

**Mini Review**

Copyright © All rights are reserved by Natalia Alegría

# Study of Hydroelectric Power Plants as a Fluid Mechanics Application Facility

**Natalia Alegría<sup>1\*</sup>, Igor Peñalva<sup>1</sup>, Charles Pinto<sup>2</sup> and María Urrestizala<sup>1</sup>**<sup>1</sup>Energy Engineering Department, Bilbao School of Engineering, University of the Basque Country, Spain<sup>2</sup>Department of Mechanical Engineering, Bilbao School of Engineering, University of the Basque Country, Spain**Corresponding author:** Natalia Alegría, Energy Engineering Department, Bilbao School of Engineering, University of the Basque Country, Spain.**Received Date:** October 28, 2024**Published Date:** November 04, 2024**Introduction**

In most Engineering Degrees, such as the Industrial Technology Engineering Degree or the Degree in Mechanical Engineering, in the 2<sup>nd</sup> or 3<sup>rd</sup> year, the subject of Fluid Mechanics is studied. It is a necessary subject in which flotation, capillarity, statics and dynamics of fluids, etc. are explained, which have multiple applications. The starting hypothesis of this study is that students, when they take it, do not visualize these applications, studying the subjects as isolated compartments.

At the School of Engineering of Bilbao (EIB/BIE) [1], a faculty of the University of the Basque Country (UPV/EHU), one of the subjects taught is the subject 'Fluid Mechanical Power Plants' (4.5 ECTS) [2], in the Industrial Technology Engineering Degree, in the pre-intensification of Energies (during the 4th course).

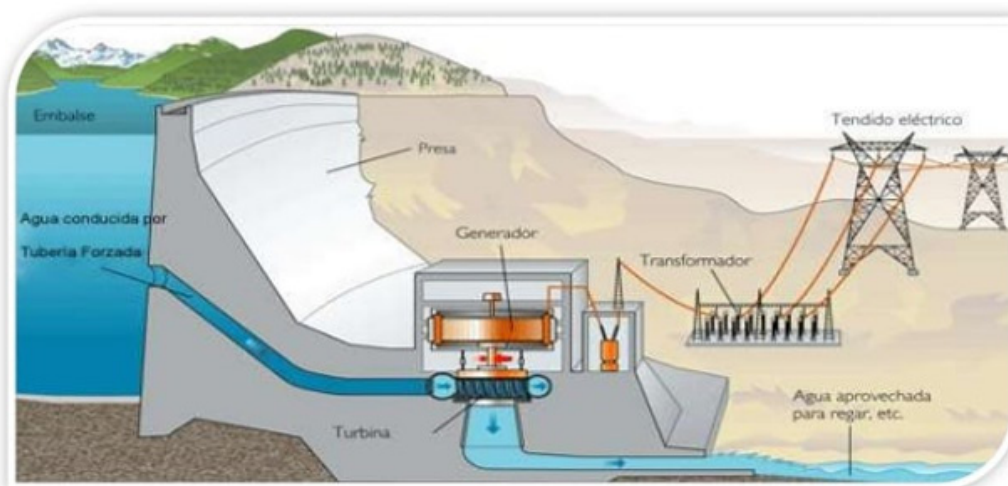
By taking this subject, students are expected to learn about the different elements that make up a Fluid Mechanical Power

Plant. The approach of the subject aims to identify the part of Fluid Mechanics that is characteristic of each of these elements, providing practical content to the previous study of Fluid Mechanics.

**Fluid-Mechanical Power Plants**

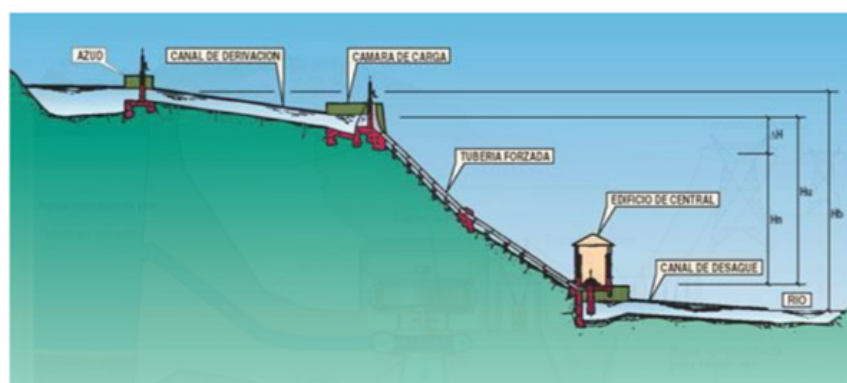
A Fluid-Mechanical Power Plant is a power plant that generates energy from a fluid, in most cases for subsequent conversion to electrical energy through a generator. Although Wind Farms [nº] could also be considered Fluid-Mechanical Power Plants, this term is usually used to refer to Hydroelectric Power Plants.

Hydroelectric Power Plants have many classifications [3], depending on whether the water is dammed or flowing, whether they are pumped, etc. The ones considered as typical Hydroelectric Power Plants are those with dammed water, called "Accumulation power plants". Figure 1 shows an example.



**Figure 1:** Accumulation hydroelectric power plant [4].

## Elements



**Figure 2:** Diagram of an Accumulation hydroelectric power plant [3].

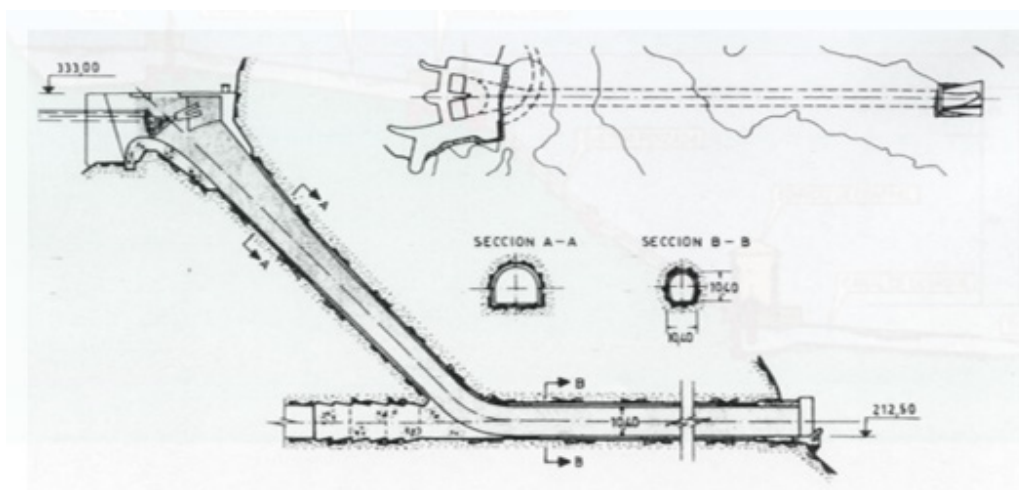
The constituent elements of hydroelectric power plants, shown in Figure 2, are as follows: reservoir, dam, canal, load chamber, forced pipe, turbine and suction-diffuser pipe

The methodology applied consists of identifying the constituent elements of a Fluid Dynamic Plant or Hydroelectric Power Plant, in which the fundamentals studied in Fluid Mechanics will be applied:

The reservoir is a container or open tank that takes advantage of the slopes of the mountains and the sides of it and accumulates water; it can be considered to be at rest, and therefore, the fundamental static equations are used.

In case there are measurement platforms in the reservoir, their study is carried out by applying the theories of floating and submerged bodies.

The reservoir is enclosed by a dam. There, surface forces (horizontal water force, gravity force, under pressure force and sliding force) are studied, in order to prevent the dam from overturning. In addition, the dam usually has spillways, and in many cases these spillways are closed by gates. Spillways can be solved mathematically by applying the equations of orifice discharges, stilling basin and hydraulic overtopping, as shown in Figure 3. The types of dampers are also studied in the topic of statics.



**Figure 3:** Tunnel type spillway [3].

The channel installed below is an open conduit in which the Manning formulas must be applied for the height of the water in the channel, satisfying the conservation of mass and energy. In addition, the flow is often laminar.

The loading chamber is the place where the flow changes from laminar to turbulent and it is usually accompanied by the equilibrium stack, which is the element responsible for damping the water hammer.

The penstock, which is the pipe in which the water must reach

the maximum energy to be extracted and in which the flow is in complete turbulence, can be calculated by applying the Darcy-Weisbach equations for the head losses and surface forces in the valves installed in them, complying with the conservation of mass and energy.

In the turbine, which will be sized according to the head and flow rate of the hydroelectric power plant (Figure 4), in addition to the conservation of mass and energy, the conservation of the quantity of motion is also fulfilled.



**Figure 4:** Example of a runner of a Francis type hydraulic turbine [5].

Before installing the turbine, scale models of the prototypes are often tested (considering homogeneity and similarity).

Finally, the suction-diffuser tube (where cavitation can occur) is based on the conservation of mass and energy and is the residual speed recovery element of the turbine.

After having related the elements of the power plants with the fundamentals of fluid mechanics, the students will be able to check if the different elements of the power plants are well defined and, in case there is a possibility of improvement, to propose it technically. For this reason, in this subject they are required to carry out a study of a power plant, which is planned according to the different elements that are explained in the subject.

The results obtained in the evaluation of this subject are satisfactory, with a 95% pass rate out of those enrolled and a 100% pass rate out of those presented.

After passing the course, students will have acquired the knowledge to study a hydroelectric power plant and propose technical and economic improvements, which is a very attractive subject for Final Degree Projects and will have given a real practical meaning from an engineering point of view to the concepts of Fluid Mechanics studied previously: fluid statics and dynamics, types of flow, forces on surfaces, head losses, water hammer, etc...

## Conclusion

The conclusion of this work is that after taking this subject, students apply Fluid Mechanics correctly to these facilities so they can carry out their Final Degree Projects on this topic.

## Acknowledgement

The authors would like to thank the Water Hall "CABB" (The Bilbao Bizkaia Water Consortium (CABB, in Spanish), a Business Hall located at the Bilbao School of Engineering, where data to make this revision related to energetic generation along the water supply system of Greater Bilbao were available.

## Conflict of Interest

No conflict of interest.

## References

1. Bilbao School of Engineering - UPV/EHU.
2. Credits and subjects - Degrees - UPV/EHU.
3. Lecture notes on the subject of Hydropower Plants.
4. What is hydraulic energy?
5. TURBINE FRANCIS - Hydro Power Plant.