drag at the rear of the trailer.

> "Because base drag increases as forebody drag is reduced and these components of drag are additive, afterbody refinement (base drag reduction) will be required in order to achieve an overall aerodynamic drag coefficient of 0.25."
>
> *Page 30 item 5 http://www.dfrc.nasa.gov/DTRS/1999/PDF/H-2283.pdf*

What does this statement mean?

"Onset flow velocity" (the speed of the air at the point of interest) arriving at the base region (the rear of the trailer) increases if the forebody is better streamlined. Therefore, there will be an increase in actual suction on the base because that suction is a function of the airspeed that actually reaches the base. In other words, if the mean velocity at the trailing edges of the sides and roof is increased due to forebody streamlining, the base flow mechanisms "think" the entire vehicle is traveling faster.

A simple example: Let's take a typical truck and trailer traveling at 60 mph. Let's say the mean velocity of airflow arriving at the base (rear of the trailer), has been sufficiently slowed by upstream flow separation and entrainment, so that the onset flow velocity at the rear of the trailer is 45 mph. That gives a baseline amount of base pressure drag on the trailer doors.

Now let's streamline the front of the entire rig sufficiently so that the onset flow velocity at the rear of the trailer is increased to 50 mph. Obviously, that faster flow at the rear of the rig will create more suction on the doors of the trailer.

To further illustrate, let's examine an absurd example of HUGE forebody drag. Let's mount a HUGE flat plate of clear lexan to the nose of a big rig 18-wheeler. So big that it extends 15 ft. above the roofline and 15 ft. beyond each side of the tractor! Obviously, such a configuration would make the aerodynamic configuration at the rear of the trailer irrelevant. Trailer base drag would be greatly "diminished" simply because even the rear of the trailer would be traveling along almost entirely within the monstrous wake of the tractor.

This extreme example should clarify why a less streamlined forebody reduces base pressure drag, whereas a better-streamlined forebody increases base pressure drag.

However, because the drag at these two locations is cumulative, it becomes evident that as tractor manufacturers make continued streamlining progress, an ever-increasing share of total drag will be at the rear end.

Finally, there is one last thing to consider. Aerodynamic drag forces on a moving object increase as the square of the velocity. The same law of aerodynamics applies at the back of the trailer!

This means that if the velocity at the trailing edges of the trailer is doubled, the base pressure drag at the trailer doors increases FOUR times. That means the drag increases by a factor of four if the trailer velocity increases from, say, 45 mph (with no wind) to 90 mph (65 mph speedometer plus a 25 mph headwind).

In conclusion: Improved tractor streamlining causes more suction at the rear of the trailer. This increased "base pressure drag" (suction) at the rear partially offsets the gains up front. Put another way, the more attention that is paid to streamlining the front end, the more important it becomes to consider the results at the rear end.

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