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AEROBYTES

with Simon McBeath

Rear spoilers part 2

More glimpses into the mechanisms that make rear spoilers so useful on a racecar

Figure 1: NASCAR model with rear spoiler variants

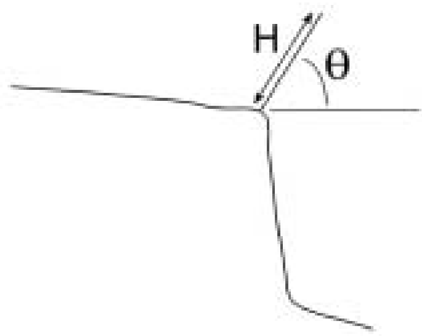

Figure 2: spoiler length and angle definitions: H = length, θ = angle

Rear spoilers can reduce rear end lift or add downforce surprisingly efficiently. In some instances a small or shallow angle rear spoiler can actually reduce drag. And even when large enough to create substantial downforce, a spoiler produces relatively low drag – up to a point, at least. Although spoiler effectiveness is related to both angle and length, last month we looked at spoiler angle in isolation and this month we'll focus on spoiler length. We'll also look at how those drag reductions occur.

Advantage CFD again used the full size virtual model of a NASCAR racer that we've seen in previous issues as the basis for this study. The project looked at changes to rear spoiler angle and spoiler length, and figures 1 and 2 illustrate the racecar model and the spoiler geometry. The spoiler was modelled as an infinitely thin plate for simplicity.

Figures 3, 4 and 5 show the results in graphical form, with dimensionless coefficients multiplied by frontal area plotted against spoiler length. Positive C_LA values represent total downforce, while negative C_LA values represent lift. The main conclusions here are:

- The rear spoiler adds downforce (at the rear, and overall, although front end downforce is reduced slightly).
- Longer spoilers make more downforce, although the benefits appear to be tailing off with increasing length.
- Short spoilers (at any angle) reduce the drag.
- Over a given length, increased spoiler length (at any angle) adds to drag.
- Efficiency increases with spoiler length at any angle, although this benefit is tailing off with the lessening gains in downforce.

So in general, with this model at least, as we saw with spoiler angle last month, bigger is better – both in terms of downforce and efficiency. Note that, as stated in reference to spoiler angle, different vehicle body shapes will yield different results and therefore merit individual evaluation.

Figure 6 shows the changes to static pressure that occur around the car as the result of fitting a 20mm spoiler at just 20 degrees. The red and yellow colours indicate increases in pressure over the rear deck, while the green just visible in the wake and under the car shows small reductions in local pressure in these regions. Longer spoilers show similar but much augmented pressure changes that correspond to bigger increments of downforce and of drag. With longer spoilers there is greater pressure over the rear deck, and lower pressure beneath the car to create the extra downforce, while the low pressure in the increasingly large wake contributes much of the increased drag. Further drag increments come from the spoiler itself as it gets longer, and from the underbody, where increased flow promoted beneath the car by the low wake pressure interacts with the rough underside of the car and causes drag against the pipes and chassis rails.

Produced in association with Advantage CFD

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Lift and drag together

The short, shallow spoiler case is an interesting one however, and CFD can help explain why we get the rare double whammy of simultaneous lift and drag reduction here. Figure 7 plots the static pressure coefficients on the rear of the car for the baseline – no spoiler case (left) and for the short, shallow spoiler case. Without the spoiler there is significantly lower pressure (blue and green) on the upper part of the rear panel, just below the rear deck lip, than there is when the spoiler is fitted. And overall there is more area at lower pressure without a spoiler, which of course creates drag since it is acting on the essentially vertical rear panel. Those →

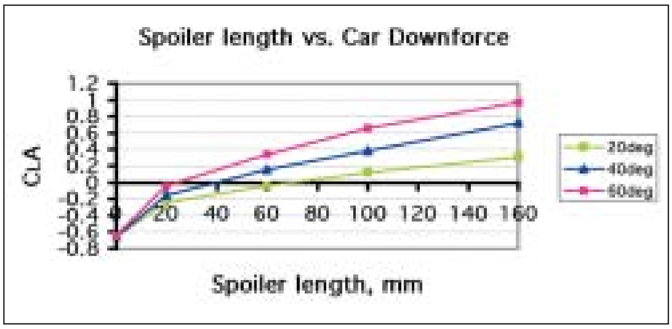

Figure 3: graph showing spoiler length plotted against total car downforce

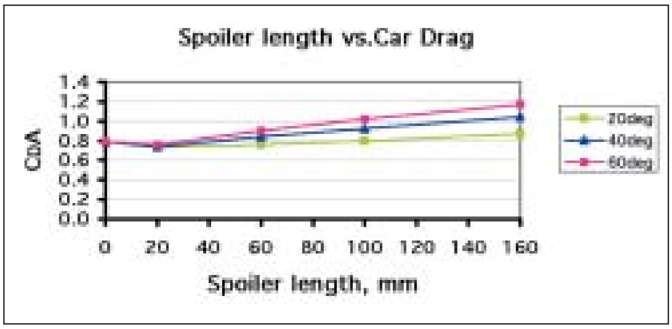

Figure 4: graph showing spoiler length plotted against car drag

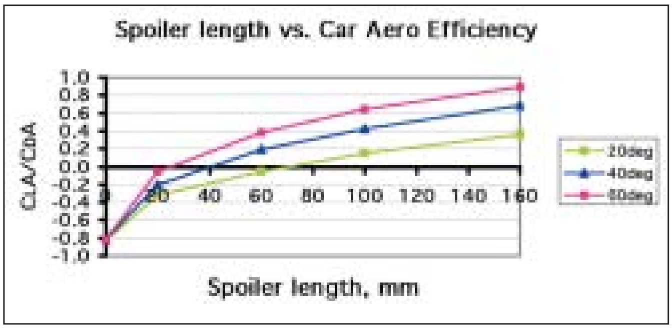

Figure 5: graph showing spoiler length plotted against the car's aerodynamic efficiency

circular areas of low pressure (green) in the case with the small spoiler are interesting and we'll return to them very shortly.

The table below shows in greater detail the sources of the changes to drag and downforce as the result of fitting the 20mm shallow spoiler. Clearly the car body sees the lion's share of the force re-distribution, with most of the drag reduction and downforce increase being felt here. Drag reduction must be on the rear vertical surface, as shown in figure 7, while figure 6 shows the downforce increase to be occurring over the rear deck.

So the changes to the local static pressures on the rear panel cause the drag reduction that occurs when the small, shallow spoiler is used, and figure 8 supplies a clearer indication of how the flow is modified by the spoiler. This pair of graphics shows the simulation of the visualisation technique that uses oily fluid on body surfaces to provide evidence of how the air is moving adjacent to those surfaces. In the no spoiler case the air is flowing around the rear deck lip, and separation patterns can be seen along the upper part of the rear panel. When the spoiler is present these

Sources of changes

	Change to drag, N	Change to downforce, N
Body	-101	485
Wheels	-3	4
Underfloor	12	114
Underfloor pipes etc	9	14
Spoiler	5	14

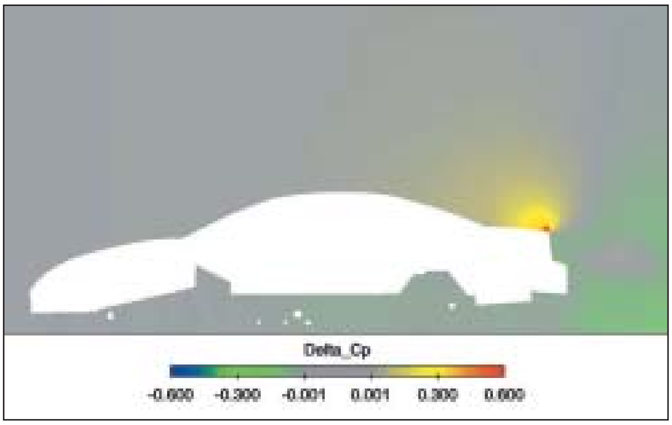

Figure 6: effect of adding a 20mm, 20-degree rear spoiler on static pressure

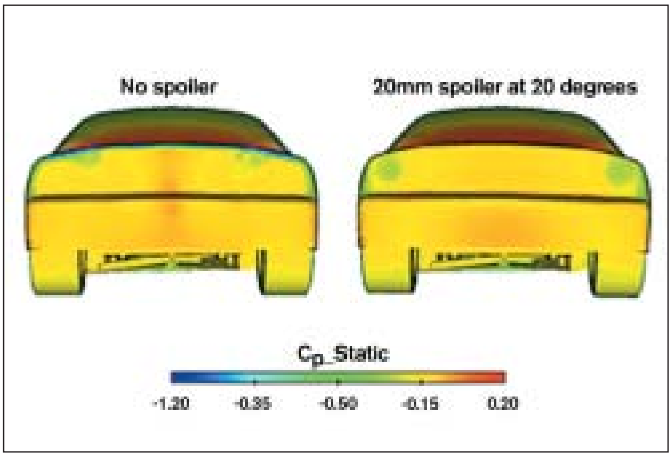

Figure 7: static pressures on the rear panel, with and without the short, shallow spoiler

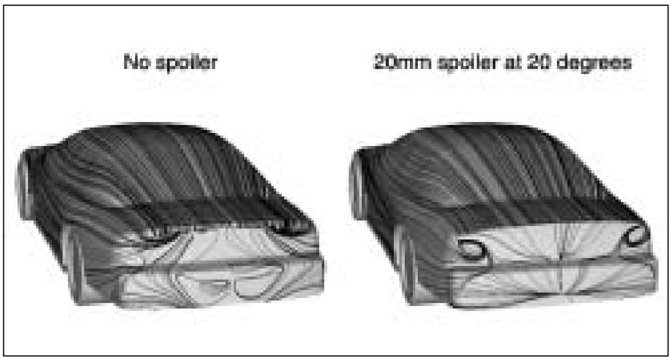

Figure 8: oil flow plots both with and without the short, shallow, 20-degree rear spoiler

separation patterns are not seen, because the spoiler is causing the air to separate sooner. There are also pronounced circular patterns produced on either side, and these correspond to vortices formed by the spoiler.

These flow patterns can be matched to the static pressures observed in figure 7. In the no spoiler case, the low static pressure on the uppermost part of the rear panel is associated with the airflow accelerating sharply around the radius here before separating slightly below the lip. This acceleration creates lift (on the horizontal part of the radius) and drag (on the rear facing part of the radius). But fitting the spoiler eradicates the zone of flow acceleration, resulting in higher pressure on the rear panel and less drag. And the pair of vortices at the sides can be seen to align with the reduced pressure within those small circular regions, although these reductions (which add to drag) do not outweigh the overall increase in pressure on the rear panel caused by the spoiler.

So although most of the results of this spoiler trial may not have been surprising, the unusual short spoiler case reminds us that it never pays to over-generalise about racecar aerodynamics. RE

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