Aerodynamics and flow pattern performance evaluation of off road vehicle for various velocity range and angle of incidence

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Abstract. It is complex to amplify the significance of flow visualization. This is factual whether the methodology is strictly theoretical, primarily experimental, primarily computational or some combination as is always the most effective. The ability to see flow patterns on and around the device under investigation often gives insight into a solution to an aerodynamic problem. The reasonable mental image of a flow about a body is almost necessary for a researcher to have a useful understanding of an aerodynamic or hydrodynamic problem. We researcher and aerodynamicist believe possibilities of some significant difference in results obtained by computation and mental image and the experimental evidences resolve the uncertainty. In our research primitive variables that describe the flow and qualities are found to be use full in flow visualization phenomena. We resolve this with the concept of path line, stream line, streak line and time line approaches. A selective off road vehicle scaled model is tested by considering all the parameters. A low speed wind tunnel test facility with a calibrated test section size of 200 X200mm, low flow angularity providing acceptable laminar level and smoke tunnel facility is used for experimentations. The scale downed model is rationed with an allowable blockage factor not more than 10% is tested to a velocity range of 10m/s –50 m/s. Entire study and experiments on this Off-Road vehicle aerodynamics bounces adequate results. This experimental results and solutions will be useful for future young researchers in the field of off road vehicle design Aerodynamic analysis, more over this results gave a conceptual study for the person who drives the vehicle about the maximum occurrences, maximum possible drag and side slips over the vehicle.

1. Introduction

Aerodynamic studies of passenger and special purpose vehicles become essential when optimization and performance evaluation parameters need to be enhanced for new models or upgraded models. As competition among the different manufacturers have increased due to the globalization of industries and every industry wants to have higher shares in the market thus it becomes crucial for them to launch new models having good esthetic and performance compared to other competitive models. Also, due to increase in the fuel prices, efficient aerodynamic designs are required to increase the fuel efficiency of the vehicle. In this regard, drag calculation becomes critical as it can affect the esthetic and performance of the vehicle. Aerodynamics play an important role in increasing the overall performance of the vehicle. Various computational analysis needs to be done by the manufacturers before starting the actual production of the vehicle however, due to copyright issues, the results of same are not frequently available in the public domain. Few researchers have performed aerodynamic studies on the vehicles in order to evaluate the impact of various flow parameters like velocity, surface area of wind shield, aerodynamic design [1] etc. Usually, aerodynamic drag has two components; i) skin friction drag and ii) pressure drag. Out of which pressure drag is depending upon the skin geometry due to flow separation issues and formation of wake region behind the vehicle and it contributes about 80%. The point of separation determines the size of wake region and it helps in finding out the magnitude of the aerodynamic drag. From the past studies, it has been identified that this drag is responsible for the large fuel's consumption and contributes 50% of total fuel consumption at top speeds [2]. Drag reduction itself provides a great and inexpensive solution in order to improve the fuel economy therefore it becomes essential part of the optimization [3]. The drag is also depending on the angle at which air strikes the windshield of the moving vehicle. Studies related to aerodynamic design of the on-road vehicle are very rare as it requires plenty of instruments to be installed during the testing [4-20]. Therefore, it is always recommended to test the scale down or exact model in the wind tunnel in order to get more clarity and control on the flow situations. Therefore, in the present study, a selective off road vehicle scaled model is tested by considering all the flow parameters. A low speed wind tunnel test facility with a calibrated test section size of 200x200mm, low flow angularity providing acceptable laminar level and smoke tunnel facility is used for experimentations. The scale downed model is rationed with anallowable blockage factor not more than 10% is tested to a velocity range of 10m/s –50 m/s. Under gone testing of the scale downed model of off road vehicle made of MS and sheet metal with various condition and parameters such as (A) with wind shield (B) Without wind shield (C) Angle of incidence of ranging from 0°to -10° (D) Side force (C) drag force (F) flow patterns over the vehicle. Entire study and experiments on this Off-Road vehicle aerodynamics bounces adequate results. Those outcomes are used in real coordination before manufacturing and before challenging the race contest. This experimental results and solutions will be useful for future young researchers in the field of off road vehicle design Aerodynamic analysis, more over this results gave a conceptual study for the person who drives the vehicle about the maximum occurrences, maximum possible drag and side slips over the vehicle. And it is crystal clear with this well-convinced flow visualization and aerodynamic testing approach, produces results to the designers an ushers in a sterling performance variation is their between shield and unshielded vehicle for a range of velocity and angle of incidence range.

2. Methodologies

A selective off road vehicle scaled model with contraction ratio 100:1 is tested with and without wind shield in a low speed wind tunnel facility. For different angle of attack, the drag force and side force on the vehicle, with and without wind shield at different velocities is obtained. Then, the drag force and side force for vehicle with wind shield and without wind shield are compared. Subsonic wind tunnel facility is used for the aerodynamic research to study the flow properties of the vehicle with and without wind shield. Test section type: 200x200mm Contraction ratio- 100:1

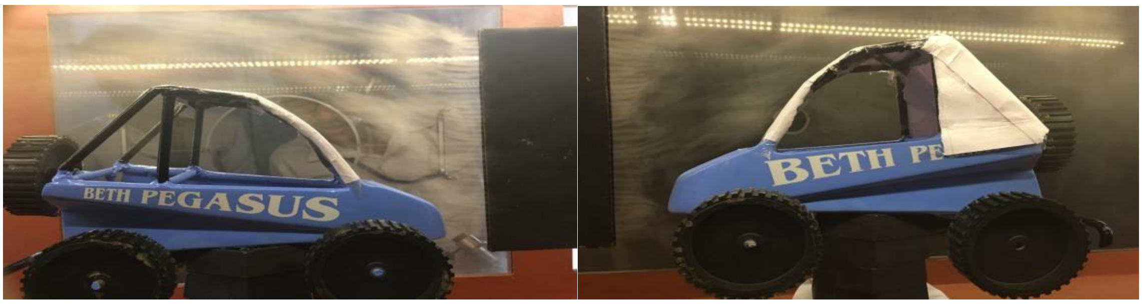


Figure .1 set up at wind tunnel test section

3. Results and Discussion

Table 1 shows the values of side force and drag force for different velocities at 0, 5, -5, 10 and 10 degree angle of attack for the vehicle without wind shield and Table 2 shows the values of side force and drag force for different velocities at 0, 5, -5, 10 and -10 degree angle of attack for vehicle with wind shield.

Without wind shield				With wins shield			
Velocity	AOA	Drag force	Side force	Velocity	AOA	Drag force	Side force
20	10	4.1	0.2	20	10	5.2	0.2
30	10	9.2	0.4	30	10	10.7	0.4
40	10	17.3	1.1	40	10	18.5	0.6
20	5	3.9	1.4	20	5	5	0.7
30	5	9.3	0.9	30	5	10	1.2
40	5	16.5	1.6	40	5	17.6	2.5
20	0	3.7	0.2	20	0	4.4	0.3
30	0	7.9	0.9	30	0	9.2	0.5
40	0	15.4	1.6	40	0	17.2	1.6
20	-5	4.3	0.4	20	-5	5	0.7
30	-5	9.6	0.9	30	-5	10.8	1.4
40	-5	16.4	1.8	40	-5	17.4	2.3
20	-10	5.1	0.2	20	-10	6.4	0
30	-10	10.7	0.4	30	-10	13.1	0.3
40	-10	18.5	0.13	40	-10	20.3	0.7

Table 1. Without and with wind shield

3.1 Result discussion of drag force

Fig 2 shows that at 10 degree angle of attack, the drag force acting on the vehicle with wind shield is more than the drag force acting on the vehicle without wind shield. This implies that for usage of wind shield, the drag has to be compensated with mass or other parameters. Fig 3 shows that at 5 degree angle of attack, the drag force experienced by the vehicle with wind shield is slightly more than the drag force experienced by the vehicle without wind shield Figure 4 shows that at at 0 degree angle of attack, the drag force acting on the vehicle with wind shield and drag force acting on the vehicle without wind shield is initially somewhat similar but gradually the drag force acting on the vehicle with wind shield increases. Figure 5 shows that at -5 degree angle of attack, the vehicle with wind shield experiences more drag force compared to the vehicle without wind shield. The difference in their drag forces remain constant at every velocity. Figure 6 shows that at -10 degree angle of attack, the drag force experienced by the vehicle with wind shield is much more compared to drag force experienced by the vehicle without wind shield.

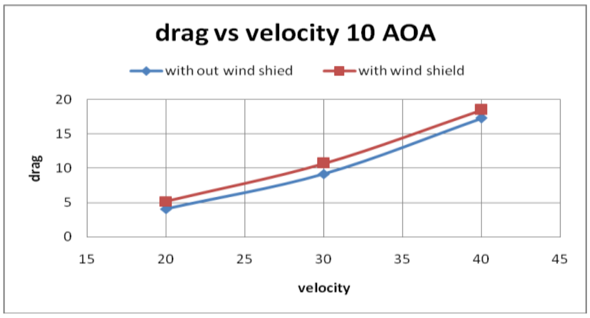
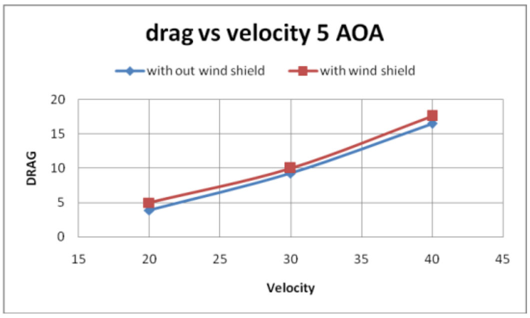


Figure 2



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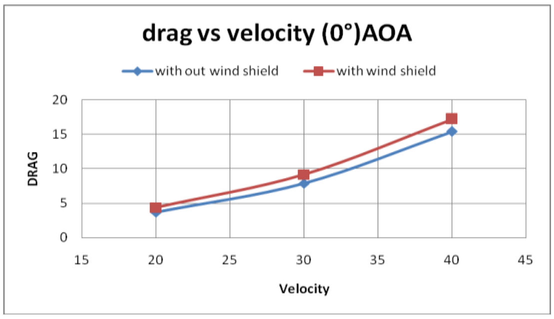

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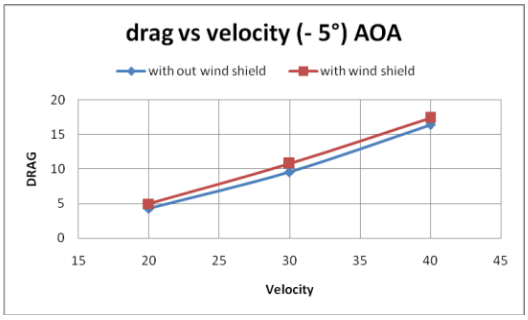

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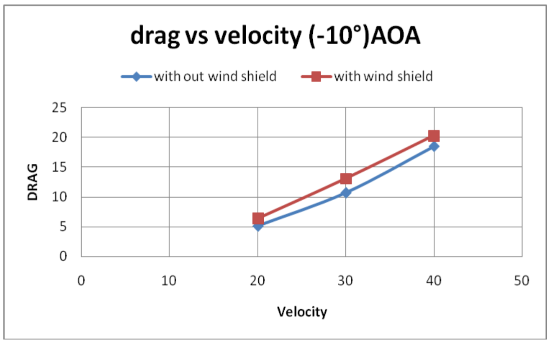

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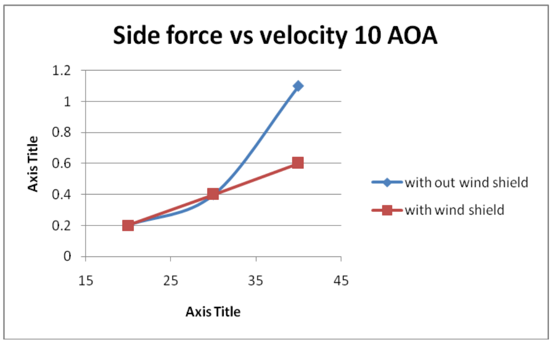

Figure7

3.2 Result and discussion on side force

Figure 7 shows that at 10 degree AOA, for vehicle without wind shield, the side forces first increase gradually with velocity to a particular point and then experience a sudden rise in side forces, whereas for vehicle with wind shield, the increase in side force is constant with increase in velocity and is less than that of vehicle without wind shield. .Fig 8 depicts that at 5 degree AOA, the vehicle without wind shield experiences a linear rise in side forces with velocity increment. The vehicle with wind shield experiences a sudden increment in side forces with velocity after a gradual rise of the forces till a particular value of velocity. Fig 9 shows that at 0 degree AOA, the side forces experienced by vehicle without wind shield increase at a constant rate with velocity. For vehicle with wind shield, the side forces increase suddenly after some time. At a particular point of velocity, the side forces acting on both the vehicle is the same. Fig 10 shows that at -5 degree AOA, the side forces acting on vehicle with wind shield is higher than the side forces experienced by vehicle without wind shield. Fig 11 shows that at -10 degree AOA, in vehicle without wind shield, the side forces first increase with velocity to a particular point and then gradually decrease, whereas the side forces on vehicle with wind shield increase constantly with velocity.

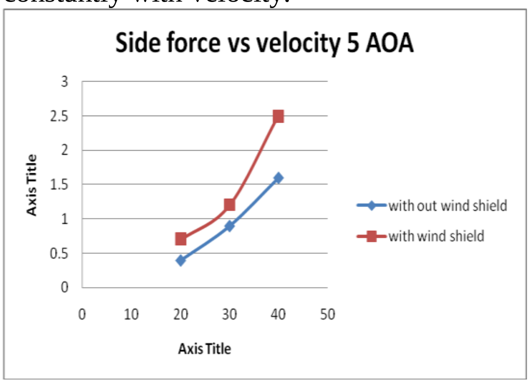

Figure 8

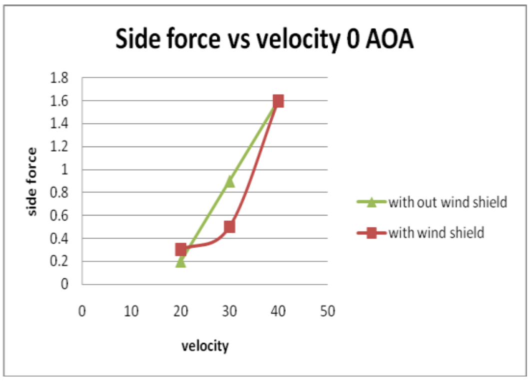

Figure 9

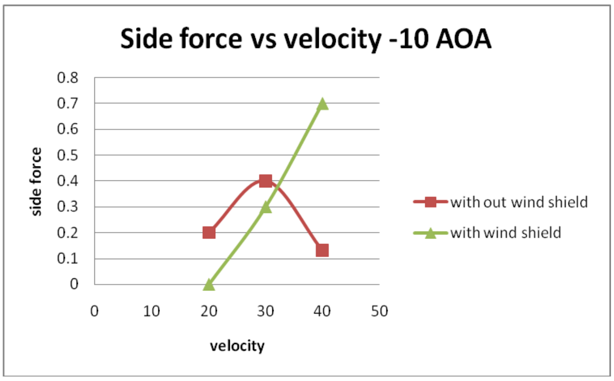

Figure 10

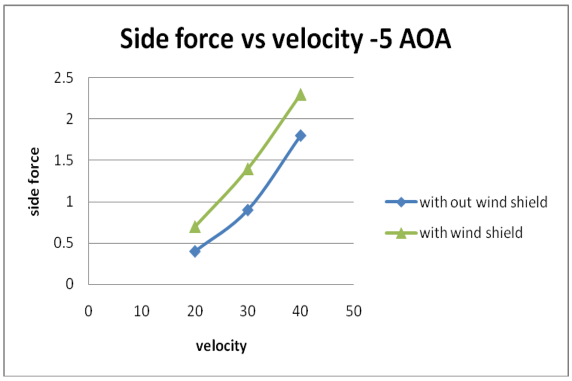

Figure 11

4. Conclusions

Aerodynamics surely has a pivotal role when the overall performance of a vehicle comes into play. This has been proven for all kinds of vehicles with even and uneven surfaces. The flow visualization during the testing of the off road vehicle scaled model with and without wind shield in subsonic wind tunnel facility shows that variation always occurs to the drag and side forces acting on the surface affecting the overall performance of the vehicle. These experimental results can be utilized by our university for the construction and arrangement of off road vehicles including Go Kart championships.

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