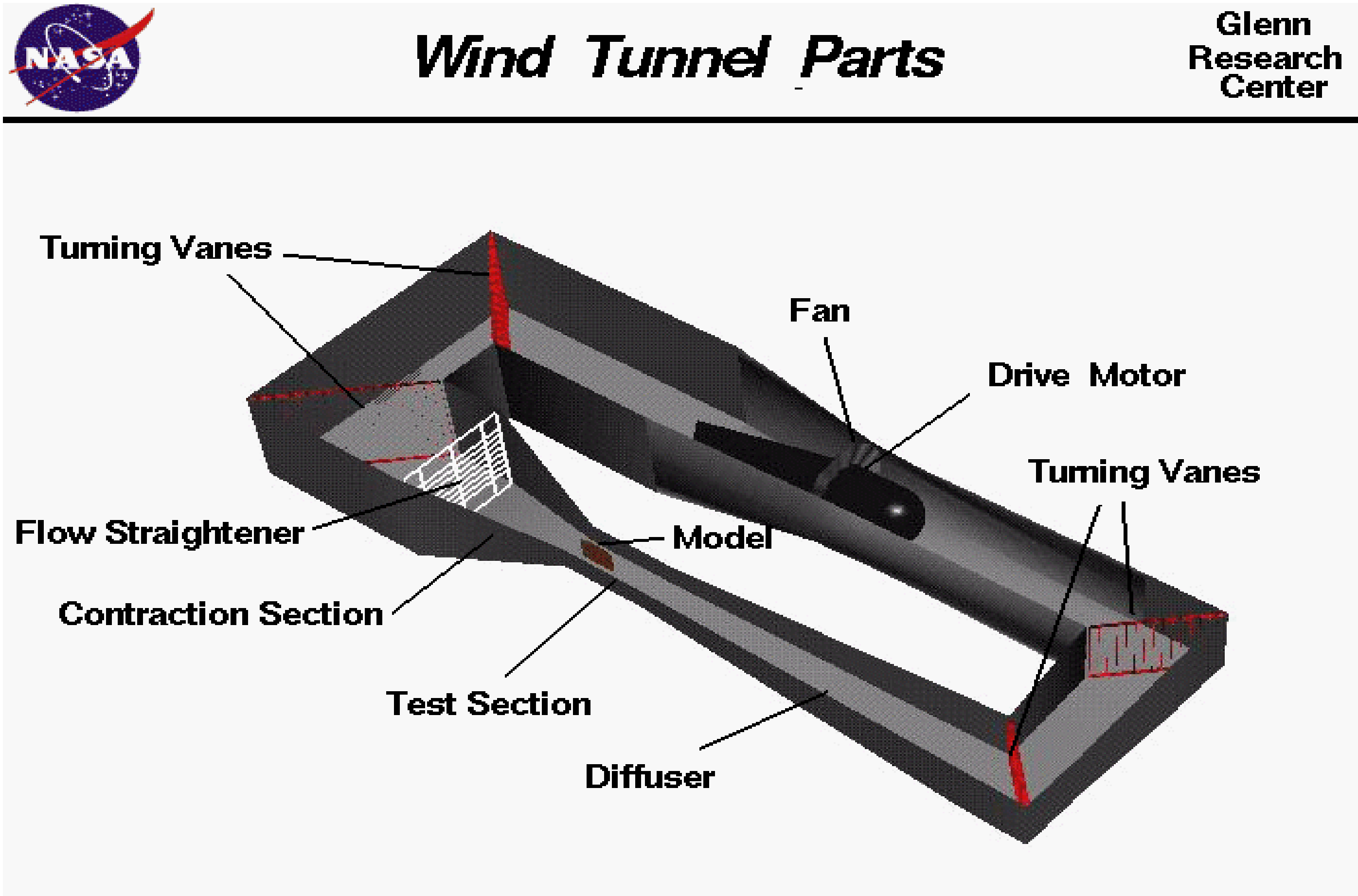
WIND TUNNEL TECHNIQUE NOTES FOR AERONAUTICAL ENGINEERS

According to the syllabus of **Punjab technical university** for aeronautical engineering. The second topic in syllabus is :

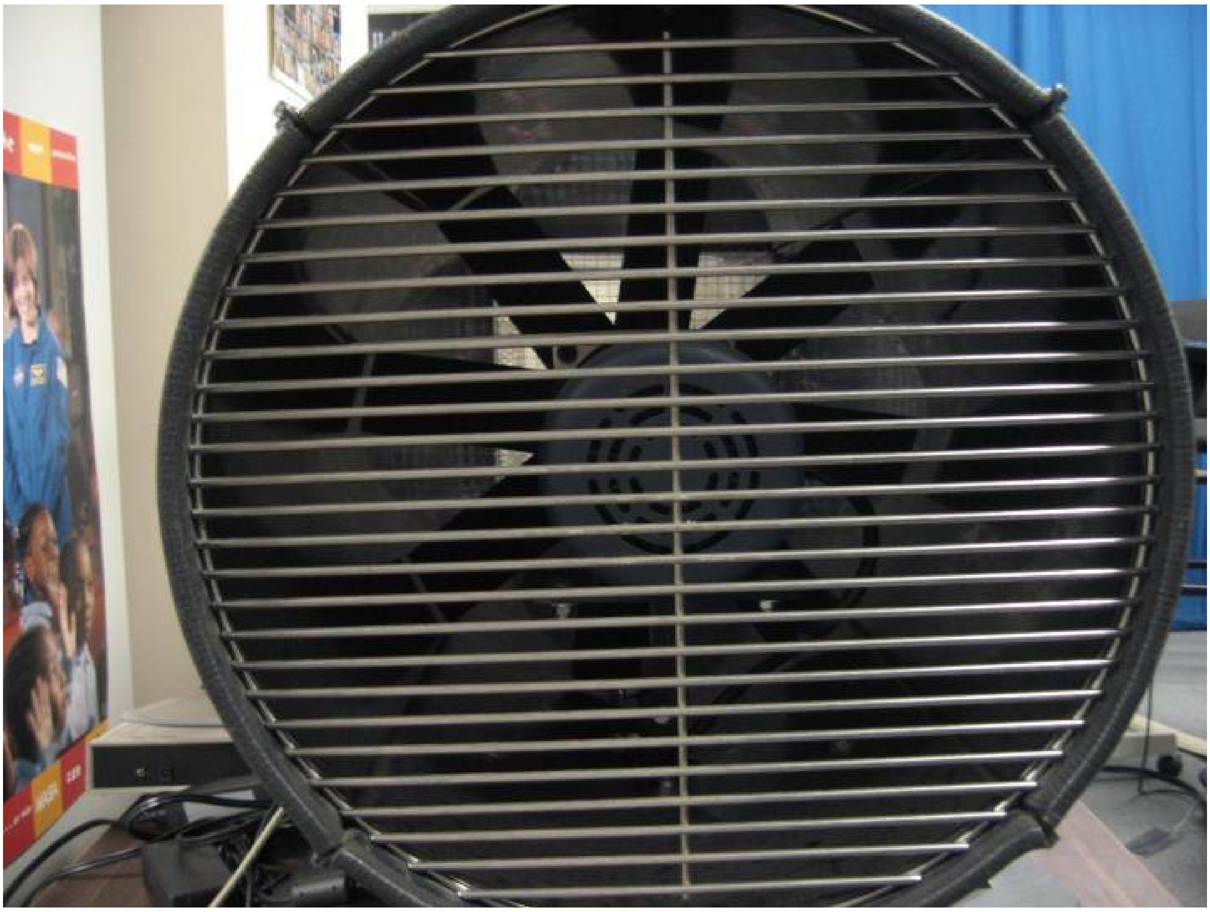
2)WIND TUNNEL DESIGN

Closed type wind tunnel picture below:



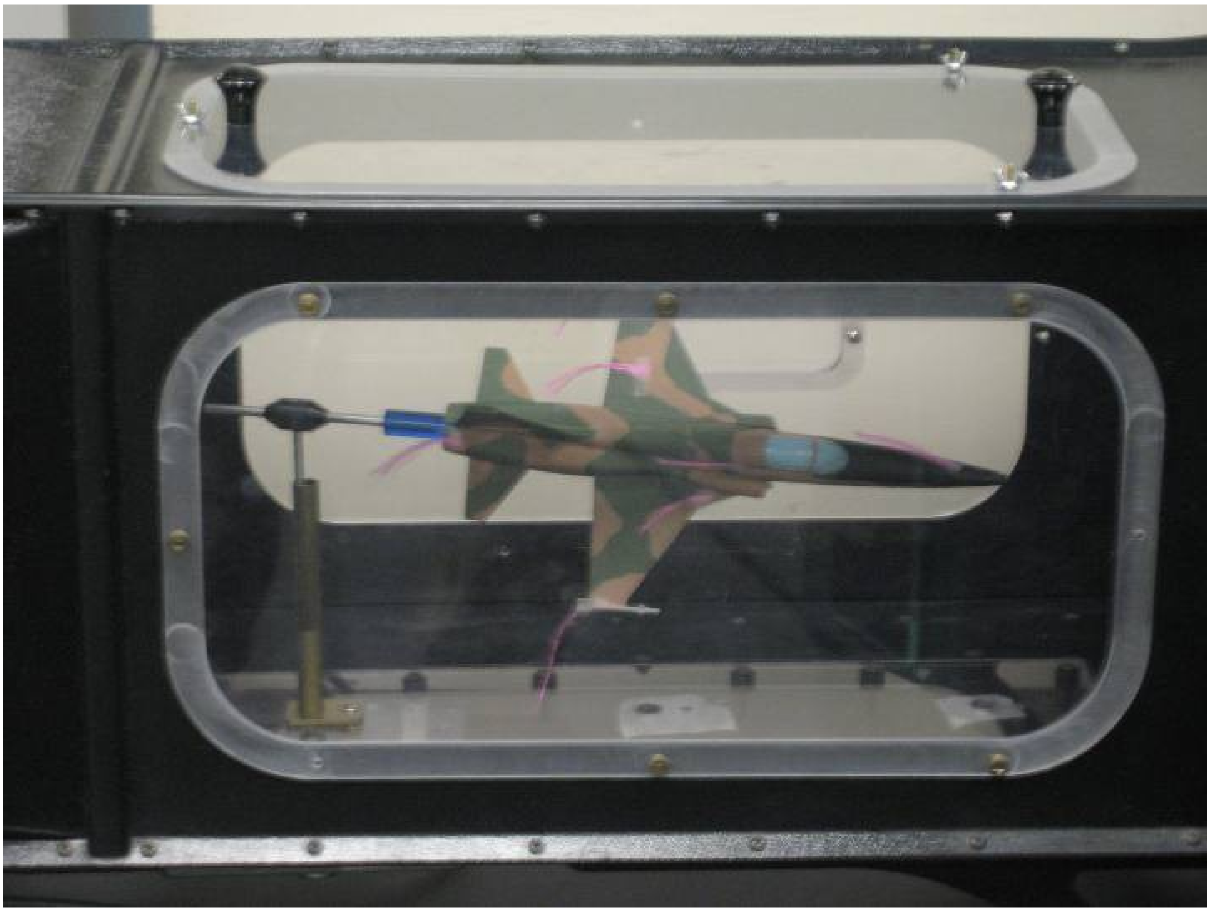
Wind tunnels are designed for a specific purpose and **speed range**. There is a wide variety **of wind tunnel types** and model instrumentation. The tunnel shown in the figure is a low-speed, **closed tunnel** which we are viewing from above. We can use this figure to study the various **parts** of a wind tunnel.

OPEN TYPE WIND TUNNEL PARTS DESCRIPTION:-



⌚ **FAN OF WIND TUNNEL**:

The air inside the tunnel is made to move by the **fan** on the far side of the tunnel. In this figure, air moves counter-clockwise around the circuit. The fan is turned by a large, electrically-powered **drive motor**. Leaving the fan, the air is turned in the corners by **turning vanes**. The turning vanes are a cascade of airfoils which minimize the total pressure loss through the corners. Leaving the corner at the upper left of the figure, the air passes through some **flow straightness** before entering the test section. The purpose of the flow straightness is to make the flow in the test section as uniform as possible.



TEST SECTON OF WIND TUNNEL:-

The **test section** is the part of the wind tunnel in which the model is placed. For low speed tunnel operation, the test section has the smallest cross-sectional area and the highest velocity within the tunnel. Leaving the **test section**, the air enters the **diffuser** where it is expanded and slowed before returning to the fan. Again, the diffuser is employed to minimize losses in the tunnel. For this closed circuit wind tunnel, there are two more corners with turning vanes before the air is brought back to the fan.

Airflow through this tunnel is from right to left. The largest part, at the right of the tunnel, is called the **bellmouth**. For this tunnel, the flow straightness are placed at the entrance to the bell mouth as shown here.

The flow is constricted and the flow speed is increased through the bellmouth. The flow then enters the test section shown in this photo.

A tufted model of an F-5 fighter plane is shown in the test section. Air is drawn over the model by a fan located at the far left of the tunnel. In this photo, one can see the motor that drives the fan, an exit screen to protect the user, and the diffuser from the test section to the tunnel .

Wind tunnel construction:

Building the Tunnel

Q = (VA)1=(VA)2

V = flow velocity, A = cross sectional area, and Q = volumetric flow rate

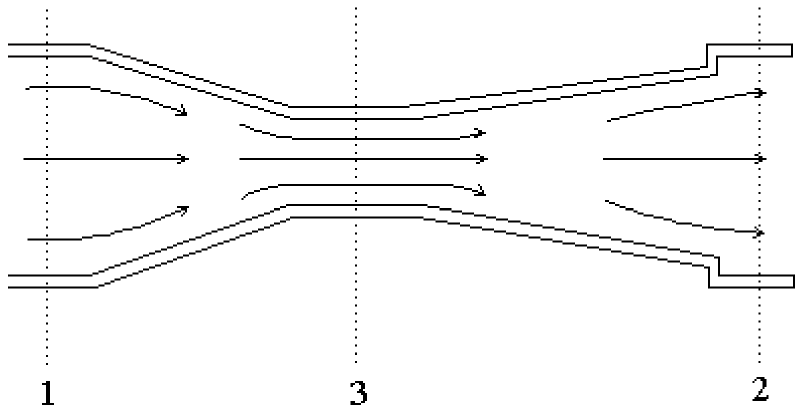


Figure 1: In this model of Venturi flow, the flow velocity at 3 is higher and pressure is lower than at 1 or 2 because of the decreased cross-section. [4]

BREATHER VIBRATIONS:

usually in four steps of nominally 90 deg. each, by rows or "cascades" of closely closed-circuit type, in which the same air is re circulated. The stream is turned, spaced vanes. There is always a small vent, called a "breather", somewhere in the circuit so that the internal pressure does not increase as the air heats up during the run: it is usual to have a slot around the perimeter at the downstream end of the test section, so that the latter is close to atmospheric pressure to reduce the effect of leaks through the holes usually cut in the walls for model support struts, etc.. If the slot mechanically disconnects the test section from the diffuser it may be useful as a vibration isolator. The remainder of the tunnel is above atmospheric pressure (by almost the full test-section dynamic pressure in the case of the settling chamber) and the flow through any leaks is outward. The compensating inflow through the breather is (i) bad for diffuser performance but (ii) easy to detect by releasing smoke just outside the breather.

WIND TUNNEL ENERGY RATIO:

Most of the power required to run a closed-circuit tunnel is absorbed by losses in the diffuser, the test section and the corners. Axial fan efficiency can exceed 90 percent if the wall boundary layers at entry are not too thick. The

contraction ratio is usually chosen so that total-pressure losses in the honeycomb and screens are acceptably small, and this usually means that losses in the third and fourth corners are small also. All losses are basically due to turbulent skin friction and therefore slowly decrease, in proportion, as the tunnel size (Reynolds number) increases.

The dimensionless parameter representing consumption of power delivered to the fan drive shaft, P, is the "power factor"

= P/[(1/2) U3A]

where U and A are the test-section velocity and cross-sectional area and the denominator is the rate of flow of kinetic energy, (1/2)U2 per unit mass, through the test section (i.e. K.E. per unit mass times mass flow rate U). In the United States, the reciprocal of power factor, the "energy ratio", is sometimes quoted. In all cases the efficiency of the electric (or, rarely, gasoline) motor is considered separately from the tunnel power factor. It can be seen that the power factor of an open-circuit tunnel with no diffuser is always greater than unity because all the kinetic energy is dumped at the exit, and there are the usual losses elsewhere.