FLUID FACILITIES AND MACHINERY

GUIDE TO LABORATORY PRACTICALS

University of the Basque Country (UPV/EHU)

Energy Engineering Department

THEME 8: RADIAL FAN

1. REQUIRED BACKGROUND KNOWLEDGE

Fluid Mechanics.

Hydraulic Machinery. Turbomachinery. Fans.

2. PRE-LABORATORY

Detailed reading of the description of the practical for its completion within 1 [h]. See Video P8.

3. OBJECTIVES

To study the characteristics of a radial (also known as centrifugal) fan:

- Visual observation of the operation of a radial fan.
- The use of a Prandtl tube; calculation of flow measurement and flow velocity profiles in the suction pipe.
- Experimental determination of the characteristic curves of a centrifugal fan.
- Study of the regulation of an axial fan by modifying the rotation speed; obtaining characteristic curves at different revolutions; Similitude Laws applied to fans.

4. THEORETICAL FOUNDATION

In this practical, the use of the Prandtl tube will be presented for taking static pressure, p_e, and/or dynamic pressure, p_d readings. Note that the connections of the measuring tube will also affect the pressure measurement.

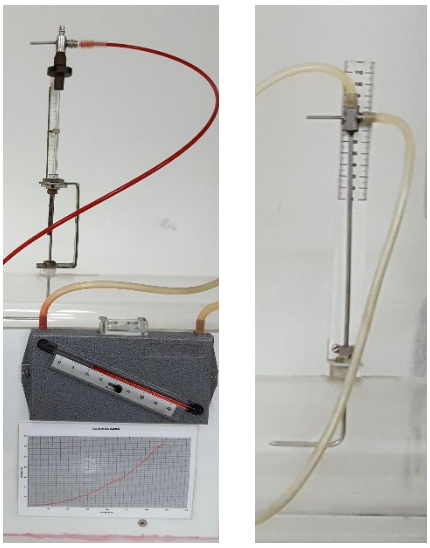

Figure 36: *Prandtl tube; static and dynamic pressure.*

The image on the left-hand-side of Figure 36 shows a connection for the measurement of static pressure. The image on the right shows a connection with which to measure the dynamic pressure. According to the mathematical expression described below, the total pressure can therefore be calculated by the sum of both static and dynamic pressures. However, it is also possible to measure the total pressure using a Prandtl tube (used as a Pitot tube), by means of a single connection located at the top of the tube (not shown in Figure 36).

Using the different measurement elements, different operating points of the fan can be experimentally obtained. This point cloud will then be fitted to a curve using the least squares method:

$$Q = K_{mean} \cdot p_e^{1/2}$$

$$\Delta p_e\,(Q) = \mathrm{A} + \mathrm{B}{\cdot}Q + \mathrm{C}{\cdot}Q^2$$

$$P_{static}\,(Q) = P_e\,(Q) = Q \cdot \Delta p_e\,(Q) \quad / \quad P_{dynamic}\,(Q) = P_d\,(Q) = Q{\cdot}p_d\,(Q)$$

$$P_{useful} = P_e + P_d$$

$$\eta_m = P_{useful} \,/\, P_{absorbed}$$

The following Similitude Laws are used to predict the operation of a centrifugal fan at other conditions, such as different rotational velocities:

- Once the $\boldsymbol{\Delta p_e}$ ($\boldsymbol{Q}$) curve is known at a given value of $\boldsymbol{N}$:

$$\Delta p_e(Q) = A + B \cdot Q + C \cdot Q^2$$

- The $\boldsymbol{\Delta p_e}$ ($\boldsymbol{Q}$) curve of this centrifugal fan at any other $\boldsymbol{N}$ velocity can be obtained using the following similitude relations:

$$\frac{\Delta p_e'}{\Delta p_e} = \left(\frac{N'}{N}\right)^2 = \alpha^2$$

$$\frac{Q'}{Q} = \frac{N'}{N} = \alpha$$

- Thus:

$$\Delta p_e'(Q') = A \cdot \alpha^2 + B \cdot \alpha \cdot Q' + C \cdot Q'^2$$

One of the most interesting aspects when operating with fans is the determination of the velocity profiles. To do so, the cross section of the suction pipe can be analyzed, in which the solid surfaces are those that define the flow boundary. That is, the fluid in contact with the solid surfaces must satisfy the non-slip condition and will therefore have a velocity equal to zero. The distribution of the flow inside the pipe is generally three-directional and three-dimensional. In this case, the pipe is straight and has a constant and regular cross section, so a unidirectional flow can be expected with the main velocity component parallel to the axis.

5. DESCRIPTION OF EQUIPMENT AND FACILITY

1. Manometric inlet
2. Suction pipe
3. Vertical manometer
4. Prandtl tube (gauge 1)
5. Sloped manometer
6. Prandtl tube (gauge 2)
7. Differential water column manometer
8. Regulating valve
9. Discharge pipe
10. Manometric checks
11. Control panel
12. Centrifugal fan

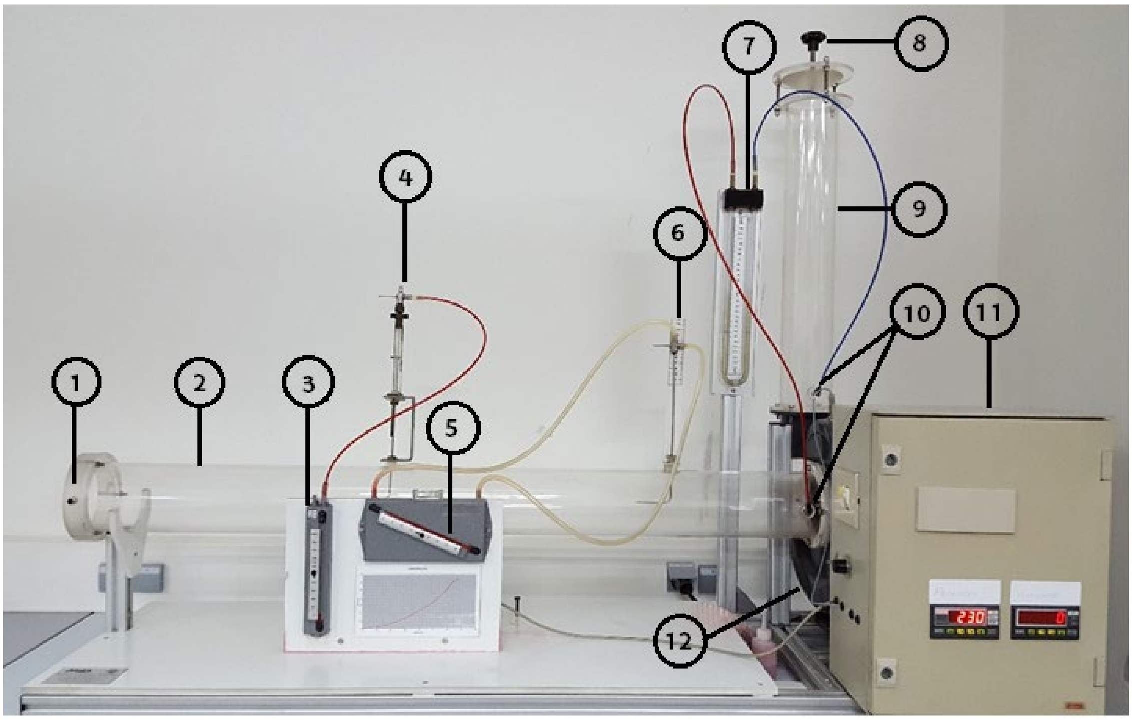

Figure 37: *Components of the centrifugal fan.*

The main characteristics of additional components of the facility are detailed below:

Inside diameters:

- Suction line: **Ø**$_{int}$ = 112 [mm]; **Ø**$_{ext}$ = 120 [mm]
- Discharge pipe: **Ø**$_{int}$ = 94 [mm]; **Ø**$_{ext}$ = 100 [mm]

Pressure gauges:

- 300 [mm] differential water pressure gauge
- 1000 vertical pressure gauge [Pa]
- Inclined manometer of 40 [mm W.C.]

Other elements:

- Frequency controller

Fan features:

- Pressure increase of 150 [mm W.C.]
- Maximum flow: 700 [m^3/h]
- Power consumed: 370 [W]
- Rotation speed: 2810 [r.p.m.] at 50 [Hz]