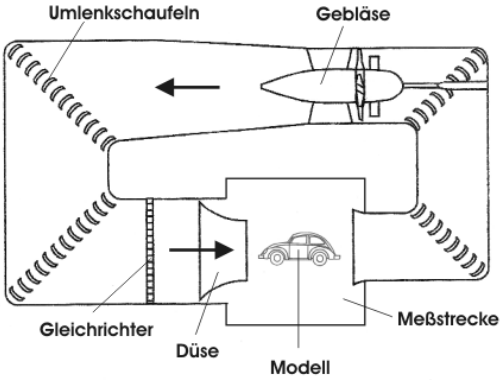
The Wind Tunnel

1. What is a wind tunnel



A wind tunnel is a research tool, developed for studying the effects of air moving over or around a solid object. Wind tunnels are used in development processes of aircraft, helicopters, cars, trains and so on. A wind tunnel is basically a long, narrow box or a circle where at one end a fan creates a steady and straight stream of air that can be controlled. Inside a wind tunnel are placed scientific instruments to measure the effects of the air moving over or a around the tested object. There are several well known wind tunnels around the world. Alone the NASA holds several different types of wind tunnels. There exist wind tunnels for experiments with air flow, with pressure or for meteorological experiments.

2. History

One of the first wind tunnels was built by the famous Wright Brothers in winter of 1901. The Wright Brothers made the first controlled, powered, heavier-than-air flight in December 17, 1903. The brothers built a wind tunnel to test their wing designs.

3. Classification

The two main types of wind tunnel are open-circuit and closed-circuit tunnels. Open-circuit wind tunnels are having the wind-generator at one end and the other end is open. Closed-circuit tunnels have a tunnel where the two ends are connected in a circle to generate higher flow speeds.

Wind tunnels are classified by the speed of the air stream they can produce. The air speed is specified by the Mach number. This number is dependant on temperature. One Mach is at 20°C (room temperature) 343 m/s or 1235km/h. In 10.000 metres and at -50°C one Mach is 299.8 m/s = 1079.3 km/h. So an airplane at travel speed of 0.85 Mach has a speed of about 917 km/h.

Wind tunnels are classified into 4 main types:

- Subsonic wind tunnels (M = 0 - 0.7)
- Transonic wind tunnels (M = 0.7 - 1.2)
- Supersonic wind tunnels (M = 1.2 - 5)
- Hypersonic wind tunnels (M > 5)

The quality of a wind tunnel can be described by the range of Mach numbers that can be tested, along with the testing equipment and size of the tunnel.

An excursus to aerodynamics:

> Aerodynamics describes the reaction of objects in gases (mostly air). It is the study of flow around or through passages in solid objects of various size and shape.
>
> A Classification of the problems is given by the ratio of flow speed to the speed of sound (c = 343 m/s (1235 km/h) at 20 °C in air).

- subsonic
  The problem is called subsonic if the speeds in the problem are less than the speed of sound.
- transonic
  It is called transonic if the speeds are both below and above the speed of sound.
- supersonic
  The problem is called supersonic it the flow speed is greater than the speed of sound.
- hypersonic
  It is called hypersonic if the speed is between Mach numbers of 3 to 12.

4. Testing and Measurement

There are many different experiments which could be performed in a wind tunnel. Some of them are listed below:

- Function of wings
- Stability of aircrafts
- Propeller performance
- Flow visualization
- Performance of jet propulsion
- Wind effects on buildings, towers, bridges
- Heat transfer

For example turbulences are measured with laser systems and could be easily made visible with smoke.

With the help of modern equipment, computer control and complex software it is possible to control, show and visualize parameters in real-time.

4.1. Model

The test section of wind tunnels is generally rectangular but mostly not big enough to put a whole airplane into the tunnel. So the researchers scale the things they want to test down. They use models on scale, which are hard to built and generally very expensive. To simulate the real conditions the aerodynamicist must kept the dimensional parameters constant. For example, a model 1:4 must be tested at four times the real speed. Hence the smaller the model, the higher the speed in the test section, this is called the scale-effect.

4.2. Problems

Like everywhere also in wind tunnels exists some problems. First is to say that the test conditions are never the same as the operational conditions. Next there must be found a compromise between the model's size and the wind tunnel size. Remember the mentioned scale-effect. Next there are problems with interferences caused by reflection of waves from the wind tunnel walls. The last thing is that the air steam should not be blocked by the object. This could occur when the test object is too big for the wind tunnel.

5. References

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