INSIDE: AUTOSPORT ENGINEERING 2005 SHOW GUIDE

The International Journal

Racecar engineering™

AOL Keyword: Racecar Engineering

KNOWLEDGE IN A BOX
New suspension software brings Lotus' know-how to racers

RACECAR SET-UP TOOLS
Guide to buying the right equipment for chassis alignment

February 2005 • Vol 15 No 02 www.racecar-engineering.com UK £4.50 • USA $8.95

AUTOSPORT SHOW 140-PAGE SPECIAL

Driven to win

The revolution that brought F1 gearboxes into the 21st century

D Sports
The new place for racecar constructors

Magnesium
Latest alloys and how to use them

SAE conference
Full report from the motorsport symposium

www.sutton-images.com

02
9 770961 109050

AEROBYTES

with Simon McBeath

Rear spoilers

The benefits of rear spoilers are legend, but the mechanisms are not so well known. CFD reveals all…

The usual texts are pretty much in agreement on what we can expect to gain and lose when fitting a rear spoiler onto a saloon/sedan-based racecar, not surprising considering how much work has been done on the effects of varying spoiler length and angle. The benefit of looking at the topic with CFD, though, is that changes to pressures and airflows can be visualised in ways that help us understand so much better what's actually going on.

Advantage CFD once again used the full size virtual model of a NASCAR racer that regular readers will have seen in the past few issues to evaluate the effects of changing spoiler angle and length. Figures 1 and 2 show the racecar model, and the geometry of the spoiler device tested (which for simplicity was modelled as an infinitely thin flat plate).

Figures 3 and 4 summarise the results in graphical form, with dimensionless coefficients multiplied by frontal area plotted versus spoiler angle, which is the aspect this column will focus on. Positive C_LA values represent total downforce, while negative C_LA values represent lift. Let's draw the obvious conclusions before proceeding: there is an increase in downforce when a rear spoiler is added (this is felt at the rear, there is actually a slight decrease in front downforce) and there is a more or less linear increase in downforce with increasing spoiler angle.

The downforce gain seems to be tailing off at the steepest angle and longest length, though at shorter lengths the gains with increasing angle are still linear. In general, steeper angles lead to greater drag. For any given length, increasing spoiler angle also increases efficiency (C_LA/C_DA).

There's no doubting the value of a simple rear spoiler on this type of generic production car shape then – substantial and perhaps surprisingly efficient gains in lift reduction/downforce creation are apparent. Indeed, a shallow (20 degree) spoiler as long as 60mm is capable of actually reducing the car's drag while reducing rear lift or creating modest downforce, and although it's likely that seeking maximum downforce will be the aim in many cases, clearly there are options to balance downforce and drag here, rules permitting of course. Note that different body shapes are likely to produce different results and therefore would ideally need individual evaluation.

Figure 5 shows the changes in static pressures (Delta Cp) that occur around the car with the fitment of the steepest (and longest) spoiler. →

Figure 1: NASCAR model with rear spoiler variants

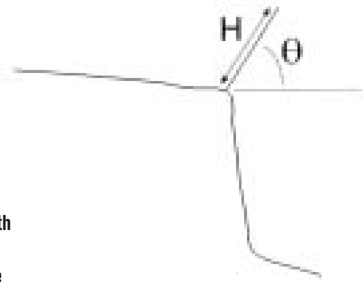

Figure 2: spoiler length and angle definitions: H = length, θ = angle

Figure 3: effect of spoiler angle on non-dimensional total downforce (0 = no spoiler)

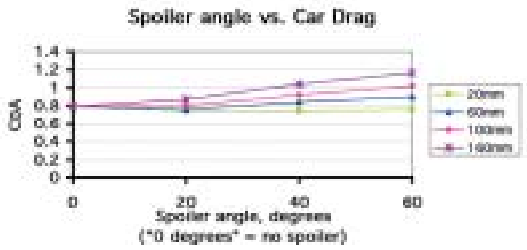

Figure 4: effect of differences in spoiler angle on non-dimensional car drag

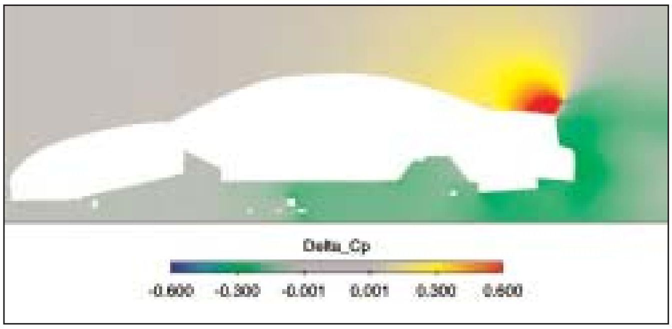

Figure 5: the effect of the addition of a 60-degree, 160mm rear spoiler on static pressure

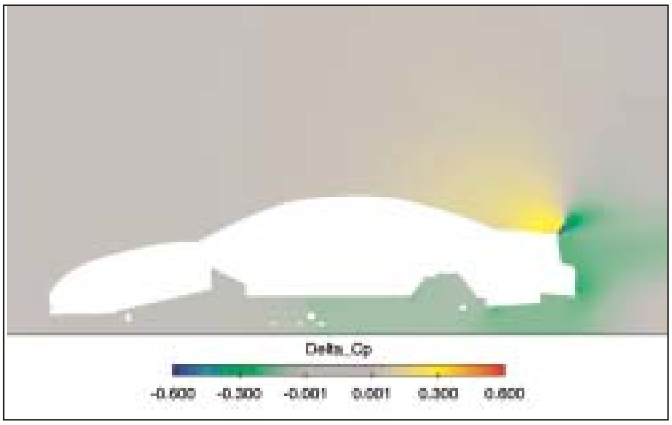

Figure 6: the effect on static pressure of increasing spoiler angle from 20 to 60 degrees

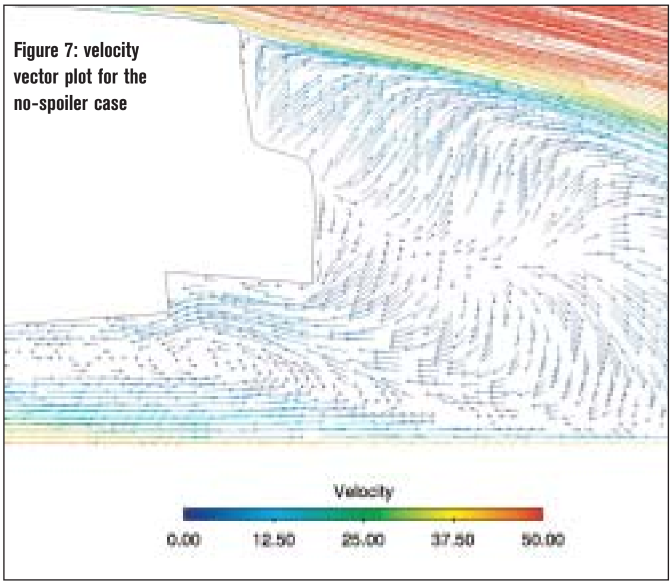

Figure 7: velocity vector plot for the no-spoiler case

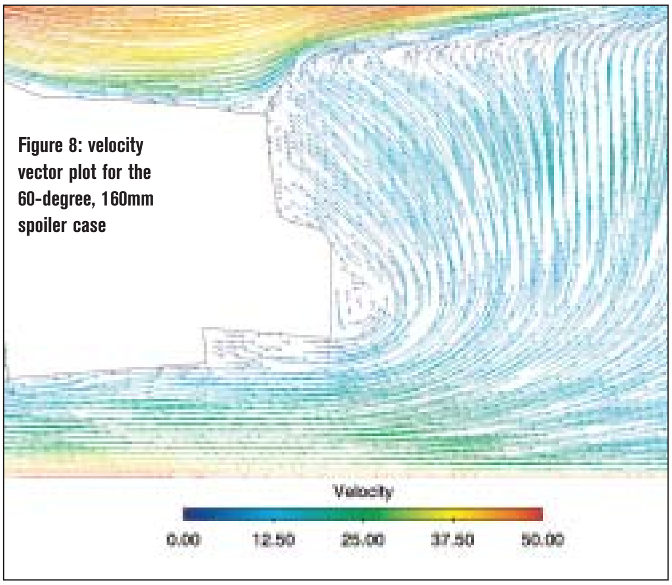

Figure 8: velocity vector plot for the 60-degree, 160mm spoiler case

Red and yellow indicate increases in local pressure, while green indicates reductions. Clearly there is a substantial increase in pressure over the rear deck of the car, extending quite a long way forward, which contributes to lift reduction/downforce generation. It is also clear that the pressure behind the car has reduced, which contributes to the increased drag in this configuration. And there is also a notable reduction in pressure beneath the car, which further contributes to downforce generation. So now let's delve a little deeper into the mechanisms themselves.

The change over the rear deck is relatively simple to explain. Adding a spoiler has slowed the airflow over the rear deck and, at steeper spoiler angles, has probably caused the flow to separate from the shallow angle rear screen, both of which have contributed to the increases in static pressure in this region. The airflow direction is also altered, the spoiler deflecting the flow upward, indicative of momentum transfer from the airflow to the car.

Behind the car the situation is more complex. Adding a spoiler increases the size of the car's wake and the low total pressure region behind the car. Increasing the spoiler angle leads to further increases in wake size and the low total pressure region. And it is the losses in total pressure that are significant here, more than any changes to air velocity. Returning briefly to Bernouilli's Equation explains the significance of this:

$$P_s + 1/\rho v^2 + \text{losses} = C$$

Where P_s = static pressure and $1/2\rho v^2$ = dynamic pressure.

The losses are large and cause the static pressure to reduce. Any reductions in dynamic pressure as the result of decreases in flow velocity, which in a more ordered flow regime would cause increases in static pressure, are outweighed by the losses.

Beneath the car a different situation prevails. The reduced static pressure region behind the car promotes an increase in mass flow under the car, air flowing happily into a low-pressure region. This has caused an increase in dynamic pressure and, in turn, a drop in static pressure under the rear of the car in classic Bernouilli style. However, although this adds to the generation of downforce, a drawback of this is that the increased mass flow that interferes with the pipes and chassis rails beneath the car also adds to the increase in drag already caused by the pressure differentials across the spoiler itself, and around the car as a whole. Increasing spoiler angle amplifies all these effects, and figure 6 shows the change in static pressures (delta Cp) that occur when the longest spoiler is increased from 20 to 60 degrees inclination.

The change to the pattern of airflow behind the car from the baseline, no spoiler case to the steepest, longest spoiler case is profound, as figures 7 and 8 illustrate. Colour-coded velocity vectors show in figure 7 that with no spoiler the airflow coming off the rear deck is fast and downward directed towards the rear, but the flow immediately behind the car is very slow and completely disordered. Contrast that to figure 8 with the steep, long spoiler, and not only has the flow over the rear deck been slowed and re-directed, but now the flow in the wake shows no re-circulation under the car, and overall is pulled strongly upwards by the presence of the spoiler. The flow emerging from under the rear is also clearly smoother and faster. RE

Next month we'll ponder the mechanisms involved with different spoiler lengths in more detail, and also examine how a short spoiler reduces drag.

SUBSCRIBE TODAY

and stay one step ahead for 30% less!

• Save 30% off the normal price

- **ALL** the latest industry insights before the competition!
- **NEVER** miss an issue
- **NO** price increases for 12 months
- **FREE** postage and packing
- **GUARANTEED** delivery to your door, worldwide
- **FULL** satisfaction guaranteed

The International Journal Racecar engineering™

For a rapid order call our hotline

Tel: +44 (0)845 676 7778

Please quote 26T. Lines open 7 days a week, 9.00am–9.00pm (UK time)

OR SUBSCRIBE ONLINE AT WWW.RACECAR-ENGINEERING.COM

Click here to download our new digital version now or go to www.racecar-engineering.com/digital

SUBSCRIPTION ORDER FORM

Simply complete this form, attach your payment and send it to:

UK: Racecar Engineering Subscriptions,
FREEPOST CY1061, Haywards Heath,
West Sussex RH16 3ZA, UK (NO STAMP REQUIRED)

Overseas: Racecar Engineering Subscriptions,
PO Box 272, Haywards Heath,
West Sussex RH16 3FS, UK (PLEASE AFFIX CORRECT POSTAGE)

☑ Yes, I would like to subscribe to **Racecar Engineering** and get **30% off** the normal price

	12 issues	Offer price
☐ UK (annual)	£37.80	SAVE 30%
☐ UK (6 monthly direct debit)	£18.90	SAVE 30%
☐ USA	$86.10	SAVE 30%
☐ Western Europe & Eire	€64.75	SAVE 30%
☐ Rest of World	£53.90	SAVE 30%

N.B. All overseas subscriptions receive an airmail service.
All prices are discounted against our standard subscription rates.

ATTENTION ALL NORTH AMERICAN SUBSCRIBERS

TOLL FREE:	**1-800 EWA 4454**
Fax:	**732 424 7814**
Web address:	**www.ewacars.com CLICK HERE**
Postal address:	**EWA, 205 US Highway 22 Green Brook, New Jersey, 08812 USA**

YOUR DETAILS

Title: ......Initial: ....Surname: ....

Address: ....

....

Postcode: ....Country: ....

Evening Tel: ....

If you would like to receive emails from Racecar Engineering and IPC containing news, special offers and products and service information, and take part in our magazine research via email, please include your email address below:

Email: ....

PAYMENT DETAILS

☐ I enclose a cheque for £/$/€ ....
made payable to IPC MEDIA LTD.

☐ I wish to pay by Mastercard ☐ Visa ☐ Amex ☐ Diners ☐ Delta ☐

☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐

Expiry Date: ....Signature ....Date ....

Data protection: Racecar Engineering, published by IPC Media Ltd (IPC), will collect your personal information to process your order. Racecar Engineering and IPC would like to contact you by post or telephone to promote and ask your opinion on our magazines and services. Please tick here if you prefer not to hear from us ☐. IPC may occasionally pass your details to carefully selected organisations so they can contact you by telephone or post with regards to promoting and researching their products and services. Please tick here if you prefer not to be contacted ☐.

Offer Closing Date: 31 December 2005 (26T)