SURFACE FLOW AND WAKE STRUCTURE OF A REAR VIEW MIRROR OF THE PASSENGER CAR

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1 INTRODUCTION

The rear view mirror as one of the blunt obstacle generates an intrinsic periodic wake which composes Karman vortex shed strongly in the re-circulating zone and conical vortex sheet warps (or, envelops) in downstream depending on its geometry. Such a spatially periodic wake causes an intrinsic acoustic noise as well as a flow induced vibration making mirror surface trembled, resulting unclear vision to the driver[1]. Worse thing happens that when such periodic vortex wraps hit the door window this vortex wrap breaks down and makes the vortex body frame interaction noise[2][3]. Therefore, it could be a smart strategy to make the vortex trail not meet the door surface as possible by a path control. Therefore, geometric shape of the mirror housing should be primarily concerned to reduce the intrinsic vortex strength as possible. Secondly, the path of vortex wrap could be put away the door window or, the door panel by changing the mounting location as well as shape to avoid the interference.

This paper has designed primarily to obtain the wake structure of the side mirror to understand its interaction with the body frame by using the experimental method. Pressure profiles over both the housing and the mirror surface were measured and the flow visualization over the boundary layer was provided as well to figure out details.

2 EXPERIMENTAL CONDITION AND RESULTS

A blow down type wind tunnel was used to make parallel flow around a real scale side mirror with a zig support (which is called as the single model hereafter). Simultaneously, to observe the body frame interaction of the mirror wake on the body skin, one of the side walls of the wind tunnel test section was replaced by the driver side skin of the real scale car. The mirror mounted on this real car is hereafter called as the mounted mirror. To observe the pressure profiles on the mirror surface and the housing, a real scale pressure model was fabricated by using the composite material with multiple pressure holes imbedded on both surfaces.
Static pressure distributions were obtained by using the pressure scanners on the mirror surfaces as shown in figure 1 for both single and mounted models, respectively.

To obtain the velocity vector field of the mirror wake the hot wire anemometry was utilized with X-configuration hot wire sensor. Wake velocity fields were measured at the several vertical sections to the main flow direction for both cases of the single and the mounted mirrors, respectively. The vertical velocity vector fields shown as in figure 2 explain that the motion of the vortex sheet wrap in downstream does not only explain how frequently the periodic conical vortex sheet appears in the downstream direction, but also show where the path of the vortex center establishes. The vortex and body frame interaction in downstream was also observed in wake measurements which will be appeared in the full paper.

Figure. 1 Static pressure distributions over the mirror surfaces for the single model (left) and the mounted model (right), respectively.

Figure. 2 Vertical velocity vector fields measured at the plane of 0.5d (left) and 2.0d (right) respectively, where d is the length of the mirror span.

Just behind the mirror a re-circulating zone was observed by the simple smoke visualization. It seemed to appear until 1.0d downstream behind the mirror. Because the hot wire anemometer can not display the negative velocity a two dimensional LDV system used to get the negative velocity contour, which is attached in figure 3. As expected towards to the center of the mirror surface the momentum influx was developed along the round edge line of the mirror housing.

To visualize the movement of the surface vortex on the boundary layer over both the mirror housing surface including the mounting device and the mirror surface an oil film visualization technique was utilized. The separation focus and separation line were observed on the
housing skin as shown in the figure 4. This oil film technique was also used to observe the body frame interaction of the conical vortex wrap by tracing where the oil streak left from the mirror arrives over the body frame. Much details will be investigated in the full paper.

Figure. 3 Inflow velocity contour over the re-circulating zone which was measured at the vertical plane of 0.5d by LDV system.

Through various measurements the flow structure around side mirror has been unveiled. Around the side mirror the intrinsic vortex is shedding across the vertical mirror surface and the resultant vortex wrap in the wake is also formed. The geometric shape of the mirror housing must be designed to reduce the vortex strength as well as the vortex path should be away from the body as possible. In this experiment it was turned out the trail of the vortex sheet wrap generated by such a blunt body tends to meet the body skin of a car, arousing the vortex-body frame interaction. The co-ande r effect seems to accelerate such interference. This requires that the path control for the vortex drift should consider rigorously more than expected. It was also found that the boundary layer structure of the single model shows many differences from those of the mounted mirror. This implies that there exists any possibility to make a misleading for the flow structure by observing only those of the single model when not
looking into the interaction. The pressure distribution and the visualization show clearly their differences.

3 SUMMARY

Compared with experimental result of the single model, the mounted one showed many differences for the position of the minimum pressure location on the mirror surface and for the location of the separation focus as well from those of the single mirror. With the inflow velocity increase the vortex sheet wrap was found to come closer to the body frame which may result in the noise increase. The trail of the vortex center moves more adjacent to the body skin than expected, which implies that the co-ander effect was prevailed. It turned out that the intrinsic vortex shedding was not much affected to the body frame interference but to the vibration of mirror surface, while the vortex sheet wrap affects strongly the interaction noise in downstream. Detail observations will be discussed in the final paper.

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REFERENCES

