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DESIGN OPTIMIZATION OF SIDE MIRRORS ON ROAD VEHICLES

Shweta Rawat and Soumya Kanta Das

Mechanical and automation engineering, IGIT,
IP University, Kashmere Gate, Delhi-110034
Mechanical Engineering, VIT University,
Vellore-632014, Tamil Nadu.

ABSTRACT

Aesthetics and aerodynamics can go hand in hand. With inevitable fuel crisis and need to make carsmore efficient, rear view side mirrors are overlooked and designed aesthetically rather than aerodynamically whereas drag contribution by them has astounding effect on fuel economy and speed. The primary objective of the paper is to outline the behaviour of air flow around a conventional rear view side mirror of a road vehicle. The optimization in the basic design has been done in pursuit of reducing drag. The careful placement of two high-cambered aerofoils around the mirror housing has been done and the external 3D flow is analysed using computational methods. Conventional housing material will be used behind mirror and ALON or metallic glass in front. At optimum speed both the bare mirror housing and the enhanced mirror design with solid aerofoils attached were simulated and results analysed. The results drastically favour the one with added airfoils to the mirror housing.

Keywords- Aerodynamics, side mirrors, fuel efficiency, computational fluid dynamics(CFD)

1. INTRODUCTION

With the advent of technology, a significant effort has been made by the automobile and component manufacturers to reduce aerodynamic drag, noise and vibration and increase fuel economy. However, relatively less attention has been drawn to the refinement of performance of automobile rear view side mirrors (RVSM). The primary function of RVSM is to provide the clear vision of the rear and side of the vehicle. Bur, there are significant problems associated with it such as much pronounced "30 counts of drag" and adverse effects on fuel economy consequently, image distortion dueto aerodynamically induced and structural vibration due to complex mirror shapes and airflow around it. Being a bluff body, it causes significant periodic flow separation at the housing, which produces oscillating aerodynamic force on mirror surface. These pressure fluctuations not only cause the mirror surface to vibrate but also generate aerodynamic noise.

2. CONVENTIONAL FLOW AROUND THE HOUSING

The placement of mirror on an automobile is crucial from aerodynamic point of view. Mirrors along with the A-pillars contribute to creation of trailing vortices at side front of the car. Also, the inappropriate placement of mirror has been a major contributor towards the undesirable vibrations and consequent noise resulting from it. Due to excessive vibration,the rear view mirror may not provide a clear image. Thus, vibrations of the mirrors can severely impair the driver's vision and safety of the vehicle and its occupants. From CFD simulation, a significant downstream wake has been observed through the side view mirror.

3. EXPERIMENTAL SETUP FOR FLOW AROUND PROPOSED RVSM

The characterization of the unsteady flow field in the wake of the mirrors was performed using Solid Works Flow Simulation. The dimensions of the standard mirror were taken from a hatchback model car. The reflecting part of the mirror is close to 20,000 mm^2 which is well above the required area needed for the Indian road regulation standards of 6,900mm^2. The computer aided modelling was done using Solid Works with precision and necessary curvatures were added to smooth out the flow around it as shown in Fig-1.

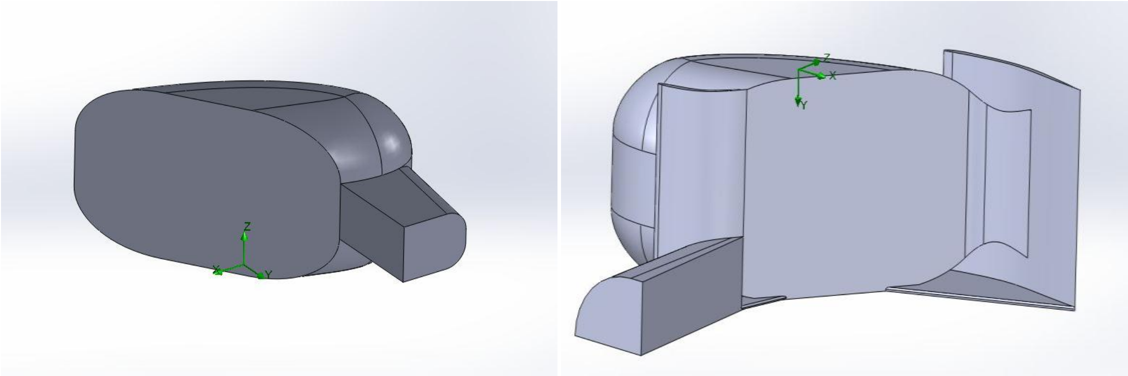

Figure 1. *Conventional (left) and proposed modified RVSM (right) modelled in SolidWorks*

The computational analysis was conducted and the characteristic forces along all the coordinate axes and drag equations were formulated to achieve the drag coefficient offered by the standard mirror model in use on present generation cars. Then, the modified mirror with the two highly cambered airfoil profiles (made up of metallic glass such as ALON) and the body mounts were modelledand simulation carried out on it. The airfoil profiles were not picked up from the universal airfoils used around but were carefully optimizedthrough the software to get the perfect airflow across them, thereby decreasing the drag penalty. The unsteady computational study of the both the standard and optimized mirrors were simulated at speeds ranging from 70 km/h to 120 km/h. The data was collected for each permutation and graphs constructed.

4. RESULTS AND DISCUSSION

4.1 Force Measurements

The total force offered by air flow was measured with respect to change in velocity from 70 km/h to 120 km/h with increments of 10 km/h as shown in Fig-2.As was expected the force kept on increasing with speed increment.

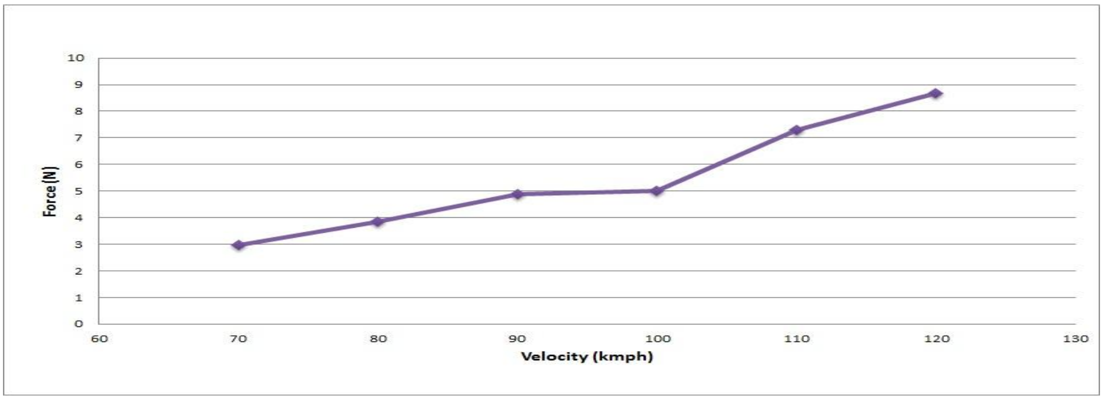

Figure 2. *Drag penalty offered by the original mirror housing with increase in speed*

Fig 3& 4 shows the alternate vortices shed from both the top and bottom sedges of the mirror.

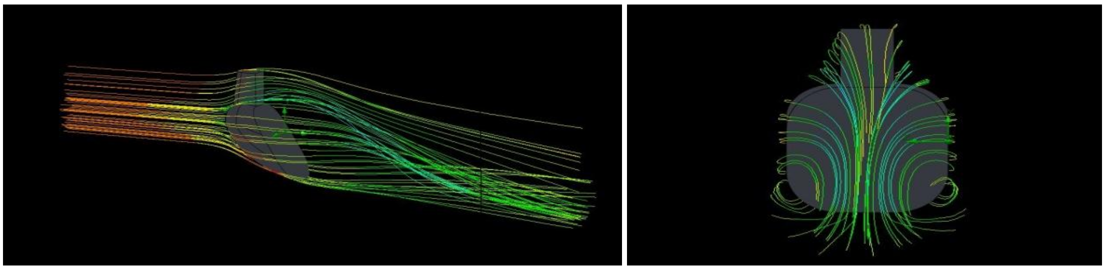

Figure 3 &4. *Alternate vortices shed from top and bottom edges of the mirror*

The wake region created by these contra-rotating vortices is large and move along the length of the mirror in the downwash. Fig-5 shows the relationship of the total force at various increasing speeds on the modified mirror design. A similar uniformly increasingbehaviour is seen in this too.

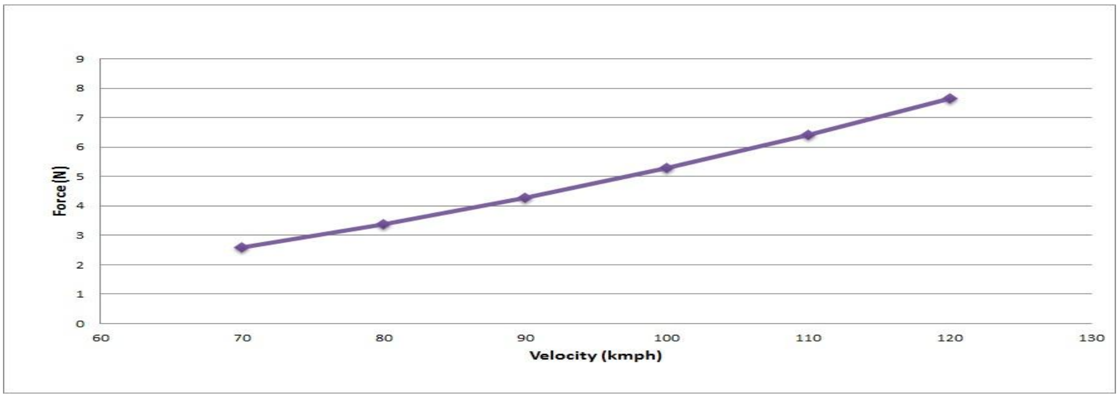

Figure 5. *Relationship of total force at increasing speeds on modified mirror design*

4.2Drag Coefficient Measurements

Computationally, the coefficient of drag of the original mirror housing was measured and it came to a maximum value of 0.206 as shown in Fig-6.

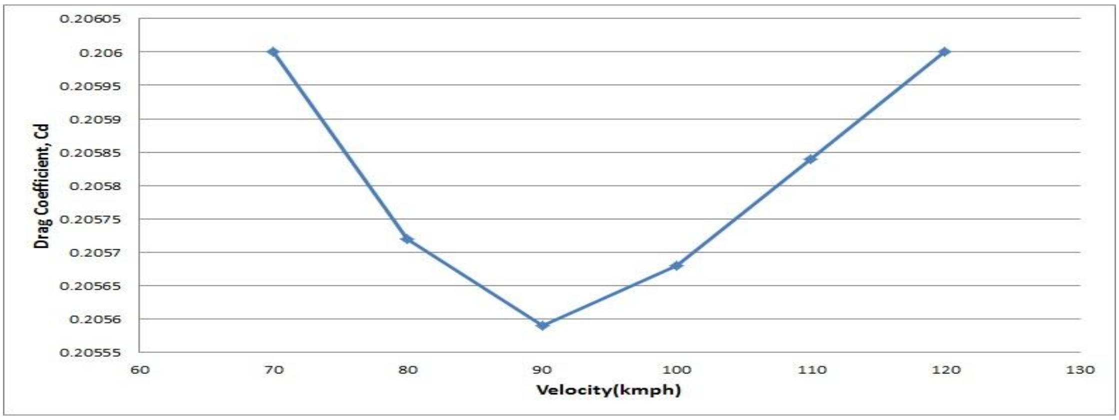

Figure6. *Behaviour of drag coefficient with increasing velocity*

Looking at the shape and flow characteristics of the standard mirror, a low drag value and low drag coefficient was reckoned. But experimentally, the behaviour completely changed and the maximum drag coefficient of the modified mirror came to be 0.189 as shown in Fig-7.

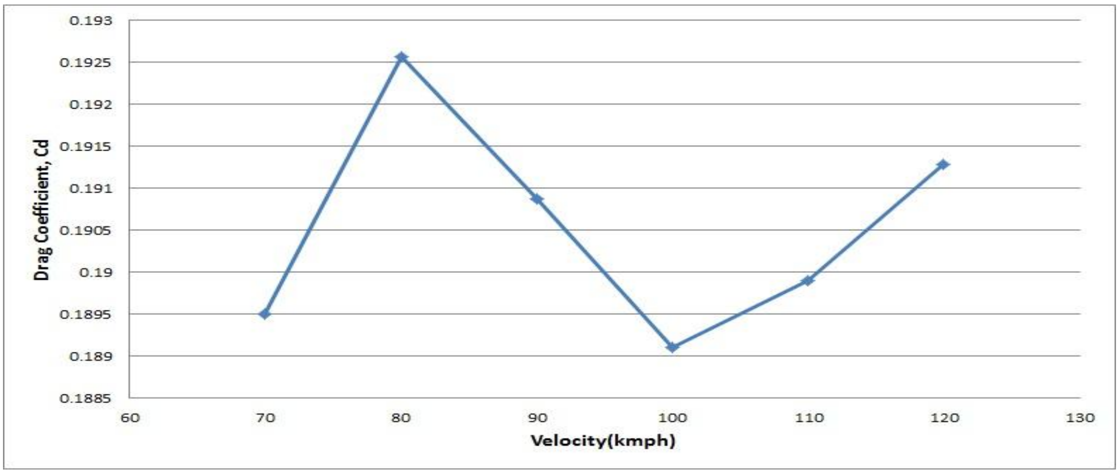

Figure 7. *Drag coefficient vs. speed*

The flow around the modified mirror looks very turbulent as in Fig-8, but the reduced wake region just behind the mirror due to the carefully placed airfoils around it decreased its drag value.

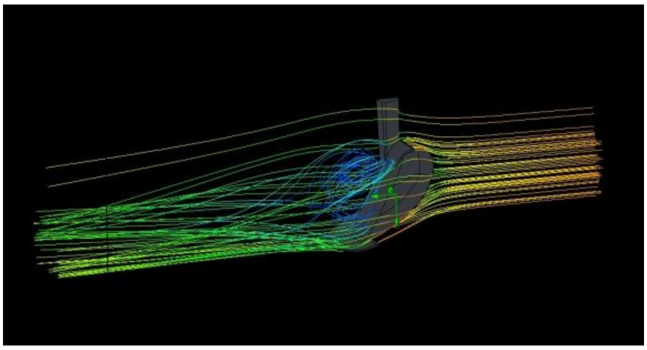

Figure 8. *Flow around modified mirror*

5. CONCLUSION

RVSM thus plays a vital role in contributing towards the drag for the entire vehicle and hence, we conclude from this work that with the slightest modifications to the RVSM, we can get a substantial drag reduction from them. The current results signify the average coefficient of drag drop from 0.205 to 0.187 which shows a drag reduction of 8.85% which is significant in term of fuel economy. This is important information for designing the RVSM to reduce drag and increase fuel efficiency.
Thus, a feasible trade-off between wind tunnel testing and CFD simulation is a necessity for optimum mirror design that intends to decrease drag significantly thus contributing to the improved fuel economy which is one of the vital needs of the hour.

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