Aerodynamics for LANCER EVOLUTION X

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Abstract

Aerodynamics technology for the LANCER EVOLUTION X was developed not only to reduce drag but also improve lift and cooling performance. The applied aerodynamics technology includes the nose shape like that of a shark, the cooling, the rear spoiler shape, etc. As a result, the drag coefficient (C_D) and lift coefficient (C_L) values are less than that of the LANCER EVOLUTION IX. This paper describes the aerodynamics technology for the LANCER EVOLUTION X and also introduces the Under Floor Air Guide, a new aerodynamic device.

Key words: *Aerodynamics, Fluid Dynamics, Aerodynamic Devices, Cooling*

1. Introduction

Since the appearance of the first-generation model, the LANCER EVOLUTION has been continually improved to excel in various motor sports by outstanding driving performance superior to competitors. A lot of model tests, CFD analyses, and tests using actual vehicles have been performed (**Fig. 1**) that aims not only to reduce the drag coefficient (C_D), but also to reduce the lift coefficient (C_L) and enhance cooling performance. The resulting aerodynamically shaped bodies offered a sophisticated combination of riding comfort and body design. In developing the LANCER EVOLUTION X, additional efforts have resulted in lower C_D and C_L compared to the LANCER EVOLUTION IX. Particularly, the C_L value is world-leading for this class of vehicle. The development work is summarized below (**Fig. 2**).

2. Aerodynamic development of the LANCER EVOLUTION X

In the aerodynamic development of the LANCER EVOLUTION X, first the entire body was optimized aerodynamically, and then the specific aerodynamics parts shown in **Fig. 3** were optimized. The shapes of the body have been optimized through repeated studies to combine the low drag coefficient styling with impressive design of the EVOLUTION – for example, shark nose, the over-fenders which gently incline along the length, and the rear combination lamps with sharp edges. The wheel arch air dam and the shape of the bottom edge of the bumper actively separate the air flow, creating negative pressure which reduces the lift of the body. For cooling, the hood inlet, based on the NACA scoop shape, and hood outlet which have adopted from LANCER EVOLUTION IX, and the new fender outlets located at suitable positions on the body surface enhance the cooling performance for the engine compartment. Details of the rear spoiler, the

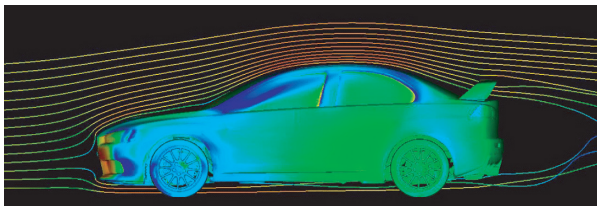

Fig. 1 Pressure distribution and air flow trace line

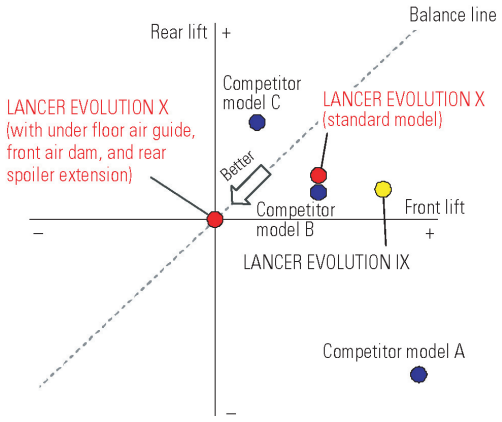

Fig. 2 Comparison of lift coefficient (C_L)

under floor air guide (optional part), and the cooling air intake construction with effective opening are described below.

3. Development of a new shape (twisted wing) rear spoiler

In the case of a sedan body, the flow separated at the C pillar is drawn in above the rear window, resulting in a pair of vortices (**Fig. 4**). As a result of these vortices, the downflow angles at the center and the outside

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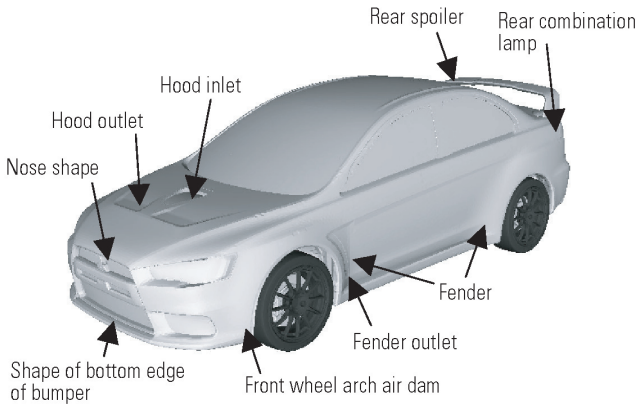


Fig. 3 Body shape with aerodynamic functions

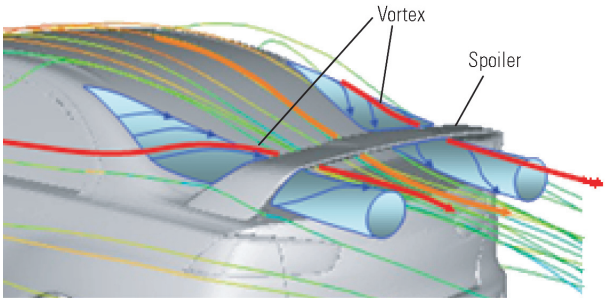


Fig. 4 Air flow on rear of vehicle

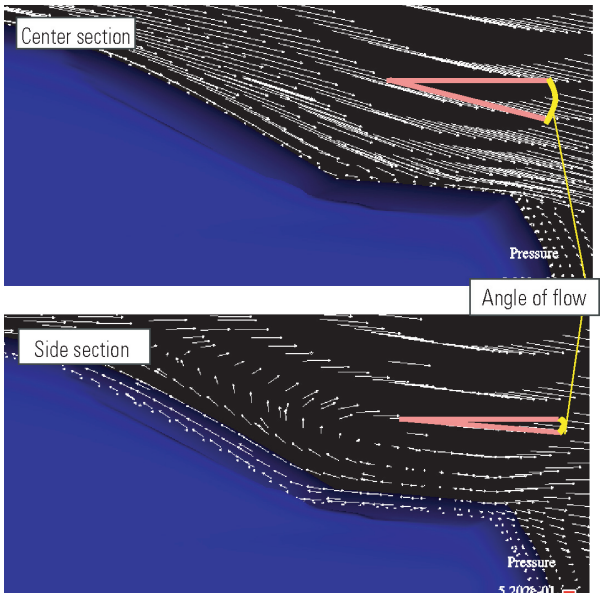


Fig. 5 Angle of flow at each position

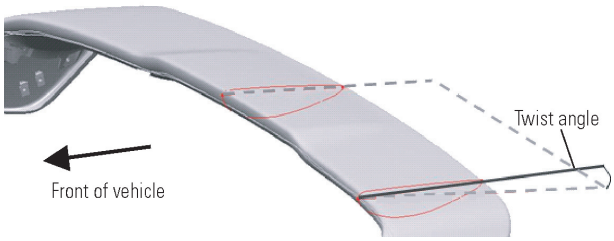


Fig. 6 Twisted wing

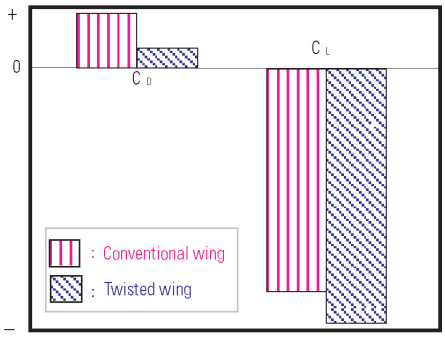


Fig. 7 Comparison of twisted wing and conventional wing

of the body are different from each other (**Fig. 5**), which could cause the following problems with the conventional wing.

(1) Where the downflow angle is deep, the angle of attack of the wing is excessively large, and the flow separates at the trailing edge side.

(2) Where the downflow angle is shallow, the angle of attack of the wing is excessively small, reducing the full performance of the spoiler.

To overcome these problems, the wing angle of the LANCER EVOLUTION X differs at the center and the outside of the vehicle body (**Fig. 6**). As the wing performance is enhanced, the increase in drag is curbed and the lift is significantly reduced (**Fig. 7**). The height of the spoiler, its position in the lengthwise direction, and the shape of the wing cross-section were also optimized by wind tunnel tests.

4. Under floor air guide

The under floor air guide which effectively reduces lift has been newly developed as an optional part for the LANCER EVOLUTION X (**Fig. 8**). This device is the fins installed under the floor to diffuse the airflow from the under floor to the outside of the body, thus increasing the flow velocity at the center section of the under floor. This high-velocity airflow and the vortices created the lower pressure region at the under floor behind the fins and this area contributes to reduce the lift of the body.

Fig. 9 shows the results of a model test performed with a pair of air guides installed on a flat plate simulating an under floor of the vehicle. The top half of the figure shows the change in the surface pressure when the air guides are installed. The blue area indicates the region in which the pressure falls (reducing lift), and the red area indicates the region where the pressure rises. These results reveal that the maximum pressure reduc-

Fig. 8 Under floor air guide

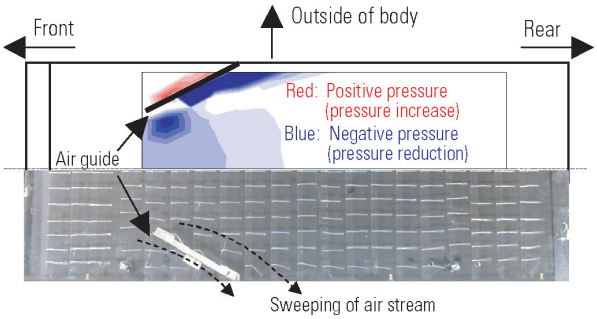


Fig. 9 Model test results of under floor air guide

tion occurs downstream of the air guide, and also that pressure is reduced even at the center of the body between the left and right air guides. Although there is a red region where the pressure rises upstream of the guides, it is smaller in area than the blue region where the pressure falls. The bottom half of the figure shows the results of a flow visualization test of the under floor using tuft method. It can be seen that the flow is diffused to the outside of the vehicle and vortices are created behind the air guides. The flow at the center part of the vehicle is thought to be drawn toward the outer part by the negative pressure of these vortices, that accelerate the flow velocity at the center part and thus reducing pressure of the under floor.

Fig. 10 shows the pressure distribution obtained by CFD analysis performed both with and without the air guides on an actual under floor model. The image also shows that the air guides have increased the area of the negative pressure region (blue area).

A lift reduction device represented by a front air dam and a rear spoiler are normally effective in reducing the lift at the front or the rear alone. The remarkable feature of the new air guide is that it reduces both the front and rear lift in a well-balanced manner depending on where it is installed (**Fig. 11**). In the LANCER EVOLUTION X, the air guide was set in the optimum position in consideration of the balance between the front and rear lift of the standard model.

5. Optimization of cooling performance by redesigning the body structure

Extensive development work on engine cooling was carried out in order to obtain the maximum perfor-

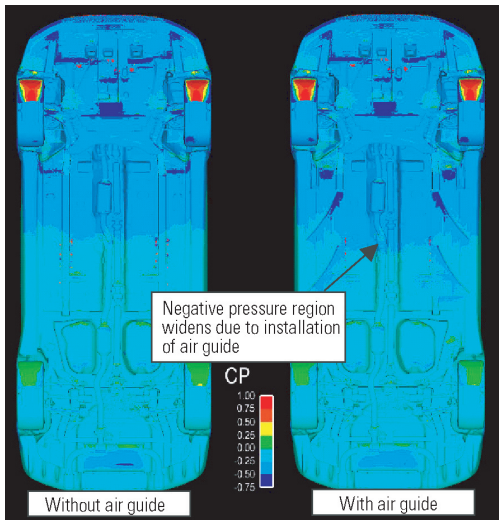


Fig. 10 Effect of under floor air guide

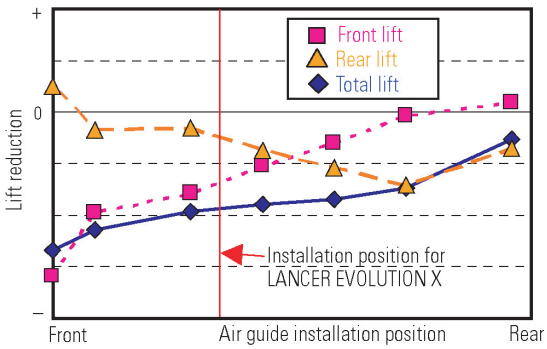


Fig. 11 Change of lift in relation to position of under floor air guide

mance from the LANCER EVOLUTION X. As an example of enhanced cooling performance, the structure for guiding air to the twin clutch SST oil cooler and the engine oil cooler is described below. **Fig. 12** shows the front view of the vehicle. In order to efficiently cool the oil, the air taken from the center opening is guided via an air duct to the oil coolers (**Fig. 13**).

Fig. 14 shows the CFD results of the flow for cooling. It can be seen that the cooling air enters the duct from the center opening and passes through it then flows into the oil coolers. **Fig. 15** shows measurements of actual air flow velocity; the air flow velocity has increased by about 50 %.

6. Conclusion

The LANCER EVOLUTION X employs a newly developed rear spoiler and under floor air guides on the body which harmonize dynamic design and aerodynamic characteristics. As a result, the performance far surpasses that of the previous EVOLUTION models not only the reduction of aerodynamic drag but also the lift

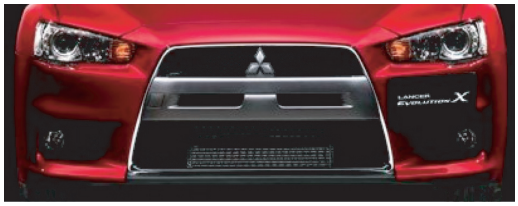


Fig. 12 Openings for cooling

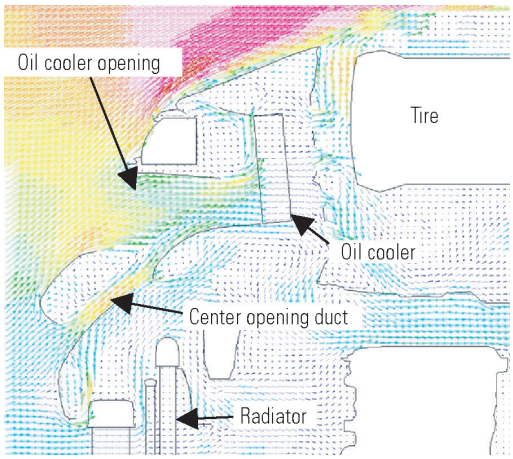


Fig. 14 Velocity vector in air duct (horizontal section)

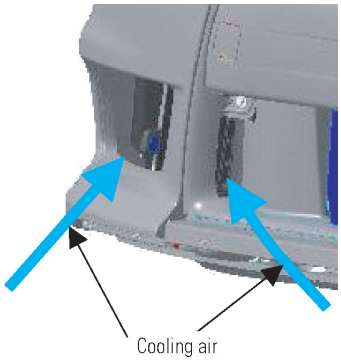


Fig. 13 Oil cooler opening and air duct at center opening

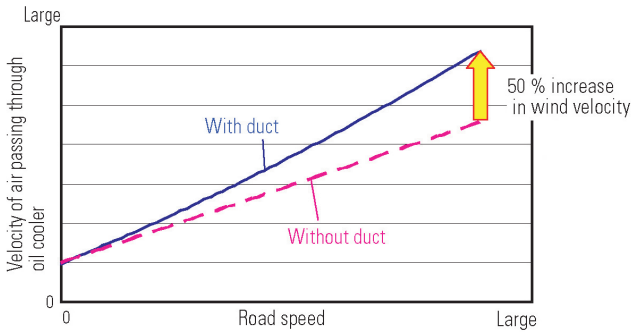
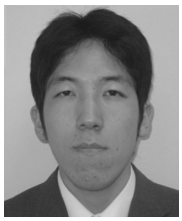


Fig. 15 Comparison of wind velocities through oil cooler

which greatly affects the steering stability. With this excellent aerodynamic balance, the LANCER EVOLUTION X will uphold the reputation of its predecessors in motor sports such as rallies.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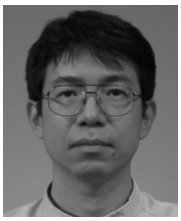
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