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Drag Force Analysis of Car by Using Low Speed Wind Tunnel

[1]Ashfaque Ansari, [2]Rana Manoj Mourya

[1](Research scholar), Department of Mechanical Engineering, Lakshmi Narain Collage of Technology, Bhopal, India
[2]Asst. prof. Department of Mechanical Engineering, Lakshmi Narain Collage of Technology, Bhopal, India

***Abstract*: In this paper we are discussing about the Wind Tunnel and its types. The Wind Tunnel Testing Machine is used in Aerodynamic research to study the effects of Air moving past to the solid objects. This paper we discuss the Drag force analysis of car by using low speed wind tunnel. In the testing we use the pitot tube, manometer and solid object (airfoil). Solid object is representing the original shape of the object. The testing chamber is main part of wind tunnel. We calculate the velocity of fluid and drag & lift forces. It is use to experimental analysis of object. Experiment conducted after build to find drag coefficient of a shape. An impression of fluid field flow around a shape is using air.**

***Keywords*: Open Circuit Wind Tunnel, Single Testing Section, airfoil analysis, drag & lift forces.**

1. INTRODUCTION

A wind tunnel is used in aerodynamic research to study the effects of air moving past solid objects. A wind tunnel consists of a tubular passage with the object under test mounted in the middle. Air is made to move past the object by a powerful fan system or other means. The test object, we measure aerodynamic forces, pressure distribution, or other aerodynamic-related characteristics. [1][3] The earliest wind tunnels were invented towards the end of the 19th century, in the early days of aeronautic research, when many attempted to develop successful heavier-than-air flying machines. Wind-tunnel testing was applied to automobiles, not so much to determine aerodynamic forces per se but more to determine ways to reduce the power required to move the vehicle on roadways at a given speed. In these studies, the interaction between the road and the vehicle plays a significant role, and this interaction must be taken into consideration when interpreting the test results. In an actual situation the roadway is moving relative to the vehicle but the air is stationary relative to the roadway, but in the wind tunnel the air is moving relative to the roadway, while the roadway is stationary relative to the test vehicle. Some automotive-test wind tunnels have incorporated moving belts under the test vehicle in an effort to approximate the actual condition, and very similar devices are used in wind tunnel testing of aircraft take-off and landing configurations. [2][1][14]

1.1 Measurement of aerodynamic force

Air velocity and pressures are measured in several ways in wind tunnels. Air velocity through the test section is determined by principle. Measurement of the dynamic pressure, the static pressure and compressible flow only. The temperature rise in the airflow. The direction of airflow around a model can be determined by tufts of yarn attached to the aerodynamic surfaces. The direction of airflow approaching a surface can be visualized by mounting threads in the airflow ahead of and aft of the test model. Air, Smoke or bubbles of liquid can be introduced into the airflow upstream of the test model, and their path around the model. Aerodynamic forces on the test model are usually measured with beam balances, connected to the test model with beams, strings or cables. The pressure distributions across the test model have historically been measured by drilling many small holes along the airflow path, and using multi-tube manometers to measure the pressure at each hole. Pressure distributions can more conveniently be measured by the use of pressure-sensitive paint, in which higher local pressure is indicated by lowered fluorescence of the paint at that point. Pressure distributions can also be conveniently measured by the use of pressure-sensitive pressure belts, a recent development in which multiple ultra-miniaturized pressure sensor modules are integrated into a flexible strip. The strip is attached to the aerodynamic surface with tape, and it sends signals depicting the pressure distribution along its surface. Pressure distributions on a test model can also be determined by performing a wake survey, in which either a single pitot tube is used to obtain multiple readings downstream of the test model, or a multiple-tube manometer is mounted downstream and all its readings are taken. The aerodynamic properties of an object cannot all remain the same for a scaled model. However, by observing certain similarity rules, a very satisfactory correspondence between the aerodynamic properties of a scaled model and a full-size object can be achieved. [12][13]

The choice of similarity parameters depends on the purpose of the test, but the most important conditions to satisfy are usually:

1.1.1 Geometric similarity

All dimensions of the object must be proportionally scaled.

1.1.2 Mach number

The ratio of the airspeed to the speed of sound should be identical for the scaled model and the actual object (having identical Mach number in a wind tunnel and around the actual object is -not- equal to having identical airspeeds) [12]

1.1.3 Reynolds number

The ratio of inertial forces to viscous forces should be kept. This parameter is difficult to satisfy with a scaled model and has led to development of pressurized and cryogenic wind tunnels in which the viscosity of the working fluid can be greatly changed to compensate for the reduced scale of the model. [13]

1.2 Pressure measurements

Pressure across the surfaces of the model can be measured if the model includes pressure taps. This can be useful for pressure-dominated phenomena, but this only accounts for normal forces on the body. [12][13]

1.3 Force and moment measurements

With the model mounted on a force balance, one can measure lift, drag, lateral forces, yaw, roll, and pitching moments over a range of angle. This allows one to produce common curves such as lift coefficient versus angle of attack.

The force balance itself creates drag and potential turbulence that will affect the model and introduce errors into the measurements. The supporting structures are therefore typically smoothly shaped to minimize turbulence. [12][13]

1.4 Types of Wind Tunnel

Wind Tunnel can be classified on the basis of construction as-

a. Open Loop

b. Closed Loop

a. Open Circuit

In an open loop wind tunnel, there is an intake and an exhaust. There is no use for corners and long diffusers but the power needed to drive the wind-tunnel is high because of the loss of energy in the out- flowing air. The open circuit wind tunnel is the simplest and most affordable to build. In these tunnels air is expelled directly into the laboratory and typically reinvested after circulating through the lab, though some tunnels utilize instead a compressed gas source. In addition to their low costs, open circuit tunnels are also advantageous because they have are relatively immune to temperature fluctuations and large disturbances in return flow, provided that the volume of the laboratory is much greater than that of the tunnel. [5]

There are two basic types of open circuit tunnels.

(a)Suck down

(b) Blower

The two are most easily differentiated by the location of the fan. Blower tunnels are the most flexible because the fan is at the inlet of the tunnel, so the test section can be easily interchanged or modified with seriously disrupting flow. These tunnels are so forgiving that exit diffusers can often be completely omitted to allow easier access to test samples and instruments, though the omission often results in a noticeable power loss. Suck down tunnels are typically more susceptible to low frequency unsteadiness in the return flow than blowers, though some claims have been made that intake swirl is less problematic in these tunnels because it does not pass through the fan before entering the test section. [5]

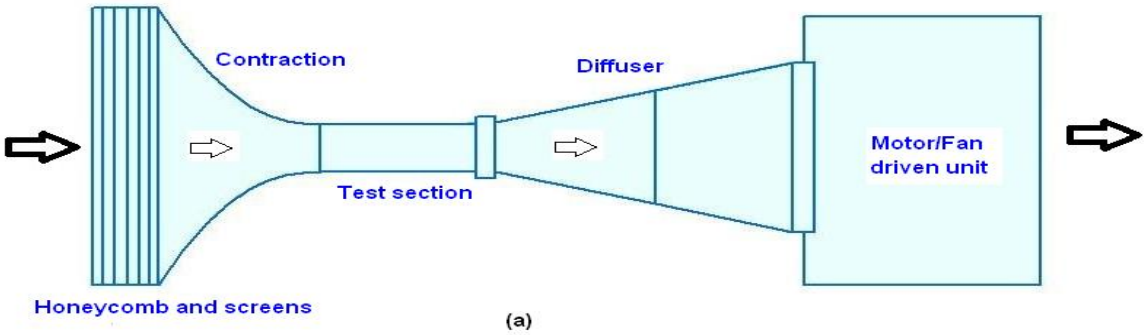

Figure 1: Open Circuit Wind Tunnel Layout

b. Closed Loop

As the name implies, closed circuit tunnels (also called closed return) form an enclosed loop in which exhaust flow is directly returned to the tunnel inlet. In a closed loop wind tunnel, the air is recalculated to improve efficiency for high speed testing. These tunnels are usually larger and more difficult to build. They must be carefully designed in order to maximize uniformity in the return flow. These tunnels are powered by axial fan(s) upstream of the test section and sometime include multistage compressors, which are often necessary to create trans-sonic and supersonic air speeds. Closed circuit wind-tunnels recirculation the air and thus normally need less power to achieve a given low speed, and, above all, facilitate the achievement of well controlled low conditions in the test section. The present, and most low-speed tunnels used for research, are of the closed circuit type. [5]

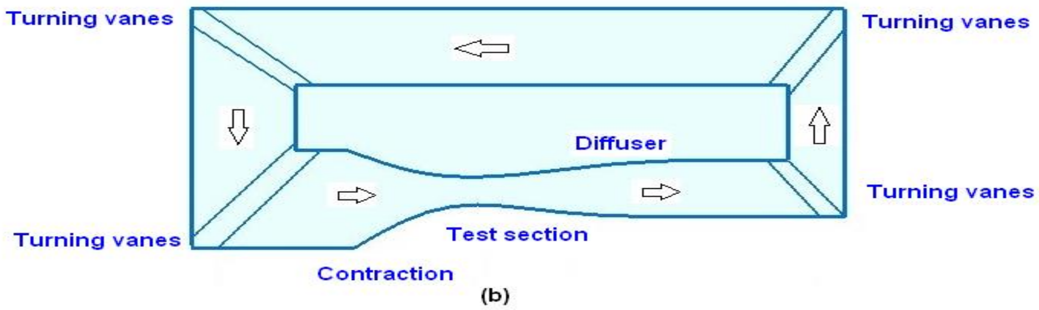

Figure 2: Closed Circuit Wind Tunnel Layout

There are many different kinds of wind tunnels.

- Low-speed wind tunnel
- High-speed wind tunnel
- Supersonic wind tunnel
- Hypersonic wind tunnel
- Subsonic and transonic wind tunnel

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2. PROBLEM IDENTIFICATION

2.1 There is no clear information about car, if the accessories are inbuilt on the car, than what is the pressure and velocity variance.

2.2 There is no clear information about car, if the accessories are neglecting on the car, than what is the pressure and velocity variance and difference between inbuilt and neglecting situation.

2.3 There is no show what is a changes upward and downward position aerofoil.

3. PROPOSED METHODOLOGY

The common of all wind tunnels they worked on Bernoulli's theory and Venturi effect. Bernoulli's principle thus says that a rise (fall) in pressure in a flowing fluid must always be accompanied by a decrease (increase) in the speed, and conversely, if an increase (decrease) in, the speed of the fluid results in a decrease (increase) in the pressure. This is at the heart of a number of everyday phenomena. [5][6][11]

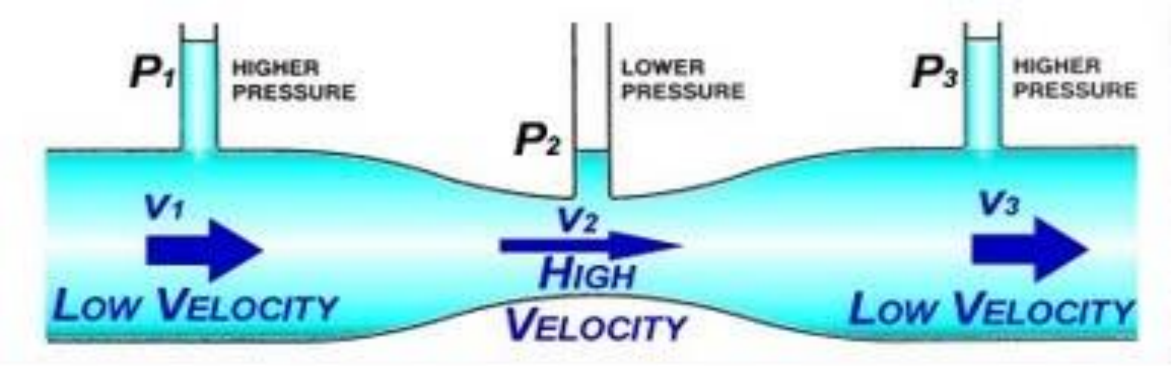

Figure 7: Principle Bernoulli's theory

$$\frac{p_1}{\rho g}+\frac{u_1^2}{2g}+z_1=\frac{p_2}{\rho g}+\frac{u_2^2}{2g}+z_2 \quad \text{Eq-3.1}$$

According to the laws governing fluid dynamics, a fluid's velocity must increase as it passes through a constriction to satisfy the principle of continuity, while its pressure must decrease to satisfy the principle of conservation of mechanical energy. Thus any gain in kinetic energy a fluid may accrue due to its increased velocity through a constriction is negated by a drop in pressure. [11][12][13]

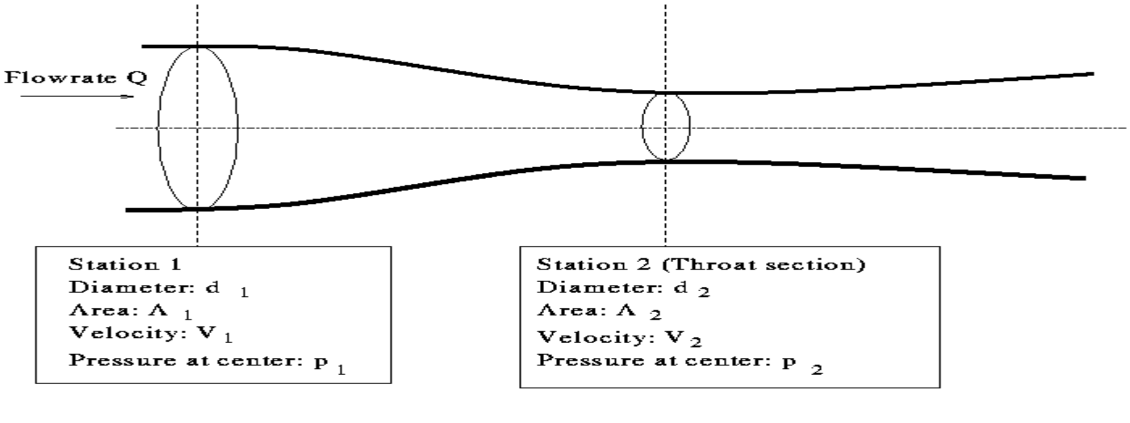

Figure 8: Principle Venturi effect

$$p_1 - p_2 = \frac{\rho}{2}\left(v_2^2 - v_1^2\right) \quad \text{Eq-3.2}$$

Flow rate

$$Q = v_1 A_1 = v_2 A_2$$

$$p_1 - p_2 * h1 = \frac{\rho}{2}(v_2^2 - v_1^2)$$ Eq-3.3

Then,

$$Q = A_1 \sqrt{\frac{2}{\rho} \cdot \frac{(p_1 - p_2)}{\left(\frac{A_1}{A_2}\right)^2 - 1}} = A_2 \sqrt{\frac{2}{\rho} \cdot \frac{(p_1 - p_2)}{1 - \left(\frac{A_2}{A_1}\right)^2}}$$

Eq-3.4

Figure 9: Wind tunnel layout

3.1 Two meager Instruments who are very helpful to experimental analysis is Pitot tube and Piezometer. Use to this we find stagnation pressure, static pressure, and dynamic pressure. All of part to find the Head drag & lift forces and velocity of fluid. [6][12][13]

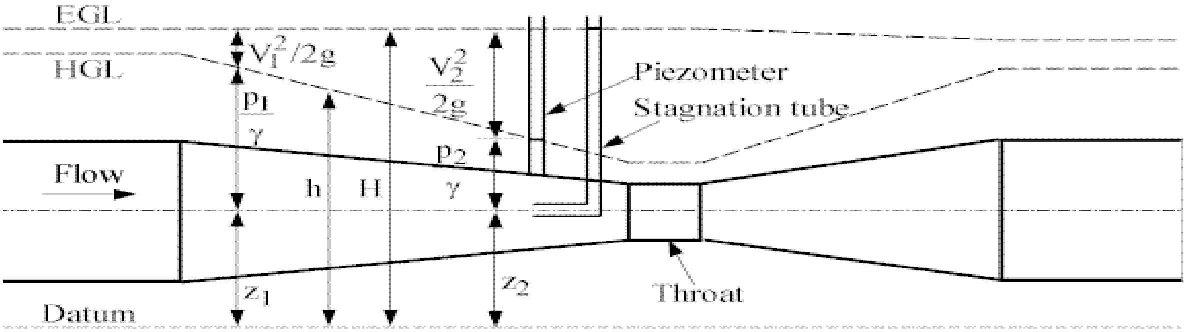

Figure 11: Working principle of wind tunnel

The drag coefficient c_d is defined as:

$$c_d = \frac{F_d}{\frac{1}{2}\rho v^2 A}$$ Eq- 3.5

Where:

F_d Is the drag force, which is by definition the force component in the direction of the flow velocity?

ρ Is the mass density of the fluid?

v Is the speed of the object relative to the fluid and

A Is the reference area.

The lift coefficient C_L is defined by

$$C_L = \frac{L}{\frac{1}{2}\rho v^2 S} = \frac{2L}{\rho v^2 S} = \frac{L}{qS}, \text{ Eq-3.5}$$

where L is the lift force, ρ is fluid density, v is true airspeed, S is plan form area and q is the fluid dynamic pressure. [6][7][10][12][13]

4. CONCLUSION

Wind tunnel is a testing or analysis setup of solid objects. The Design of low speed open circuit wind tunnel is some different to other wind tunnel. Its diffuser is flexible. We set the diffuser different angle. The construction of machine is low cost and Design is very easy. It's using materials easily available in the market. The machine is useful to educational and research purpose. Design is easy to read and construction and study the flow visualization of an object. The study of fundamental design process is resolve. To get an impression of fluid flow around a scale model of a real object. Use to it calculates the drag coefficient of the object design.

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