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Analysis of Improvement in Aerodynamics of a Vehicle Type Baja SAE - And the Impact on Performance

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SUMMARY: *The constant search for greater efficiency in any type of project, is one of the top searches of a professional in engineering, this being linked directly to cost reduction, performance improvement and analysis from an environmental point of view. Specifically, in Mechanical Engineering it is possible to achieve greater efficiency of a machine or equipment, just performing settings related to its operation and / or its interaction with the external environment. Aerodynamics is the science that studies the dynamics and fluid behavior, specifically the air, which causes stress on bodies through which it flows. Studies and aerodynamic analysis can be done through various tools and so it can be determined very close to the actual values for the efforts from the same (CASTEJON, 2011). Such studies are divided into two main areas: the computational, known as Computational Fluid Analysis and experimental, based in Coast Down analysis or by experiment in a wind tunnel simulation. So many studies are conducted to get the best and most desired aerodynamic performance, as will be discussed in this work. The work will be based on the prototype of a Baja-SAE vehicle Bajarara Team Hermínio Ometto University – UNIARARAS, Araras, SP, aiming a contribution to the development of the Baja project and the study of aerodynamic, more specifically in its longitudinal performance.*

Keywords*: Aerodynamics, Simulation, SolidWorks.*

I. INTRODUCTION

The increased efficiency in any type of project, is one of the top searches of a professional in engineering, this being linked directly to cost reduction, performance improvement and analysis from an environmental point of view. In Mechanical Engineering, it is possible to achieve greater efficiency of a machine or equipment, just performing settings related to its operation and / or its interaction with the external environment.

In the automotive field this search comes down largely to the reduction of external loads on the vehicle resulting in lower fuel consumption and consecutively reducing pollutant emissions. In these studies, aerodynamics becomes essential because it is responsible for much of the loss of propulsion power, i.e. the energy that is generated by the vehicle engine (BRUNETTI, 2012).

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So many studies are conducted to get the best and most desired aerodynamic performance, as will be discussed in this work. The work will be based on the prototype of a Baja-SAE vehicle Bajarara Team Hermínio Ometto University Uniararas, Araras, SP, Brazil, aiming a contribution in the development of Baja project and the study of aerodynamic, more specifically in its longitudinal performance.

1. Objective

Analyze simulations, experimental and computational aerodynamics of a vehicle Baja SAE-type, obtaining and using such data to estimate the impact on performance due to changes made to the vehicle fairing.

II. MATERIALS AND METHODS

In fluid mechanics, the boundary layer is the fluid layer around a bounding surface, where you can feel the diffusive effects and the dissipation of mechanical energy (FOX; YOUNG; OKIISHI, 2010). The concept of boundary layer was introduced by Ludwig Prandtl, a student of aerodynamics, in 1904 (ÇENGEL, CIMBALA, 2008). This theory has contributed to analytical analysis of some phenomena that previously could only be analyzed empirically.

An important factor that should be considered is that considers the ratio of viscous forces and inertial forces, known as the Reynolds number, expressed by the following equation:

$$Re_x = \frac{V\,x}{\;} = \frac{\text{Inertia Forces}}{\text{Slimy Forces}} \qquad (1)$$

P is the fluid density, V the speed of flow, μ the dynamic viscosity of the fluid and x is the characteristic length used in the Reynolds number. This factor is important because it determines the flow regime of the fluid, which can be Laminar, Turbulent and Undetermined (WHITE, 2010).

Anybody in any form, when immersed in a fluid stream, will experience forces and moments arising from the flow (WHITE, 2010). The main force to be analyzed during the work will be the drag force, or simply aerodynamic drag, which has great effect on the object displacement in the longitudinal direction.

$$Fa = \frac{Cd\ A\ V^2}{2} \qquad (2)$$

Fa is the drag force, Cd a dimensionless coefficient representing how aerodynamic the object is, the frontal area of the object, and V the relative speed of the object and the fluid. The value of Fa can be measured both by simulation software (CFD) and experimentally (Wind Tunnel) (BARBIERI, 2012). But a key factor in the automotive industry engineers have sought, it is to reduce the amount of Cd. And for analysis it is necessary to isolate it from the equation (2) obtaining a new equation.

$$Cd = \frac{2\ Fa}{A\ V^2} \qquad (3)$$

For this analysis, will be used some tools, such as SolidWorks Software 2013® for CFD simulations, and the aerodynamics laboratory of EESC-USP (LAE) to experimental analysis, which will be held with a range vehicle prototype 1 by 4 scale. And so, a dimensional analysis will be necessary, because according Çengel and Cimbala (2008) for both analysis it is valid to compare the Reynolds number should be maintained, i.e.:

$$Re_{(model)} = Re_{(prototype)} \qquad (4)$$

However, as for the fluid experiment to be used is the air, the value of ρ and μ would be maintained in this way can only change the value V, which is to scale, should be 4 times higher than that used in simulation, so that the results are valid and can be compared.

Figure 1: Prototype illustration to be used in the experiment.

To assess their impact on performance, Fa chart for V will be prepared to be thus easier to be analyzed, in addition to the theoretical analysis of the difference of the vehicle's performance during a speed test, like that it is submitted, where it uses a straight 100 meters to evaluate its speed at the end of this line (SAE, 2014).

III. EXPECTED RESULTS

The results should be close. In both cases, there are various limitations, used as simplifying assumptions. These assumptions provide greater ease of resolution, but less accurate.

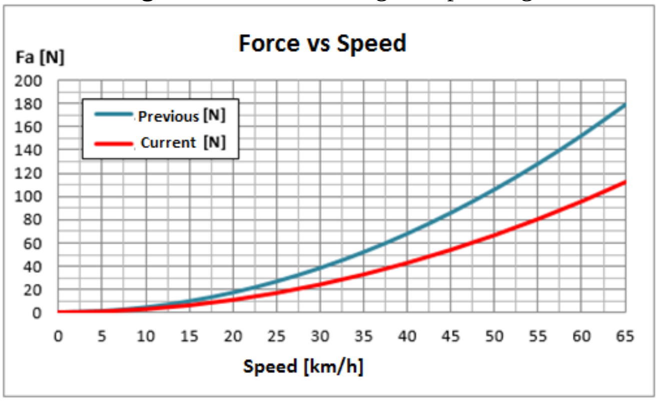
Results already prepared by the Baja team University (Team Bajarara) show that the changes made in the cowling of the previous year and the current, provides a significant improvement in its aerodynamics, as shown in the table below:

Table 1: Vehicle Aerodynamic Data obtained by CFD simulation.

Aerodynamic Data				
Input Data	Temperature [ºC]	30,0		
	Setting Pressure [kPa]	101.325		
	Speed [km/h]	60,0		
Output Data				
Parameter		**2013**	**2014**	**Improvement**
Front Vehicle Area [m²]		1,027	0,6335	-38,32%
Drag Coefficient (Cx)		0,9207	0,9396	2,05%
Cx * Front Area [m²]		0,9456	0,5952	**-37,05%**

These results allowed the development of an F chart for V, where you can see its impact due to the change in the vehicle's aerodynamics.

Figure 2: Force of change Graph Drag.



Through CFD simulations already carried out by the team, you can see the difference in the movement of air around the vehicle for the two types of fairing (Figure 3).

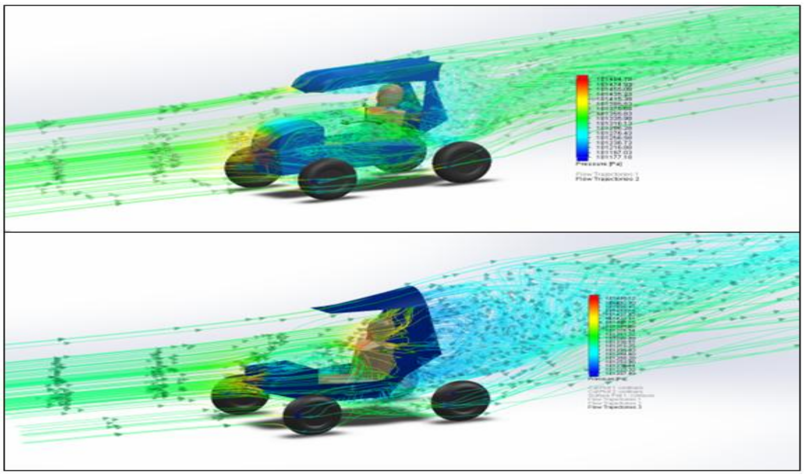


Figure 1: CFD Simulation in the prototype. Current (above) and Previous (below).

IV. CONCLUSIONS

This work was effective in determining the aerodynamic drag coefficient of the vehicle, reliably and efficiently with respect to observation of the points where there is obvious pressure of focus, helping the aerodynamic design of vehicles. Thus, we can point to the team where we can make changes that will eventually improve the aerodynamics of the vehicle, and consecutively fuel consumption.

This study can also be extended to other types of vehicles and aircraft.

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