FLUID FACILITIES AND MACHINERY

GUIDE TO LABORATORY PRACTICALS

University of the Basque Country (UPV/EHU)

Energy Engineering Department

THEME 4: FRANCIS TURBINE

1. REQUIRED BACKGROUND KNOWLEDGE

Fluid Mechanics.
Hydraulic Machinery. Turbomachinery. Turbines.

2. PRE-LABORATORY

Detailed reading of the description of the practical for its completion within 1 [h]. See Video of P4.

3. OBJECTIVES

To calculate and to demonstrate the operation of a Francis reaction turbine:

- Visual analysis of the operation of the Francis reaction turbine.
- Experimental determination of the efficiency curves of the Francis reaction turbine.
- Reading to gain an understanding of the parameters to take into account when selecting, designing, and optimizing the operation of a Francis reaction turbine.

4. THEORETICAL FOUNDATION

The Francis turbine is a reaction turbine. The basic components that define this turbine are: the wicket gates (system composed of a crown of vanes that guide the water onto the rotating blades of the runner, regulating the flow rate) and the runner coupled to the shaft of the turbine that rotates when the water drives the rotating blades. The wicket gates are of a larger diameter than the runner, so that the movement of the water is centripetal in relation to the shaft. The rotational movement mainly results from the reaction within the channels between the walls of the blades due to their curved pathway and variable section, and to the action of the water colliding with the walls of the blades.

The characteristics or the points of operation of a Francis turbine are usually shown by means of these curves (Figure 16):

1. Mechanical torque as a function of rotation speed: $C_m = C_m (N)$
2. Mechanical power as a function of rotation speed: $P_m = P_m (N)$
3. Efficiency as a function of rotation speed: $\eta = \eta (N)$

These curves will change according to the opening/closing level of the wicket gates.

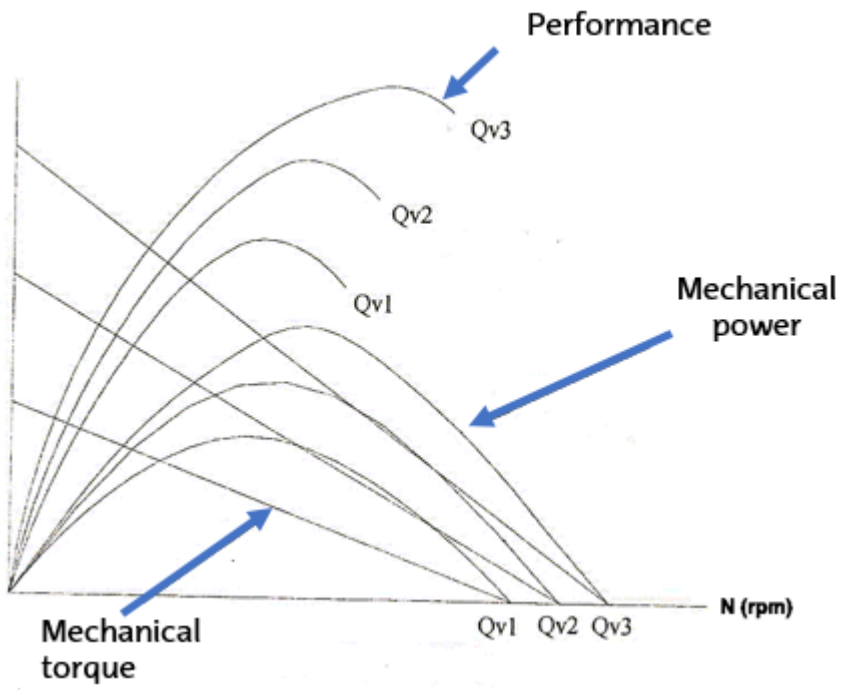

Figure 16: *Graph of the characteristic curves of a Francis turbine at a constant net head (H_n) and at 3 different angles of the wicket gates.*

As shown in Figure 16, the mechanical power and the efficiency values reach maximums and then decrease. Turbines usually work and transform energy at constant rotation speeds. They must therefore be carefully designed, in order to obtain maximum efficiencies at those rotation speeds.

The characteristic parameters that define the operation of a turbine are as follows:

- Flow rate (Q)
- Net head (H_n)
- Hydraulic power (P_h)
- Mechanical torque (C_m)
- Mechanical power (P_m)
- Efficiency (η)

5. DESCRIPTION OF EQUIPMENT AND FACILITY

The Fluid Mechanics laboratory is equipped with a Francis turbine mounted on a multifunctional Armfield hydraulic bench (Figure 17).

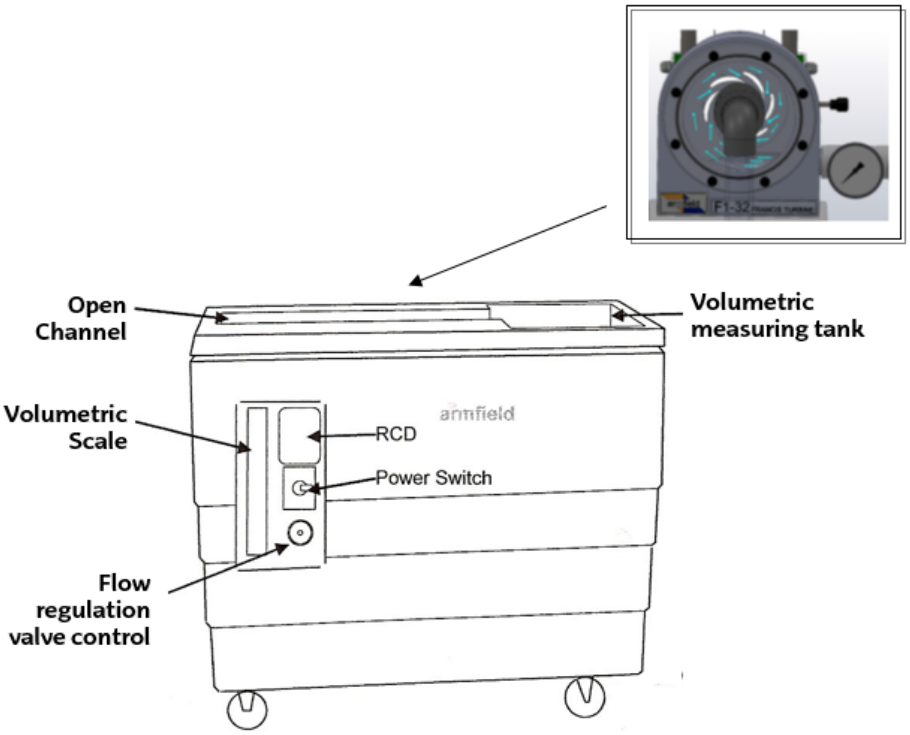

Figure 17: *Armfield hydraulic bench.*

The hydraulic bench has water in its lower part that is pumped up to the Francis turbine. The pressure is regulated by a flow regulation valve in the bench and there is a volumetric scale for flow measurement. Once the water leaves the draft tube, it returns to the water tank of the hydraulic bench in a closed circuit. Figure 18 shows the main components of the turbine.

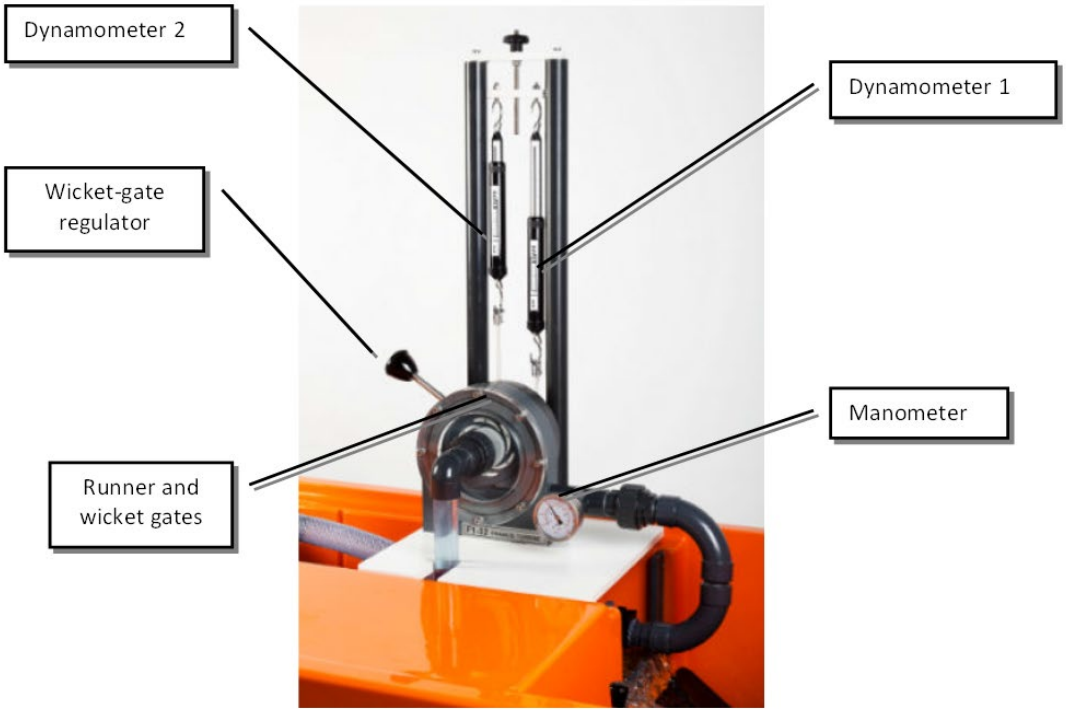

Figure 18: *Components of the Francis turbine assembly.*