Experiment No 1

Objective: - Study of flow through Linear cascades and calculation of lift & drag forces

Measurement of: -

- Pressure distribution on the airfoil at various Reynolds numbers.
- Measurement downstream Velocity profile in cascades at various Reynolds numbers.

Prerequisites: -

1. A rough idea about turbo machine blades.
2. What is cascade and what are various types of cascades used in Research and Development?
3. What are airfoils and what is the nomenclature used to identify the same?

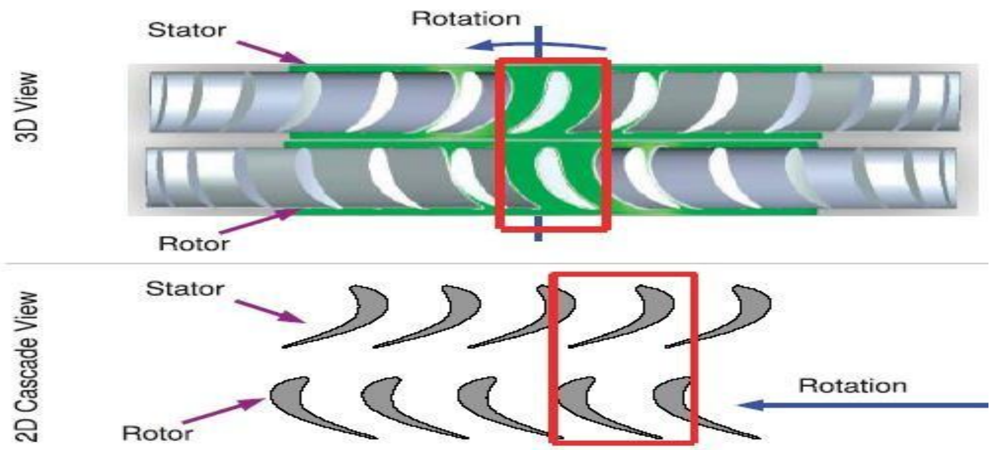
Minute details about the practical Setup :-(or the theoretical brief background)

For the Cascade: -

A row of blades representing the blade ring of an actual turbo machine is called cascade.

The blades can be arranged in a straight line or along an annulus. Before studying a particular turbine, compressor or fan stage, it will be useful to study the behavior of flow through blade rows of such machines.

The boundary layer growth on the suction and pressure sides of the blades in a real flow leads to the formation of low energy regions in the exit flow field. There are distinct separate lanes of chaotic flow with considerably low fluid velocities and the presence of vortices. These lanes are referred to as blade wakes. The fluid velocity rises from the wake regions to a maximum in the free stream.



Flow through cascade

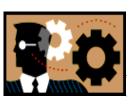
Construction of a cascade:

A cascade is constructed by assembling several blades of a given shape and size at the required pitch and the stagger angle. The assembly is then fixed on the test section of the wind tunnel. Air at slight pressure and near ambient temperature is blown over the cascade of blades to simulate the flow over an actual blade row in a turbo machine.

Upstream and downstream traversing:

Though it is expected that the flow parameters are uniform in the test section of the upstream of the cascade, it is preferable to check the variations of these quantities at the mid-section of the blades over at least one blade pitch(s) in the central region.

The stagnation pressure (Po_{1}) is measured through wall tapping in the settling chamber is a good reference. The losses from the settling chamber to the test section in the free stream are negligible. Therefore, stagnation pressure measured by a pitot tube in the test section is almost equal to (Po_1). Measurement of static pressure, temperature, velocity and direction is also important. Similarly, the flow parameters are checked downstream.

**Experimental Procedure/what you should aim at: -**

Description:

The wind tunnel is of suction type with an axial flow fan driven by a variable speed DC motor. It consists of an entrance section with a bell mouth inlet containing a flow straightener, screen and straw honeycombs. This section is followed by a nozzle section, test section, a diffuser section and a duct containing the axial flow fan. The schematic of the blade is shown in fig.1.

Theory:

Wind tunnels are generally used for testing the models of various shapes like aerofoils, cylinders, cascade of blades etc. In a wind tunnel the important part is the test section. The object to be tested are placed in the test section. The wind tunnel can be of suction type or blower type. The air enters the settling chamber on account of the large cross section area of the setting chamber. Its velocity is reduced, and the presence of wire gauges and honeycomb straightens the flow before it is expanded in the contraction zone. The working or test section receives a uniform stream of air from the contraction zone.

Procedure:

1. The given cascade is rigidly fixed in the test section through the slots present in the body of the test section. The angle of incidence (α) is kept at zero initially.

2. The test sections relate to cables for attachment with the pressure measuring device.

3. The motor is started and speed is maintained. The manometer deflection from the Pitot tube is measured.

4. Anemometer is used to measure the flow velocity in upstream and downstream regions.

5. The experiment is then performed on the test section.

<u>For Cascade:</u>

- Draw a neat sketch with all the major dimensions of the test rig and details of all the instruments available on the test rig.
- Measurement of velocity profile at the upstream of the cascade.
- Measure the static pressure distribution on the central aerofoil as shown in table 1. Here, 1 to 13 is the pressure side and 14 to 27 is the suction side of the blade.
- Measurement of velocity at the downstream of the cascade at several horizontal points to obtain the complete velocity profile.
- The above process needs to be repeated for three different inlet speeds between 3 m/s and 10 m/s.

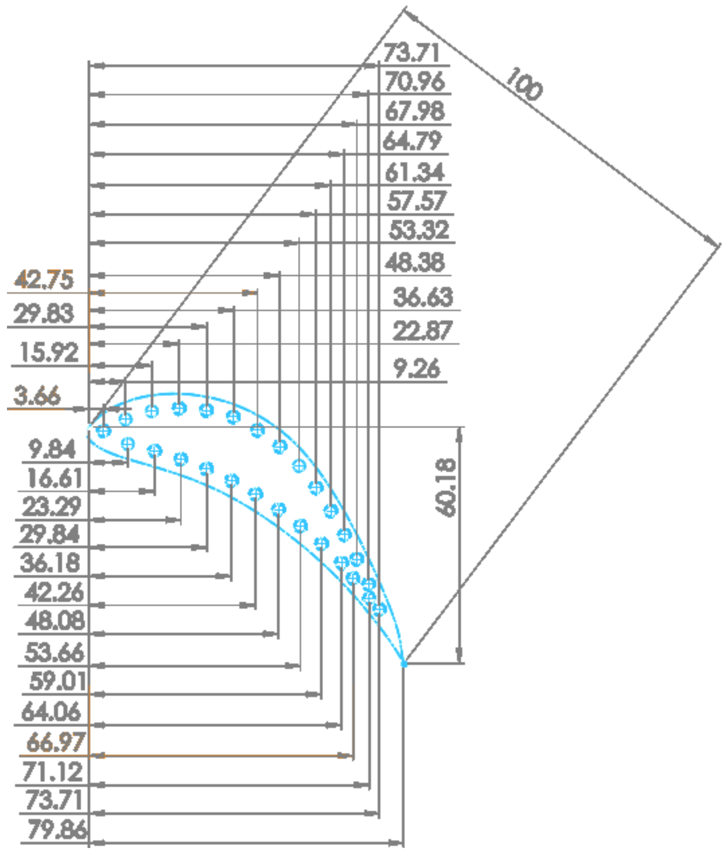


Figure 1: Profile of airfoil and Locations of the taps for connecting the pressure tunes.

<u>Table 1: Variation of pressure at different pressure points along the blade profile</u>

S. No.	Distance from leading edge	Pressure (Pa)
1		
2		
3		
4		
5		
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26		

27		

Measurement of Downstream Velocity:

Transverse Location (cm)	Velocity Head (Pa) or velocity (m/s)

What next (Things you can ponder over):-

1. Why did I do this whole experiment? (What is the technical applicability in real world?)
2. What difference does a single airfoil have in comparison to a cascade of blades?
3. Calculate the lift force and drag force on the blade at three inlet speeds considered in the experiment.
4. Draw the corresponding characteristic curves of these forces vs the inlet speed.

Submission of Report:

- A single report per group.
- All are equally responsible for the preparation of the report.
- The above questions should be answered in your report.
- Each Report will be evaluated for 10 points.

References:-(Books to consult)

1. Fluid Mechanics and thermodynamics of turbo machinery by S.L. Dixon.
2. Turbines, compressors and Fans by S. M. Yahya.