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Flow Analysis according to the Installation of an Aero Part in a Sports Car

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스포츠카의 에어로 파츠 설치에 따른 유동해석

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ABSTRACT

In this study, flow analyses of a vehicle at driving were carried out after each installation of a tuning part, specifically the bonnet air ducts, the rear spoiler, and the rear diffuser. The study models were designed to comprise a total of eight cases in which each of the three parts were mounted individually or all together in vehicles. Assuming that the vehicle were driven with an average high speed of 100 km/h, the speed and pressure around the vehicle were obtained using CFD when driving. The rear diffuser that becomes the most effective among the three mounting parts has a major role in reducing air resistance.

Key Words : Sports Car(스포츠카), Aero Parts(에어로 파츠), Air Resistance(공기 저항), Flow Analysis(유동 해석), Pressure(압력)

1. Introduction

At the market for automobile with high performance, the research and development of various aerodynamic devices become the important part of the general vehicle market. Even a small improvement at efficiency can save a lot of manufacturing cost by developing the high performance vehicle with much fuel consumption. So, many research centers have been carried out the flow analysis as a part of the effort to reduce the air resistance at driving a passenger car or a lorry which is mainly used by the general public. Because there is a tendency to develop the vehicles in accordance with Europe's pioneering methods at Korea, the research on air flow on the cars with these high performance is also expected to become active in future. In case of the vehicles with high performance, the studies such as controlling the air flow of radiator grille are being conducted with the air enhancing design in order to reduce air resistance. But, in case of the rear spoiler, various studies have already been conducted and the optimized products have been designed and sold at after-market with a variety of installations at

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ordinary vehicles. In this study, the models composed of three tuning parts are made by referring to the model of the sports car on sale. And the flow models around vehicle are designed and the finite element results are compared with each other[1-12]. Assuming that the vehicle is driven with an average high speed of 100 km/h, the speed and pressure around the vehicle by using CFD are obtained when driving. The rear diffuser which becomes the most effective among the three mounting parts has major role at reducing air resistance. Through the flow analysis result[6-12] due to the installation of the aero part at the sports car, it is thought to be able to design the car body efficiently[11] with the effort to reduce the air resistance when driving the car.

2. Study Models and Boundary Conditions

The front and rear sides of vehicle models used in this study are shown by Figs. 1 and 2 as the same model. In this study, the front side as shown by Fig. 1 allows the flow of air into the engine through the bonnet air duct to escape through the front glass. The rear side as shown by Fig. 2 are the rear spoiler and rear diffuser. The total car body models are designed with eight analysis models. With no mounting model, Table 1 illustrates all kinds of car body models compounded of the bonnet air duct or rear spoiler, or rear diffuser.

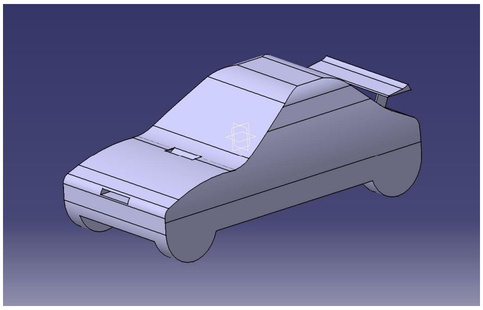

Fig. 1 Car body model at front side

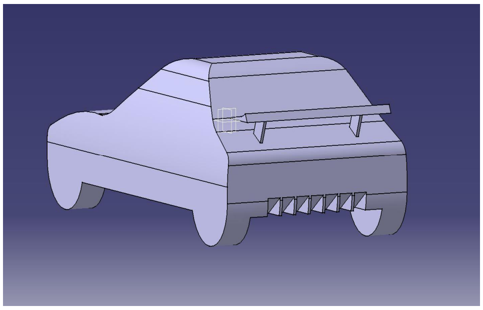

Fig. 2 Car body model at rear side

Table 1 All types of car body models

Type	No installation	Bonnet Duct	Rear Spoiler	Rear Diffuser
Model 1	O			
Model 2		O		
Model 3		O	O	
Model 4		O		O
Model 5				O
Model 6			O	
Model 7			O	O
Model 8		O	O	O

Finally, as shown by Fig. 3, the air zone is designed separately to remove the vehicle solid model in order to make the analytical flow model. Table 2 shows the informations on the nodes and elements of meshes at all flow models in order to carry out the flow analyses.

Fig. 4. shows the boundary condition for the flow analyses on all models. In this study, the flow speed at the inlet is set at 100 km/h and the temperature of the flowing air is kept at 25°C.

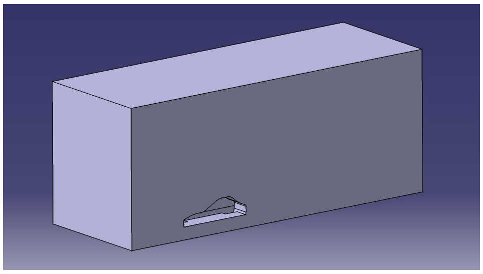

Fig. 3 Analysis flow model

Table 2 Meshes of flow models

	Nodes	Elements
Model 1	10,763	45,118
Model 2	7,128	40,752
Model 3	7,236	41,460
Model 4	7,122	40,755
Model 5	7,096	40,624
Model 6	7,201	41,259
Model 7	7,219	41,409
Model 8	7,256	41,606

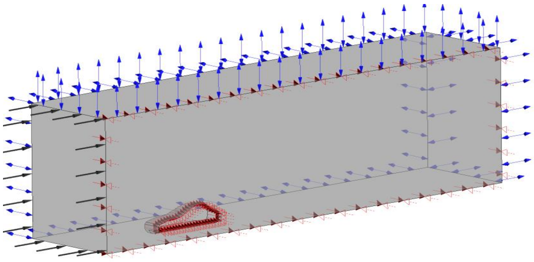

Fig. 4 Boundary condition of flow model

3. Study Results

3.1 Analysis result of model 1

As shown by Figs. 5 and 6, a vehicle model 1 is assumed to be driven with the speed of 100 km/h, showing the surrounding flow rate near the vehicle and the air pressure around it. It can be seen that the maximum air speed around the vehicle is 38.92 m/s and its location is the upper part of

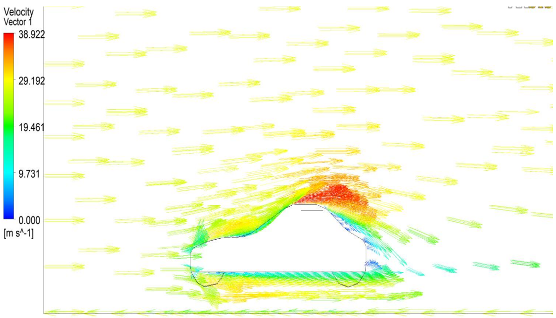

Fig. 5 Contour of air velocity at model 1

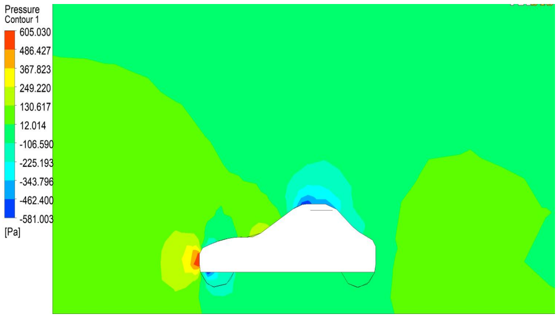

Fig. 6 Contour of air pressure at model 1

the vehicle. The pressure of surrounding air becomes the highest in the area where the car body is hit by the front air of the vehicle and the pressure at the top is very low, indicating that the downward force is poorly formed.

3.2 Analysis result of model 2

As shown by Figs. 7 and 8, a vehicle model 2 is assumed to be driven with 100 km/h, showing the surrounding flow rate near the vehicle and the air pressure around it. As can be seen in Fig. 7, the maximum air velocity around the vehicle is 38.72 m/s and its position is at the upper part of the vehicle. Also, as can be seen in Fig. 8, The part of contact with the air at the front of the vehicle is shown to have the highest pressure and the pressure in the upper part is somewhat increased due to the flow rate of the air passing through the duct.

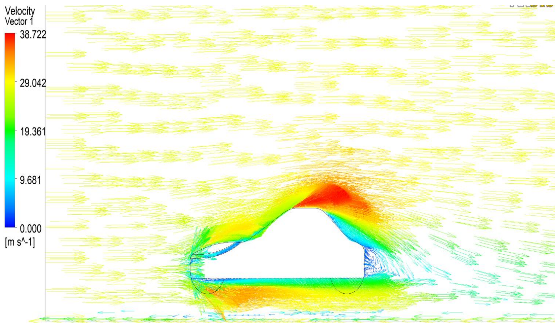

Fig. 7 Contour of air velocity at model 2

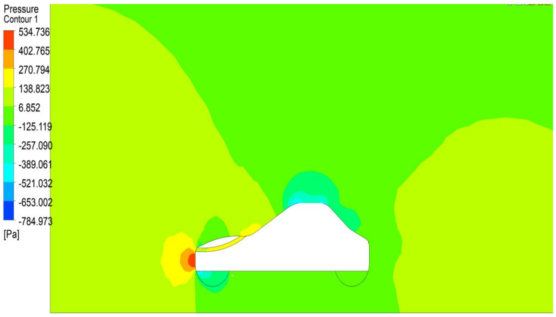

Fig. 8 Contour of air pressure at model 2

3.3 Analysis result of model 3

As shown by Figs. 9 and 10, a vehicle model 3 is assumed to be driven with the speed of 100 km/h, showing the flow rate of stream surrounded with the vehicle and the air pressure around it. As can be seen in Fig. 9, the maximum air velocity around the vehicle is 39.02 m/s and its position is the upper part of the vehicle. And it can be seen that the current flow is formed by the air in the lower rear section of car.

As can be seen at Fig. 10, the pressure of the air surrounded with car body becomes the highest at the area matched with the air in the front of the vehicle.

3.4 Analysis result of model 4

As shown by Figs. 11 and 12, a vehicle model 4 is assumed to be driven with the speed of 100 km/h, showing the flow rate of stream surrounded with the vehicle and the air pressure around it.

As can be seen at Fig. 11, the maximum air velocity around the vehicle is 38.81 m/s and its position is shown to be the upper part of the vehicle and the formation of vortex is inhibited by the rear diffuser. As can be seen at Fig. 12, the

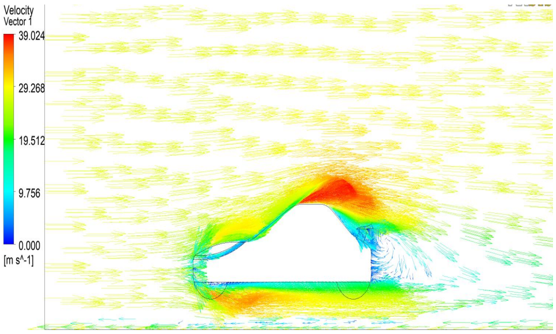

Fig. 9 Contour of air velocity at model 3

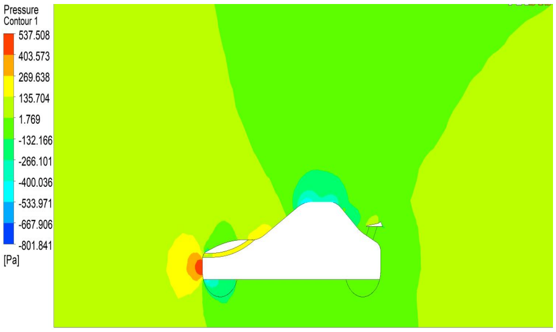

Fig. 10 Contour of air pressure at model 3

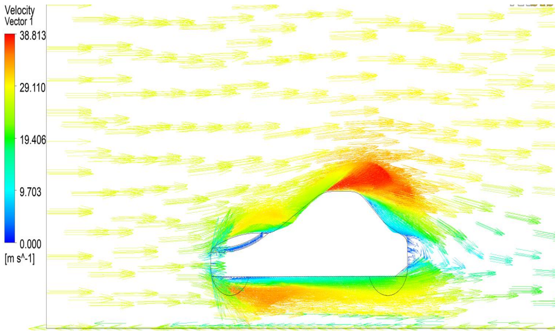

Fig. 11 Contour of air velocity at model 4

Fig. 12 Contour of air pressure at model 4

pressure of air surrounded with vehicle becomes the highest in the area matched with the air in the front of the vehicle.

3.5 Analysis result of model 5

As shown by Figs. 13 and 14, a vehicle model 5 is assumed to be driven with the speed of 100 km/h, showing the flow rate of stream surrounded with the vehicle and the air pressure around it. As can be seen at Fig. 13, the maximum air velocity around the vehicle is 40.00 m/s and its position is shown to be the upper part of the vehicle and the formation of vortex is inhibited by the rear diffuser. As can be seen at Fig. 14, the pressure acting on the vehicle and the pressure of surrounding air become the highest in the area where it is matched with the air in the front of the vehicle.

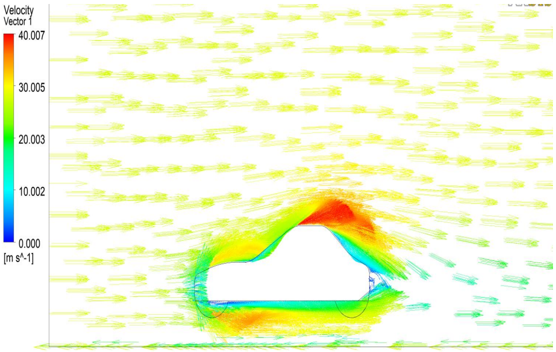

Fig. 13 Contour of air velocity at model 5

Fig. 14 Contour of air pressure at model 5

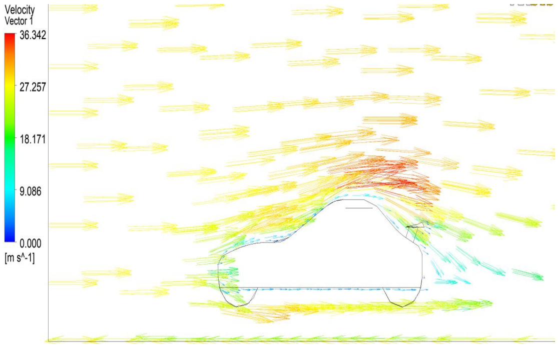

Fig. 15 Contour of air velocity at model 6

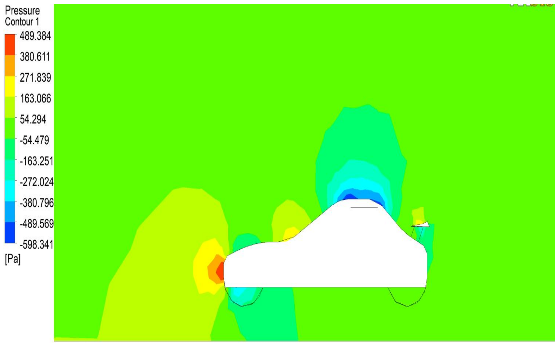

Fig. 16 Contour of air pressure at model 6

3.6 Analysis result of model 6

As shown by Figs. 15 and 16, a vehicle model 6 is assumed to be driven with the speed of 100 km/h, showing the flow rate of stream surrounded with the vehicle and the air pressure around it. As can be seen at Fig. 15, the maximum air speed around the vehicle is 37.08 m/s and its position is the upper part of the vehicle. As can be seen at Fig. 16, the air surrounded with the vehicle is most likely to match the air at the front of the vehicle, and the pressure at the top is lower than the model with air duct, but the rearward pressure is increased due to the spoiler.

3.7 Analysis result of model 7

As shown by Figs. 17 and 18, a vehicle model 7 is assumed to be driven with the speed of 100 km/h,

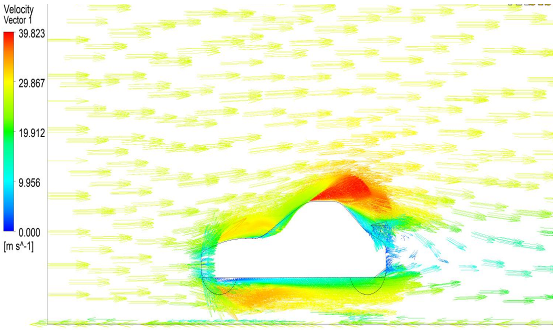

Fig. 17 Contour of air velocity at model 7

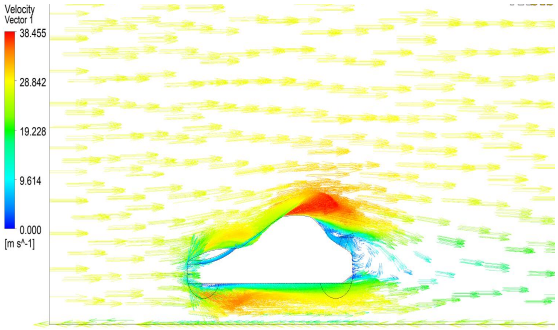

Fig. 19 Contour of air velocity at model 8

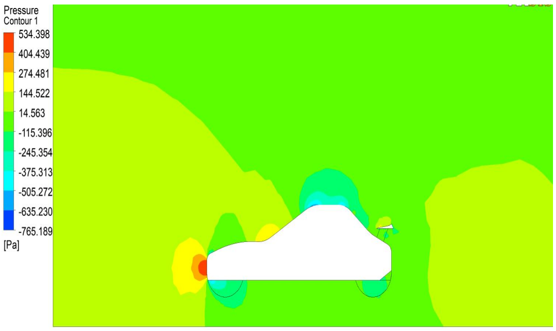

Fig. 18 Contour of air pressure at model 7

Fig. 20 Contour of air pressure at model 8

showing the flow rate of stream surrounded with the vehicle and the air pressure around it. As can be seen at Fig. 17, the maximum speed of air around the vehicle is 39.82 m/s and its position is the upper part of the vehicle. As can be seen at Fig. 18, the air surrounded with the vehicle is most likely to match the air at the front of the vehicle. The rearward pressure is increased due to the spoiler and the pressure at the bottom side of vehicle is reduced due to the escaping air.

3.8 Analysis result of model 8

As shown by Figs. 19 and 20, a vehicle model 8 is assumed to be driven at the speed with 100 km/h, showing the flow rate of stream surrounded with the vehicle and the air pressure around it. As can be seen at Fig. 19, the maximum speed of air around the vehicle is 38.45 m/s and its position is the upper part of the vehicle. As can be seen at Fig. 20, the pressure of the air surrounded with the car body becomes the highest where the car body hits the front air of the vehicle. The pressure on the parts of the spoiler and the air pressure behind the vehicle become very low.

4. Conclusion

This study is investigated on an flow analysis of air due to installation of the aero part of sports car or not. The study result is concluded as follows;

1. Through air duct, the air is seen to flow from the front glass to the top by making the fastest flow and reducing the pressure distribution.
2. The lift force increases due to the increase of the flow rate of stream at driving. The rear spoiler has the role to decrease this increased lift

force by increasing the downward force at the rear side of vehicle.
3. The rear diffuser which becomes the most effective among the three mounting parts has a major role at reducing air resistance.
4. Through the flow analysis result due to the installation of the aero part at the sports car, it is thought to be able to design the car body efficiently with the effort to reduce the air resistance when driving the car.

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