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Design and Fabrication of Subsonic Wind Tunnel

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ABSTRACT: A Wind Tunnel is a tool used in aerodynamic research to study the effects of air moving past the solid objects. Wind tunnels were first as a means of studying vehicles (primarily airplanes) in free flight. A Wind tunnel is used to find the aerodynamics and also to measure drag and down force of airfoils. The wind tunnel is composed of a contraction cone, test section and diffuser, with nessary instrumentation to measure the drag and downforce acting on the vehicles. Our project aims at using hand fabricated wind tunnel to test aerodynamics of scaled models and also to calculate the drag in them.

It is very important nowadays to consider the aerodynamics of any vehicles whiles designing, this helps in improving the efficiency and reduces the fuel consumption. With this hand fabricated wind tunnel it makes the checking of aerodynamics and calculation of drag for scaled models very easy. This reduces the time taken for designing and production.

I. INTRODUCTION

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 closed tubular passage with the object under test mounted in the middle. A powerful fan system moves air past the object; the fan must have straightening vanes to smooth the airflow. The test object is instrumented with a sensitive balance to measure the forces generated by airflow; or, the airflow may have smoke or other substances injected to make the flow lines around the object visible. Full-scale aircraft or vehicles are sometimes tested in large wind tunnels, but these facilities are expensive to operate and some of their functions have been taken over by computer modeling. In addition to vehicles, wind tunnels are used to study the airflow around large structures such as bridges or office buildings

Theory of operation:

Wind tunnels were first proposed as a means of studying vehicles (primarily airplanes) in free flight. The wind tunnel was envisioned as a means of reversing the usual paradigm: instead of the air's standing still and the aircraft moving at speed through it, the same effect would be obtained if the aircraft stood still and the air moved at speed past it. In that way a stationary observer could study the aircraft in action, and could measure the aerodynamic forces being imposed on the aircraft.

Later on, wind tunnel study came into its own: the effects of wind on manmade structures or objects needed to be studied when buildings became tall enough to present large surfaces to the wind, and the resulting forces had to be resisted by the building's internal structure. Determining such forces was required before building codes could specify the required strength of such buildings and such tests continue to be used for large or unusual buildings.Still later, 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

II. 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 Bernoulli's principle. Measurement of the dynamic pressure, the static pressure, and (for 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. Smoke or bubbles of liquid can be introduced into the airflow upstream of the test model, and their path around the model can be photographed.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.
It should be noted that the aerodynamic properties of an object do not remain the same for a scaled model

III. AERODYNAMICS

Aerodynamics, from Greek ἀήρ *aer* (air) + δυναμική (dynamics), is a branch of fluid dynamics concerned with studying the motion of air, particularly when it interacts with a solid object, such as an airplane wing. Aerodynamics is a sub-field of fluid dynamics and gas dynamics, and many aspects of aerodynamics theory are common to these fields. The term *aerodynamics* is often used synonymously with gas dynamics, with the difference being that "gas dynamics" applies to the study of the motion of all gases, not limited to air.

Formal aerodynamics study in the modern sense began in the eighteenth century, although observations of fundamental concepts such as aerodynamic drag have been recorded much earlier. Most of the early efforts in aerodynamics worked towards achieving heavier-than-air flight, which was first demonstrated by Wilbur and Orville Wright in 1903.Since then, the use of aerodynamics through mathematical analysis, empirical approximations, wind tunnel experimentation, and computer simulations has formed the scientific basis for on-going developments in heavier-than-air flight and a number of other technologies. Recentwork in aerodynamics hasfocused onissues related to compressible flow, turbulence, and boundary layers, and has become increasingly computational in nature.

Drag force:

In fluid dynamics, drag (sometimes called air resistance, a type of friction, or fluid resistance, another type of friction or fluid friction) is force acting opposite to the relative motion of any object moving with respect to a surrounding fluid. This can exist between two fluid layers (or surfaces) or a fluid and a solid surface. Unlike other resistive forces, such as dry friction, which are nearly independent of velocity, drag forces depend on velocity. Drag force is proportional to the velocity for a laminar flow and the squared velocity for a turbulent flow. Even though the ultimate cause of a drag is viscous friction, the turbulent drag is independent of viscosity.

HONEYCOMB STRUCTURE:

A honeycomb mesh is often used in aerodynamics to reduce or to create wind turbulence. It is also used to obtain a standard profile in a wind (temperature, flow speed). A major factor in choosing the right mesh is the length ratio (length vs honeycomb cell diameter) *L/d*.
Length ratio < 1: Honeycomb meshes of low length ratio can be used on vehicles front grille. Beside the aesthetic reasons, these meshes are used as screens to get a uniform profile and to reduce the intensity of turbulence.[28]
Length ratio >> 1: Honeycomb meshes of large length ratio reduce lateral turbulence and eddies of the flow. Early wind tunnels used them with no screens; unfortunately, this method introduced high turbulence intensity in the test section. Most modern tunnels use both honeycomb and screens.
While aluminium honeycombs are common use in the industry, other materials are offered for specific applications.

People using metal structures should take care of removing burrs as they can introduce additional turbulences. Polycarbonate structures are a low-cost alternative.

The honeycombed, screened centre of this open-circuit air intake for Langley's first wind tunnel ensured a steady, non-turbulent flow of air. Two mechanics pose near the entrance end of the actual tunnel, where air was pulled into the test section through a honeycomb arrangement to smooth the flow.

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Effect of friction in the Wind Tunnel :

The friction inside the wind tunnel affects the airflow. But in a small size Wind Tunnel the effect of friction is negligible. Since the inner surface of the Wind Tunnel is coated with epoxy paint material, the co-efficient of friction (**μ**) is less than 0.03. So, the frictional losses can be neglected.

Testing:

Aerodynamics:

After fabricating the Wind Tunnel, we tested for aerodynamics of scaled vehicle models with help of smoke. By this the aerodynamics for various scaled automobiles and building structures were observed.

Drag:

Then using this Wind Tunnel we tested for the drag force that was induced in the scaled model. Drag is determined by the amount that the air pushed against the car's surface. The greater the push the air made on the car, the more the car moved backward. The backward motion of the car caused the string attached in the test section to pull on the weight placed in the scale. The more the mass was pulled upward, the lower the scale went from the reference amount. That is, for example, for 100 grams weight placed, the car with no drag would read 100, while one with 20 grams of drag would have a reading of 80.

IV. Result

Thus, the **Wind Tunnel** proved to be efficient in the Aerodynamics and Drag testing of scaled models. The drag testing for the scaled models was found to be a easy technique and is also cost effective. By this the designing time of various vehicles and building structures can be reduced.

V. CONCLUSION AND FUTURE SCOPE

Based on our project, it was concluded that subsonic wind tunnel can be used for checking aerodynamics of various scaled of models of vechiles like cars, buses, trucks., etc.,

They can also be efficiently used for calculation of drag induced in the scaled models of automobiles and building structures for a particular flow rate of air. In future they can also be developed to test to airfoils of an aircraft and pressure variations caused due to various obstructions.

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