DESIGN AND MODAL ANALYSIS FOR AERODYNAMIC DRAG REDUCTION ON SURFACE OF AUTOMOBILE STRUCTURES

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Abstract: Now days, fuel efficiency is the major problem in the automobile sector. The external parts of the automobile constitutes to more than 60% of the drag for which more amount of fuel is consumed in order to overtake the drag. The flow on the surface of skewed model steps is a practical problem in the design of automobile structures. Three different hatchback car structures are used for study to investigate the coefficient of drag on the surface. CFD analysis on the surface of 3 hatchback cars is studied. To optimize the coefficient of drag on baseline models add-on-devices such as tail plates and vortex generators are used. The modified car structures with these devices are compared with the original base line models and the optimized coefficient of drag is found.

***Index Terms* - Aerodynamic, Coefficient of drag, vortex generators, tail plates, vortex generators with tail plates.**

I. INTRODUCTION

In the design of automobile structures, drag reduction on the surface has become a research area for investigating the flow behavior. Automobile shape looks from the basic design of FFS, BFS and a combination of both the models [1]. The surface of the structures in automobiles experiences more drag when compared with other surfaces. Hatchback cars are the basic models derived from the FFS models. The emissions released from the automobiles are harmful to the environment. To decrease the emissions, the drag on the surface of the automobiles has to be decreased. The reduction in drag and drag force not only increases the fuel efficiency but also reduces the harmful pollutants. A lot of energy is dissipated due to separation of boundary layer on the surface of the automobile structures. The wake region produces more drag and thereby producing vibrations on the surface of cars.

The athletic sportsperson shoes also effects the drag while running on the ground [2], marine animals [3]. The basic analysis is made first on the Ahmed body before performing on the real surface of car structures. Ahmed body is the basic model for studying the flow behavior around a car. Several add-on-devices such as splines, spoilers, vortex generators, tail plates and a combination of both the devices will decrease the drag. Numerous studies on automobiles states that even 2% reduction of drag will increase the fuel economy by 1% [4].

II. DESIGN AND MODEL ANALYSIS

Automotive design the process of implementing the appearance and some extent of ergonomics of automotive vehicles, including motorcycles, automobiles, buses, vans, coaches and trucks. Primarily this design is made by one section and tested by other sections. Experimentally this can be performed on Wind tunnels. A CFD tool is the cheapest and fastest tool for performing the flow analysis on the passenger vehicle.

2.1 Automobile specifications:

NAME OF CAR	L1	L1/L2	L1/L3	L2	L3	Θ1	Θ1/Θ2	Θ2
HYUNDAI I20	2545.833	2.74677	NA	926.9444	NA	26^0	0.52	50^0
MARUIT ALTO	2634.291	3.0606	NA	860.708	NA	30^0	0.6	50^0
MARUTI WAGONR	2781.532	3.41935	NA	813.467	NA	[illegible]	[illegible]	[illegible]

Fig. 2.1 Structure of Automobile according to stepped pattern

2.2 CFD Analysis on Hatchback and Sedan cars:

Initially to test the carmodels of hatchback and sedan, CFD analysis is performed on 3 cars namely Nissan Micra, Ford Figo and Ford Aspire. Design of these cars with dimensions is done in ANSYS and results were plotted. Results show that the least coefficient of drag is observed for Ford Aspire model. This is because of the stabilization of the car model as it is a sedan car. From this inference, Sedan car gives less coefficient of drag when compared with hathcback at particular conditons. The velocity of flow is 25m/s.

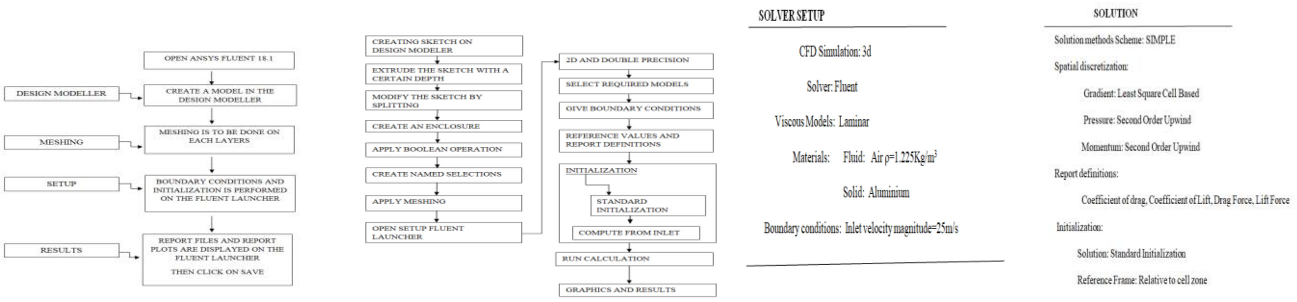
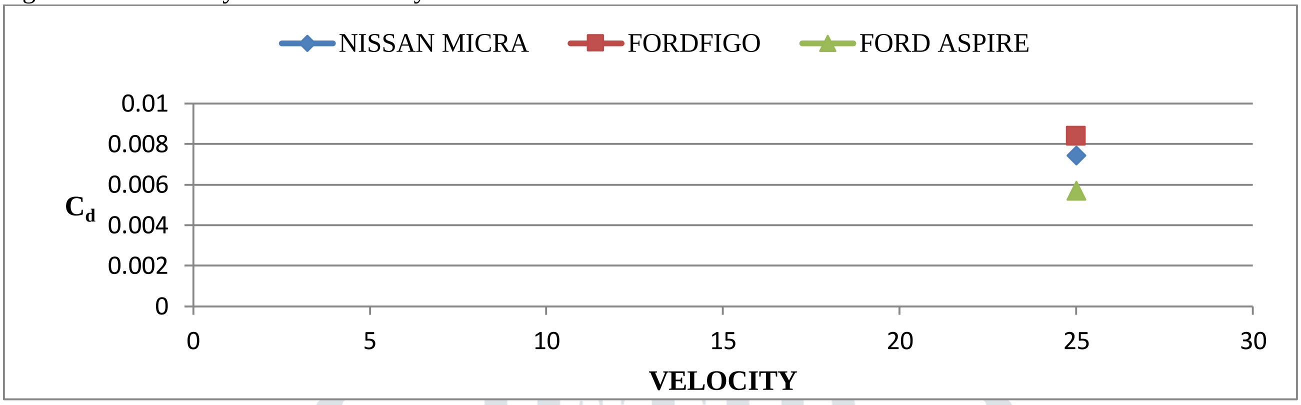
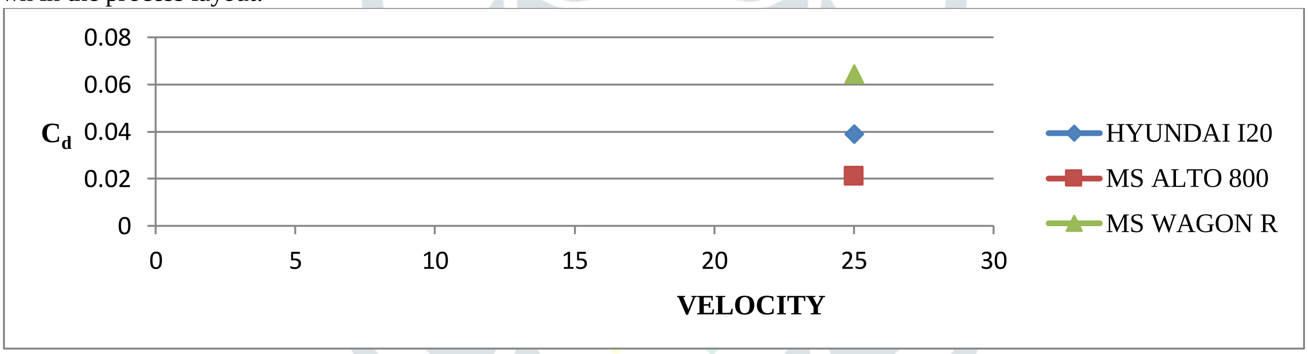


Fig. 2.2.1 Process Layout of CFD Analysis on car models



2.3 CFD Analysis on Hatchback cars

Now CFD analysis is performed on 3 hatchback cars namely Hyundai I20, Maruti Suzuki Alto 800 and Maruti Suzuki WagonR with a scaled ratio of 1:25. The base line model of this car is analyzed primarily. The analysis procedure is followed as shown in the process layout.



It was found from the analysis that MS Alto gives least coefficient of drag at 25m/s when compared with other cars. Now to decrease the drag further, certain add-on-devices [ ] are to be employed on the surface of the cars such as vortex generators, tail plates and spoilers. These devices will spoil the flow around a passenger car and decrease the drag thereby increasing the fuel economy.

III. MODIFICATIONS ON CAR STRUCTURES

Addition of tail plates, vortex generators are employed on the surface of cars which are used for reducing the drag on the car models. The decrease in the length of recirculation will decrease the coefficient of drag and reduces the harmful gases releasing into the environment. This will not only increase the drag and fuel efficiency on cars but also decrease the emissions such as CO, NO_X, SO_X and carbon compounds (HC). Production of these vehicles will lower the GGE. Aerodynamic fuel efficient vehicles could save 245 million gallons of fuel per year by improving 1%in fuel economy [5]. Awareness of environmental pollution in the world, made the researchers to concentrate on fuel efficient vehicles. This lead to manufacture low noise vehicles which possess less drag as well as low emissions and producing better fuel efficiency. Results found that 15% drag reduction will save the fuel economy by 5-7%.

3.1 Modifying the back angles on cars

The back angles [6] on the car refers to the downwards rear angle which can be optimized from the baseline model. Fig.3.1.1 shows the back angle of a car

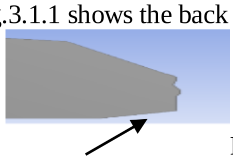


Fig. 3.1.1 Optimizing back angle

Changing this angle on the car changes the coefficient of drag. The CFD Analysis is performed at different angles and the least coefficient of drag is observed.

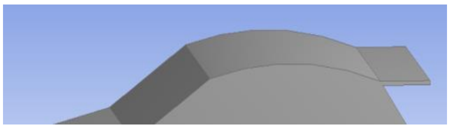
COEFFICIENT OF DRAG VALUES OF 3 HATCHBACKS AT DIFFERENT BACKANGLES:

BACK ANGLES	HYUNDAI I 20		BACK ANGLES	MARUTI SUZUKI ALTO 800		BACK ANGLES	MARUTI SUZUKI WAGON R
0	0.0443		0	0.020787		0	0.062585737
5	0.0435		3.75	0.02087		2.5	0.062324593
10	0.0424		7.5	0.02069		3.5	0.062128844
20	0.0405		15	0.021145		5	0.062585737
30	0.0387		17	0.020992266		7	0.062950108
35	0.037176		19	0.019819555		9	0.063296179
37	0.03670274		21	0.020455404		10	0.062118578
40	0.035629787		23	0.020009194		11	0.062521642
42	0.035058513		25	0.020762772		12	0.063291407
44	0.03436457		27	0.020427245		14	0.063436095
45	0.03349		29	0.020765113		15	0.063747627
46	0.033420896		30	0.02002		16	0.062839994
47	0.041357862		32	0.020760541		18	0.063499764
50	0.041232		34	0.020612929		20	0.0633
55	0.041028		35	0.020246412		40	0.06348
			40	0.020942		50	0.06425

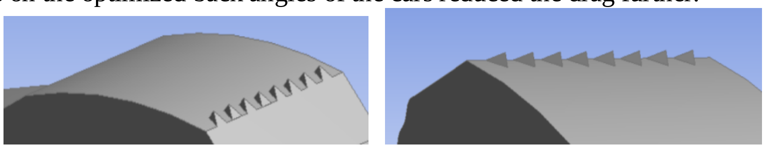
Coefficient of drag is observed to least for 46° 19° and 10° for Hyundai, Maruti Alto and Maruti WagonR. The optimized back angle is found. Now this optimized back angle is used for further reducing the drag by employing the vortex generator and tail plates.

3.2 Addition of Tail plates and Vortex generators

Addition of tail plates [6] and vortex generators on the optimized back angles of the cars reduced the drag further.



Addition of Tail plates



Addition of Vortex generators

CFD Analysis is performed by applying above changes and the coefficient of drag is observed.

CONFIGURATION	HYUNDAI I20	MS ALTO 800	MS WAGON R
BASE LINE	0.0387	0.020942	0.06425
OPTIMIZED BACK ANGLE	0.033420	0.019819	0.062118
OPTIMIZED TAIL PLATE	0.022803	0.018359	0.050966
VORTEX GENERATORS	0.022653	0.017947	0.050282

3.3 Addition of both Tail plates and Vortex generators

Individually tail plates and vortex generators are applied on the car models and CFD Analysis is performed. Now both the tail plates and vortex generators are applied to investigate the drag on the surface of car models. It was found from the analysis results that both the tail plates and vortex generators produced least coefficient of drag.

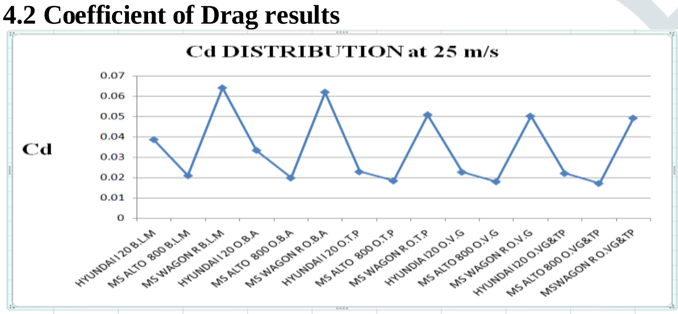
Configuration	Hyundai I20	MS Alto 800	MS Wagon R
Base line	0.0387	0.020942	0.06425
Optimized TP with VG	0.022028	0.017100	0.0493257

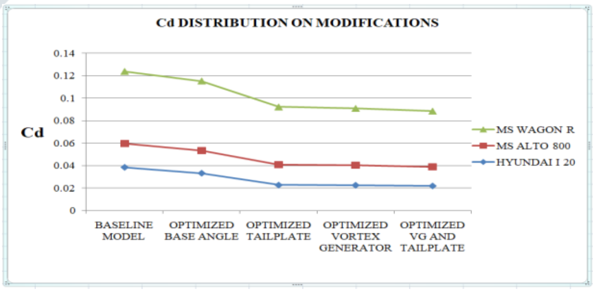
IV RESULTS AND CONCLUSION

4.1 Ansys software results

It was found that the addition of tail plates and vortex generators decreased the coefficient of drag on the car models. The percentage change in C_d is 43% for Hyundai, 18% for Alto and 23.22% for WagonR. This percentage change of drag will affect the fuel economy.

4.2 Coefficient of Drag results





4.3 Conclusion

In this paper the main concentration is on the drag reduction on automobiles. The chosen concept is optimizing the drag on surface of car structures. The developed model with the combination of both tail plates and vortex generators decreased the coefficient of drag further from applying individually. The optimized drag is found for all 3 cars and from this, the least coefficient of drag is also observed which is for Alto car with tail plates and vortex generators. The change is drag percent is 18% which shows that the fuel economy can be reduced by 9%. This analysis is also used for reducing the emission of dangerous gases into the atmosphere.

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