FLUID FACILITIES AND MACHINERY

GUIDE TO LABORATORY PRACTICALS

University of the Basque Country (UPV/EHU)

Energy Engineering Department

PRACTICAL P8: RADIAL FAN

1. EXPERIMENTAL PROCEDURE: PRACTICAL DEVELOPMENT

The following procedure must be followed, in order to develop the practical, in which the pressure tap at the inlet must initially be calibrated, before the characteristic curves of the fan are plotted.

PRESSURE CONNECTION CALIBRATION: OBTAINING THE *K* CONSTANT

1. Verify that the pressure measurement elements are correctly positioned; in the centre of the suction pipe (56 [mm]), parallel to the streamlines, and facing the direction of the flow. The flow regulation valve must be completely open and the pressure level must indicate liquid at the "zero" position.

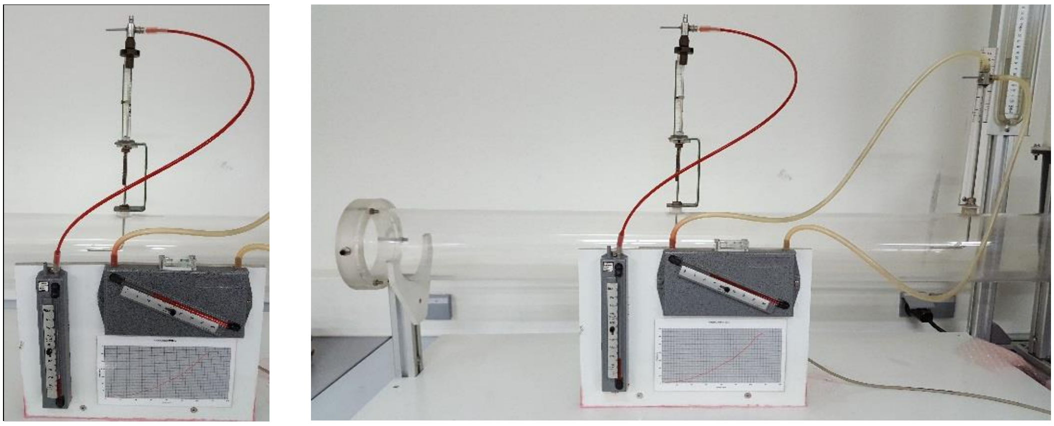
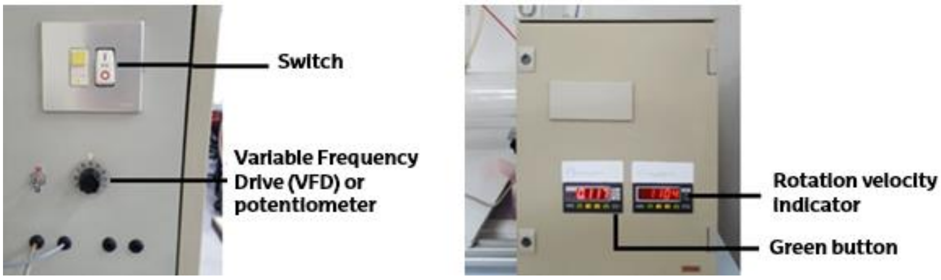


Figure 1: *Measurement of the static pressure using the first Prandtl tube (gauge 1) and the dynamic pressure using the second Prandtl tube (gauge 2)*

2. Switch on the fan with the main switch on the control panel. Adjust the power display (by pressing the corresponding green button), so that the values in units of [kW] will be displayed. To do so, the green button located to the right of the power indicator has to be pressed. Next, position the frequency controller at number 8.



(A) (B)

Figure 2: *A: Switch to turn on fan and frequency controller or potentiometer.*
B: Power display and rotation speed.

3. Neither the connections of the Prandtl tube (gauge 1) used to read static pressures nor the connections of the Prandtl tube (gauge 2) used to read dynamic pressures must be modified. Note both the static pressure measured by gauge 1 and the dynamic pressure measured by gauge 2. The position of the gauge may vary as indicated below.

4. Introduce gauge 2 up to the bottom of the tube, considering this position as the starting point or "0". Write down the static (gauge 1) and dynamic (gauge 2) pressures for that point.

5. Progressively raising gauge 2 (6 positions from the starting point to the centre of the suction pipe, 56 [mm]), observe the different readings of static pressure (gauge 1) and dynamic pressure (gauge 2), noting the values at each position of gauge 2. Attention should be continuously paid to the position of the gauges; correct readings may only be obtained when they are held in parallel position, facing the streamlines of the flow.

Table 1: *Experimental data. Inlet flow-rate calculation.*

N **[r.p.m.]**	**Nº read**	**p_e gauge 1 [Pa]**	**Position gauge 2 [mm]**	**p_d gauge 2 [mm W.C.]**
	1			
	2			
	...			

6. The flow rate is obtained from the previously obtained averages of the velocity readings, having established the internal diameter of the suction pipe:

$$Q = v \cdot S \text{ internal diameter ø 112 [mm]}$$

7. Establish a new flow rate by modifying the rotation speed. To do so, repeat the above process, setting the potentiometer at position 6.

8. The calibration of the pressure check of the fan inlet as a function of the flow is obtained by calculating the *K* constant. A value of *K* will be calculated for each of the established rotation speeds, according to the following mathematical expression. The value of *K* will correspond to the average value:

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

   To do so, the average values of the static pressure measurements will be taken (gauge 1), as well as the average value of the speed (flow-rate calculation). The mean value of the two *K* values will be used.

CHARACTERISTIC CURVES OF THE FAN

1. Verify that the pressure measurement elements are correctly positioned, parallel to the streamlines and facing the flow. The flow regulation valve must be completely open and the level of the pressure must indicate liquid at the "zero" position.

2. Set the potentiometer at position 8.

3. Use gauge 1 to determine the flow rate, following the calibration procedure in the previous section.

4. Use the differential water column manometer to obtain the fan curves. The increase in static pressure upstream and downstream of the fan must be measured.

5. Adjust the opening of the regulation valve to at least 8 positions, from fully open to completely closed.

6. Write down the values of static pressure [Pa], dynamic pressure [mm W.C.], dimensions of the differential manometer [mm W.C.], power [kW] and rotation speed [r.p.m.], for each valve opening.

   The average value of *K*, calculated with the data from the previous section, will be used to establish the flow through the fan, given the previously described relationship between *K*, p_e, and *Q*.

   Table 2. *Experimental data for the calculation of the characteristic curves at various rotation speeds.*

N [r.p.m.]	**Valve position**	p_e **gauge 1** [Pa]	p_d **gauge 2** [mm W.C.]	Δp_e [mm W.C.]	$P_{absorbed}$ [kW]
	1				
	2				
	...				

7. The steps described above must be repeated at different rotation speeds. To do so, new measurements will be taken when operating the fan, setting the potentiometer at position 6.

2. RESULTS

The student will fill in a table of results 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 gauge 2 [mm] with the velocity [m/s] for each of the different rotation speeds. 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, as they develop in each case 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.
- **Graphs 3 and 4**: Representation on the same graph of the difference in static pressure (Δp_e in [Pa]) between the suction pipe and the impulse pipe, the static power [W] and the efficiency of the facility [%], as a function of flow rate [m^3/s]. Make an individual representation for each of the rotational velocities under study.
- **Graph 5**: Static pressure difference, dynamic pressure at the suction pipe and total pressure ($p_e + p_d$) in [Pa]) as a function of centre flow rate (m^3/s) for position 8 of the potentiometer.
- **Graph 6:** Similitude: taking the Δp_e-Q curve as reference, when the potentiometer is set at position 8 to control the rotation speed, and applying Similitude Laws, calculate the Δp_e-Q curve corresponding to a potentiometer set at position 6. Represent the experimentally obtained data points above the curve that is plotted on the graph (Graph 4).

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, the students must explain 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

Nº 8	Position	Position gauge 2 [mm]	p_e gauge 1 [Pa]	p_d gauge 2 [mm W.C.]
2200 [r.p.m.]	0	0	165	10,0
	1	10	165	12,0
	2	20	165	13,0
	3	30	165	13,5
	4	45	165	14,0
	5	56	165	14,0
	6	72	165	14,0
	7	82	165	13,5
	8	92	165	13,0
	9	102	165	12
	10	112	165	10

Nº 6	Position	Position gauge 2 [mm]	p_e gauge 1 [Pa]	p_d gauge 2 [mm W.C.]
1450 [r.p.m.]	0	0	70	4,0
	1	10	70	5,0
	2	20	70	5,5
	3	30	70	6,0
	4	45	70	6,25
	5	56	70	6,5
	6	72	70	6,25
	7	82	70	6,0
	8	92	70	5,5
	9	102	70	5,0
	10	112	70	4,0

CHARACTERISTIC CURVES OF THE FAN

Nº potentiometer	N	Position	p_e gauge 1	p_d gauge 2	Δp_e		$P_{absorbed}$
	[r.p.m.]	Valve	[Pa]	[mm W.C.]	[mm W.C.]	[mm W.C.]	[kW]
8	2200	Open	165	12	52	88	0,399
		1	145	10	50	92	0,395
		2	115	8,5	45	96	0,375
		3	70	5,5	38	103	0,330
		4	10	1,5	33	119	0,241
		Closed	0	1	34	107	0,190

Nº potentiometer	N	Position	p_e gauge 1	p_d gauge 2	Δp_e		$P_{absorbed}$
	[r.p.m.]	Valve	[Pa]	[mm W.C.]	[mm W.C.]	[mm W.C.]	[kW]
7	1800	Open	105	8	60	82	0,245
		1	85	6,5	57	84	0,238
		2	70	5,5	54	87	0,230
		3	30	3	49	92	0,190
		4	5	1	48	94	0,150
		Closed	0	1	49	93	0,135

Nº potentiometer	N	Position	p_e gauge 1	p_d gauge 2	Δp_e		$P_{absorbed}$
	[r.p.m.]	Valve	[Pa]	[mm W.C.]	[mm W.C.]	[mm W.C.]	[kW]
6	1450	Open	70	5,5	63	78	0,170
		1	60	5	62	80	0,165
		2	50	4	61	82	0,160
		3	25	2	56	86	0,140
		4	5	1	55	87	0,110
		Closed	0	1	56	86	0,100