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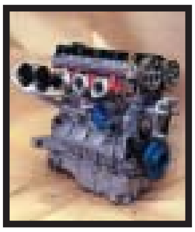

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with Simon McBeath

Smooth underfloors

Removing some of the clutter from the underfloor area can have aerodynamic benefits

We've been studying the effect of changes on a virtual model of a NASCAR racecar in recent issues, and seen that airdams, splitters and diffusers have all produced very useful and efficient benefits in terms of downforce gains for little, if any extra drag (and even reduced drag in some cases).

The model that Advantage CFD used for this work included some pretty realistic representations of exhaust pipes and some chassis members in order that the simulated underbody airflow was also reasonably realistic. With minor alterations to the CAD model it was possible to perform CFD runs with and without these underbody protuberances (see figures 1 and 2), thus simulating the tidying up of the underside as if the pipework had been tucked within the underside panelling instead of hanging below it. So, although this wasn't quite the same as installing a completely smooth panel, it did make it possible to see what a degree of 'smoothing' of the underbody could achieve.

The results were, perhaps, not exactly surprising, though the details make for illuminating study. Table 1 shows what happened to the downforce figures. As in previous articles, the simulated air velocity was 50m/s (180km/h or 112mph).

Table 1: downforce changes

	Rough floor, N	Smooth floor, N	Δ, N
Body	-1752 (lift)	-1682	70 (less lift)
Wheels	-183 (lift)	-190	7
Underfloor	3232 (downforce)	3262	30 (more downforce)
Rear spoiler	133	133	0
TOTAL	**1430**	**1523**	**93 (6.5 per cent more downforce)**

In short, there was a 6.5 per cent increase in downforce resulting from the smoother underside – a useful gain. Let's dwell on how that gain accrued.

Of the 93N benefit to overall downforce, the majority (70N) came from lift reduction over the upper surface of the car's body, on the face of it a surprising consequence of removing underbody clutter. But, as the result of removing the exposed pipes and chassis members, the airflow under the car increased. This has led to a fairly uniform reduction in flow over the body, reducing the naturally occurring lift caused by that air accelerating over the body. Figure 3, a Δ Cp_Z plot showing the effect of the change to the model on the vertical component of the pressure coefficients, illustrates this.

Figure 1: 3D NASCAR model with 'rough' underside

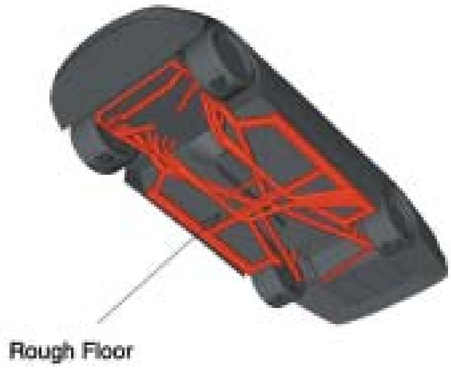

Figure 2: pipes and chassis tubes removed to smooth out underside

To aid interpretation of these plots, blue/green shows an increase in local downforce, red/yellow shows a decrease in local downforce. Here then the colours show that there has been a reduction in lift over most of the body surface as the result of removing the underbody pipes and so forth. Although the actual pressure changes are very small (see the scale in figure 3), when integrated over the whole plan area they add up to the 70N lift reduction shown in table 1.

The story for the underside is more complex, and figure 4 is once more a Δ Cp_Z plot, this time showing the effect of the removal of the underside protuberances on the vertical component of the underside pressure coefficients. Generally the dominant blues and greens in the front half of the underside show that there has been a reduction in vertically

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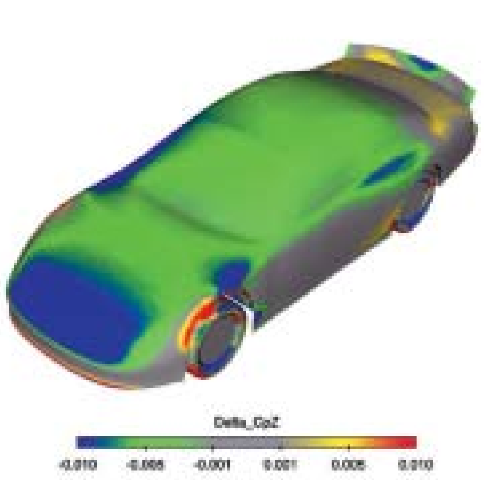

Figure 3: Δ Cp_Z plot showing there has been a reduction in lift over most of the body surface as the result of removing the underbody pipes

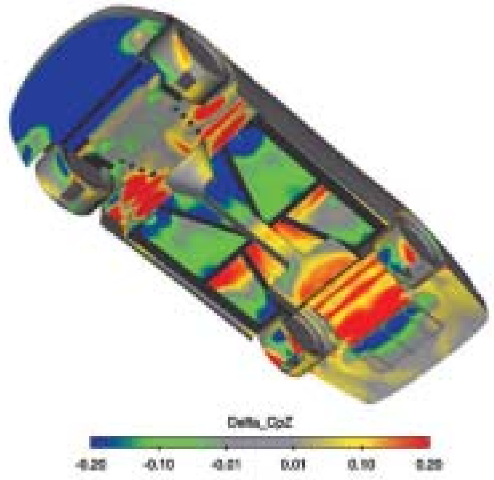

Figure 4: Δ Cp_Z plot showing complex downforce changes in the underbody after removing the pipes

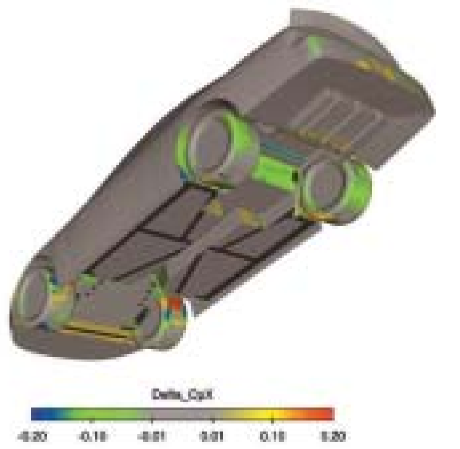

Figure 5: Δ Cp_X plot of the underside viewed from the rear shows that there is a reduction in X-direction pressure caused by removing the pipes

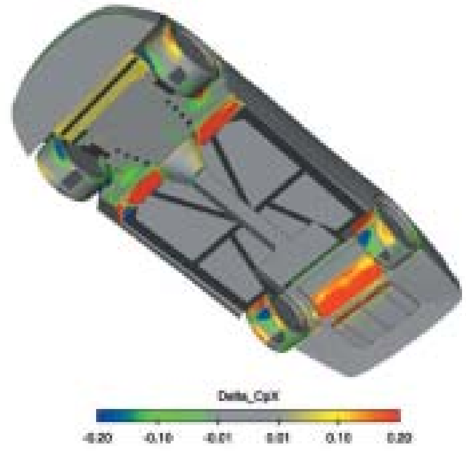

Figure 6: Δ Cp_X plot shows an increase in drag from the rear of the front and rear wheel cavities

acting static pressure in this area. This lower static pressure comes from two sources: the increased flow under the car and the reduction in total pressure arising from increased losses under the forward section.

But aft of the central crossbeam location, reds and yellows dominate, indicating that the pressure change here is upward acting, leading to downforce reduction in the rear underbody when the pipes and chassis members have been removed. This also seems curious but interestingly, when the chassis tubes are in place, the central crossbeam causes separation and hence substantial losses, leading to much reduced static pressure and hence more downforce in the rear underbody. Removing the crossbeam increases the flow, which also reduces the static pressure, but this effect is smaller than that caused by the losses from the crossbeam, so the overall effect, rather surprisingly, is a loss of downforce from the rear section when the crossbeam is removed.

Complex changes

So the changes to downforce from the underside are complex and, although there is an overall gain here, it is smaller than might have been imagined. It also points to the fact that the overall downforce gain is forward biased. The changes to drag are small, but interesting in their detail too, once more alluding to the complexity of the airflow in such a situation. Table 2 summarises.

Overall, there is a very modest one per cent reduction in drag, smaller perhaps than might have been imagined but still, in combination with a downforce increase, something of a bonus.

It appears from table 2 that the biggest part of the drag reduction accrues from the wheels. Figure 5 helps to explain this. It is a Δ Cp_X plot, showing changes in the X-direction (rearward acting) component of the pressure coefficients resulting from the removal of the pipes and tubes. Blue/green shows a decrease in local drag, red/yellow shows an increase in local drag. This view from the rear shows that there is a reduction in X-direction pressure caused by removing the pipes and tubes. This arises from the aforementioned increase in static pressure under the rear of the car acting on the rear faces of the tyres, which counteracts drag. But there is also an increase in drag from the rear of the front and rear wheel cavities – this the result of the increased flow colliding with these near vertical faces, as shown by the red colours in the Δ Cp_X plot in figure 6. Again, a complex picture that, in this instance, results in a small overall drag reduction.

Table 2: drag changes

	Rough floor, N	Smooth floor, N	Δ, N
Body	767	767	0
Wheels	247	235	-12
Underfloor	533	527	-6
Rear spoiler	271	271	0
TOTAL	**1818**	**1800**	**-18 (1 per cent less drag)**

It seems probable that a fully smooth underfloor would achieve a somewhat different result, but then the questions of rake angle and profile would come into play – these could be subjects for future Aerobytes. One thing is certain from this study however, where there are complex flows it is very unwise to make assumptions on likely results.

Next month we'll look at rear spoilers on our NASCAR model

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