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TITLE: DESIGN OF BENCH TOP WIND TUNNEL

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Abstract

Wind tunnel testing has long been an important component common to many introductory fluid mechanics and aerodynamics courses. A wind tunnel is a tool 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, often called a wind tunnel model, is instrumented with suitable sensors to measure aerodynamic forces, pressure distribution, or other aerodynamic-related characteristics.However, these wind tunnels are very big, expensive and hard to access unless you have connections to show the airflow around a very limited array of objects.The primary objective of this project is to design and fabricate mini wind tunnel which should be of low cost and easy to use. The purpose of this project is to give educators and students a cost-effective means to demonstrate airflow over different objects using a simple type of wind tunnel. The basic idea of this mini wind tunnel is to have a fan pull the air into the tunnel through a test section (behind the viewing window) where an airfoil or similar shape is placed. The tunnel necks down to increase the amount of air flow passing through the test section.

Index Term. *Fluid mechanics, aerodynamics shapes, aero foil, pressure distribution.*

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INTRODUCTION :

A wind tunnel is a tool used to aerodynamic research to study the effects of air moving past objects .A wind tunnel consists of a tubular passage with the objects under test mounted in the middle. Air is made to move past the object by a powerful fan systems or means. The test object, often called wind tunnel model, is an instrumented with a suitable sensors to measured aerodynamic forces, pressure distribution or other aerodynamic related characteristics. The earliest wind tunnels were invented towards the end of the 19^{th} century in the early days of aeronautics research, when many attempted to develop successful heavier than air flying machines. The wind tunnels was in envision as a means of reversing the usual paradigm; instead of the air standing still and an object moving at speed through past it ,the same effect would be obtained if the object stood still and air move at speed pass it. that way a stationary observer could study the flying object in action,and could measure aerodynamic forces imposed on it. The development of wind tunnels accompanied the development of aeroplane. The large wind tunnels were build during the second world war. Wind tunnel testing was considered of strategic importance during the cold war development of supersonic air craft and missile.

1.DESIGN OF WIND TUNNEL

Wind tunnel testing has long been an important component common to many introductory fluid mechanics and aerodynamics courses. A wind tunnel is a tool 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.

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smoke in front of the airfoil that is being tested. The smoke comes from regularly-spaced point sources, and the wind flow in the tunnel spreads it out into parallel lines, called streamlines. The streamlines make it possible to visualize the airflow over the airfoil. When the lines continue smoothly over and past the airflow, they show that the flow remains laminar, and that the airfoil is creating very little drag. When the streamlines show more chaotic, turbulent flow, they indicate that the airfoil is creating more drag. This mini wind tunnel can be used to demonstrate basic physical mechanisms of viscous and pressure drag associated with the formation of drag forces on various aerodynamic shapes. Understanding these physical characteristics is very important to automotive aerodynamic design, for maximizing fuel economy, and in the teaching of basic principles of aerodynamic design as applied to aircraft.

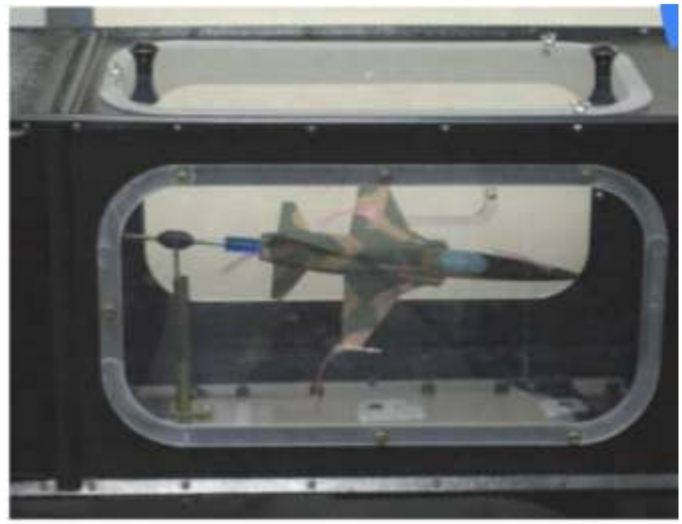

Fig. 1.Bench mini wind tunnel testing model.

Fig. 2.Digram of an open circuit, also known as wind tunnel.

An open-circuit wind tunnel is also called an open-return wind tunnel. Closed-circuit, or closed-return, wind tunnel. If the same air is being circulated in such a way that the wind tunnel does neither draw new air from the surrounding, nor return it intothe surroundings, the wind tunnel is said to have a closed-air circuit. It is conventional to call that a closed circuit (closed-return) wind tunnel. Figure 2 illustrates this configuration.

$v = \frac{2\sqrt{po-p}}{\rho}$ Equation for flow measurement . where V is the speed of fluid ,Po is the total,also called the stagnation pressure at that point of measurement, P is the static pressure at the same point these equation comes from the application of Bernoullis equation for a study flow of incompressible and inviscid fluid along a streamline.

Key equations

Thickness of the laminar boundary layer over a flat plate: Exact solution due to Blasius. For a semi-infinite flat plate, the exact solution for a laminar boundary layer was first derived by

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0$$
$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\nu\frac{\partial^2 u}{\partial y^2}$$
$$u(y=0)=0;v(y=0)=0$$
$$u(y=\infty)=U;\frac{\partial u}{\partial y}(y=\infty)=0$$

Blasius (Pritchard, 2011). In conformity with his work, the continuity equation and the Navier-Stokes equation with the corresponding boundary conditions are ordinarily written as shown below:

Where u is the component of velocity along the plate and v is the component of velocity perpendicular the plate. The origin of the coordinate system is at the leading edge of the plate, with the x direction along the plate and the y direction perpendicular to it. The magnitude of free-stream velocity, far from the plate is U. Using similarity transformations, one introduces a change of variables as shown below. Let

$$\eta\propto\frac{y}{\delta}\Rightarrow\frac{u}{U}=g(\eta);$$
$$\delta\propto\sqrt{\frac{\nu x}{U}}\Rightarrow\eta=y\sqrt{\frac{U}{\nu x}}$$
$$u=\frac{\partial\psi}{\partial y};v=-\frac{\partial\psi}{\partial x};f(\eta)=\frac{\psi}{\sqrt{\nu xU}}$$

Applying this change of variables allows the second-order partial differential equation given above to become a nonlinear, third-order, ordinary differential equation, with the associated boundary conditions shown below:

$$2\frac{d^3f}{d\eta^3}+f\frac{d^2f}{d\eta^2}$$
$$f(\eta=0)=0;\frac{df}{d\eta}(\eta=0)=0$$
$$\frac{df}{d\eta}(\eta\to\infty)=1.$$

The solution to this equation is obtained numerically. From that numerical solution, it is seen that, at ├ = 5.0, u/U = 0.992. If the boundary layer thickness is defined as the value of y for which u/U = 0.99, one gets

$$\delta\cong=\frac{5.0x}{\sqrt{\mathrm{Re}_x}};with\,\mathrm{Re}_x=\frac{Ux}{\nu}$$

Using boundary-layer theory, a sketch of the velocity profile along a vertical line in the test section of the wind tunnel is expected to look as shown below. In this application of the wind tunnel, one wishes to compare this profile to that obtained experimentally in the test section of the wind tunnel (See Figure 3.).

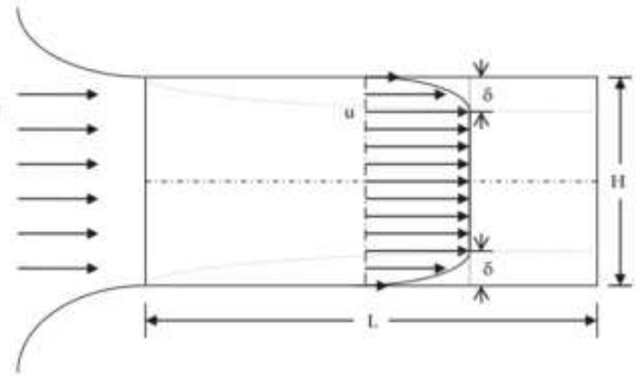

Fig.3.Graphical Representation of boundary layer in wind tunnel test section.

CONCLUSION:

This conceptual approach was implemented in our laboratory and the collected data verified that roughness on the surface of a sphere reduces the drag force on it. Thus we conclude that mini wind tunnel will be helpful for the aerodynamic testing of objects in automobiles and aerospace engineering.

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