FLUID FACILITIES AND MACHINERY

GUIDE TO LABORATORY PRACTICALS

University of the Basque Country (UPV/EHU)

Energy Engineering Department

PRACTICAL P7: AXIAL FAN

1. EXPERIMENTAL PROCEDURE: PRACTICAL DEVELOPMENT.

The procedure outlined below must be followed, in order to complete the practical. Initially the pressure tap at the inlet must be calibrated and then the characteristic curves of the fan may be plotted.

PRESSURE CONNECTION CALIBRATION: OBTAINING THE *K* CONSTANT

1. Turn on the fan using the switch located on the back of the equipment.
2. Verify that the elements for pressure measurement are correctly positioned: in the centre of the suction pipe, parallel to the streamlines, and facing the flow. The iris valve must be completely open.
3. Measure the (static) pressure at the inlet using the ± 100 [Pa] transducer. To do so, connect the static pressure check point located at the same height as the Pitot inlet to the "-" terminal of the transducer and leave the "+" terminal of the transducer unconnected.
4. Then measure the dynamic pressure within the duct with the other transducer. To do so, connect the Pitot tube (total pressure) to the "+" terminal of the transducer and connect the static pressure check point located at the same height as the Pitot inlet to the "-" terminal:

$$P_{total} = P_{dynamic} + P_{static}$$

5. Start the fan by establishing a certain rotational speed. In the practical, the rotational speed will start at N = 8000 [r.p.m.].
6. The first point corresponds to the theoretical point that satisfies the non-slip condition, defined by the position of the Pitot on the tube surface itself, 0 [mm], and a dynamic pressure, p_d, of 0 [Pa].
7. Next, place the Pitot at the top of the pipe, so that the Pitot and the pipe are in contact. The p_d reading at this point corresponds to the position of the center of the Pitot at a distance of 4 [mm] from the inner surface of the pipe.

8. The next p_d reading must be carried out at the first visible vertical mark of the Pitot, which corresponds to a distance of 7 [mm] from the inner surface of the pipe to the center of the Pitot.
9. The position of the Pitot for the next 5 measurements should correspond to the next vertical marks of the Pitot, being 10 mm the distance between each of them. Therefore, move the Pitot tube vertically, taking the different readings of dynamic pressure at each position of the Pitot tube and note down the corresponding values.

Table 7: *Experimental data. Pressure connection calibration.*

N [r.p.m.]	**Reading**	**Pitot position** [mm]	p_e [Pa]	p_d [Pa]
	1			
	2			
	...			

10. Calculate the flow from the previously measured speed readings, knowing the internal diameter of the suction pipe:

$$Q = V \cdot S \qquad \textit{the internal diameter is } ø114\ [mm]$$

11. Establish a new flow by modifying the rotation speed and repeating the process described above at the following rotation speeds: N = 6000 [r.p.m.] and 4000 [r.p.m.].
12. Obtain the calibration of the pressure check of the fan inlet as a function of the flow, by calculating the constant value of K. A value of K may be calculated for each of the established rotation speeds, according to the following mathematical expression. The value of K to be used will correspond to the average value:

$$K = \frac{Q}{\sqrt{p_e}}$$

To do so, use the average values of the static pressure measurements, as well as the average value of the speed (flow-rate calculation), not considering the non-slip point for calculation purposes.

OBTAINING THE CHARACTERISTIC CURVES OF THE FAN

1. Verify that the pressure measurement elements are correctly positioned; in the centre of the suction pipe, parallel to the streamlines and facing the flow. The iris valve must be completely open.
2. Use the ± 100 [Pa] transducer, the same instrument as previously used, for the static pressure reading. The flow may be established with the static pressure reading, by using the function that relates flow to static pressure, as calculated in the previous section.
3. Measure the increase in the static pressure both upstream and downstream of the fan to obtain the fan curves. To do so, connect the static pressure check points located before and after the fan to the 1000 [Pa] transducer.
4. Turn the potentiometer until the digital indicator shows the desired rotation speed. This part will start working at 8000 [r.p.m.].
5. Modify the valve opening between positions 1, 3, 5 and 7, and note down the pressure values that correspond to each position.
6. Repeat the steps described above at different rotation speeds. The corresponding measurements must be carried out for $N = 6000$ [r.p.m.] and $N = 4000$ [r.p.m.].
7. Having collected the data, complete the following table.

***Table 8**. Experimental data for the calculation of the characteristic curves at different rotation speeds.*

***N* [r.p.m.]**	**Iris position**	**p_e inlet [Pa]**	**Δp_e [Pa]**
	1		
	3		
	5		
	7		

2. RESULTS

The student will complete a results table in an Excel file. This table will show the experimental data collected in the laboratory, which will justify the experimental results. Following the analysis of the experimental results, the following graphs will be prepared:

- **Graph 1**: Velocity profiles: Representation on the same graph of the curves that relate the position of the Pitot tube with the velocity (m/s) at each different rotation speed. Numerical calculation of the constant *K* in [$m^3 \cdot h^{-1} \cdot Pa^{-1/2}$]. Indicate, according to the velocity profiles obtained, the type of regime -laminar or turbulent- that develops along the suction pipe of the fan.
- **Graph 2**: Representation of the flow as a function of the root of the average static pressure at the inlet. Calculation of the constant *K* as a function of the adjustment obtained (slope of the line). Comparison with the value of the constant *K* obtained in the previous section.

- **Graph 3**: Representation on the same graph of the difference in static pressure (Δp_e in [Pa]) between the suction pipe and the impulse pipe as a function of flow [m^3/s], for each of the rotational velocities under study.
- **Graph 4**: Similitude: taking the Δp_e-Q curve as a reference, obtained when operating at a rotational speed of 8000 [r.p.m.], and applying Similitude Laws, calculate the Δp_e-Q curve both at 6000 [r.p.m.] and at 4000 [r.p.m.]. Compare the similitude of the curves at those two different [r.p.m.] with those obtained experimentally (Graph 3).

All curves must be fitted to the corresponding polynomial degree, the regression must be clearly shown, and the corresponding equation must also be displayed. All graphs must have a title and each axis (x,y) must be labelled with the corresponding units. These graphs must be presented in the report and the traceability of the information in each graph back to a primary source must be ensured.

3. CONCLUSIONS

In the Excel file that will be handed in within 48 h [not inclusive of weekends], the students must explain the form of the trends of the results and any possible differences between the experimental and the theoretical results.

4. EXPERIMENTAL DATA

PRESSURE CONNECTION CALIBRATION: OBTAINING THE *K* CONSTANT

N (r.p.m.)	Reading	Pitot Position (mm)	p_e (Pa)	p_d (Pa)
8000	1	0	43	116
	2	10	63	119
	3	20	71	118
	4	30	72	117
	5	40	72	118
	6	50	73	120
	7	57	72	118

N (r.p.m.)	Reading	Pitot Position (mm)	p_e (Pa)	p_d (Pa)
6000	1	0	19	54
	2	10	29	53
	3	20	30	54
	4	30	31	54
	5	40	31	53
	6	50	32	53
	7	57	32	53

N (r.p.m.)	Reading	Pitot Position (mm)	p_e (Pa)	p_d (Pa)
4000	1	0	10	27
	2	10	14	27
	3	20	15	27
	4	30	15	27
	5	40	16	27
	6	50	16	27
	7	57	16	27

OBTAINING THE CHARACTERISTIC CURVES OF THE FAN

N (r.p.m.)	Iris position	p_e inlet [Pa]	Δp_e [Pa]
8000	1	88	277
	3	40	290
	5	8	497
	7	1	694

N (r.p.m.)	Iris position	p_e inlet [Pa]	Δp_e [Pa]
6000	1	47	163
	3	20	160
	5	5	283
	7	1	390

N (r.p.m.)	Iris position	p_e inlet [Pa]	Δp_e [Pa]
4000	1	24	83
	3	8	90
	5	3	144
	7	1	203