4. Recognition of adiabatic process of outflow from nozzle in range β(-1)

4.1 Experiment description

Experiment is carried out on test stand as shown in fig. 1. Ambient air with pressure “po” and temperature “To” goes through a flow-meter (1) to the nozzle (2). Flow is made by vacuum pump (5) which gives negative pressure “p_2” out of nozzle. This pressure is controlled by valve (4) at the tank (3).
Drops of pressure are measured by differential manometers (U-pipes type). So, Δh_1 means drop of pressure inside nozzle and Δh_2 – pressure difference between in and out points of nozzle.

1

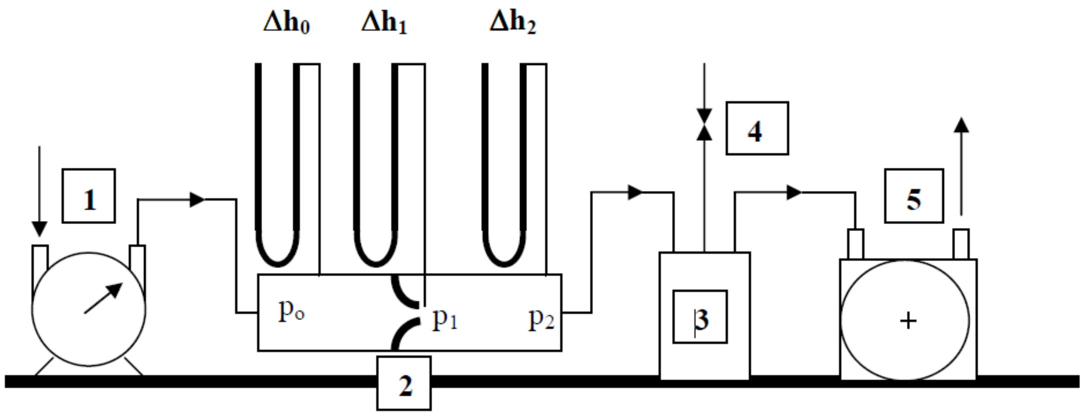


Fig 1 Layout of test stand to recognize adiabatic nozzle outflow

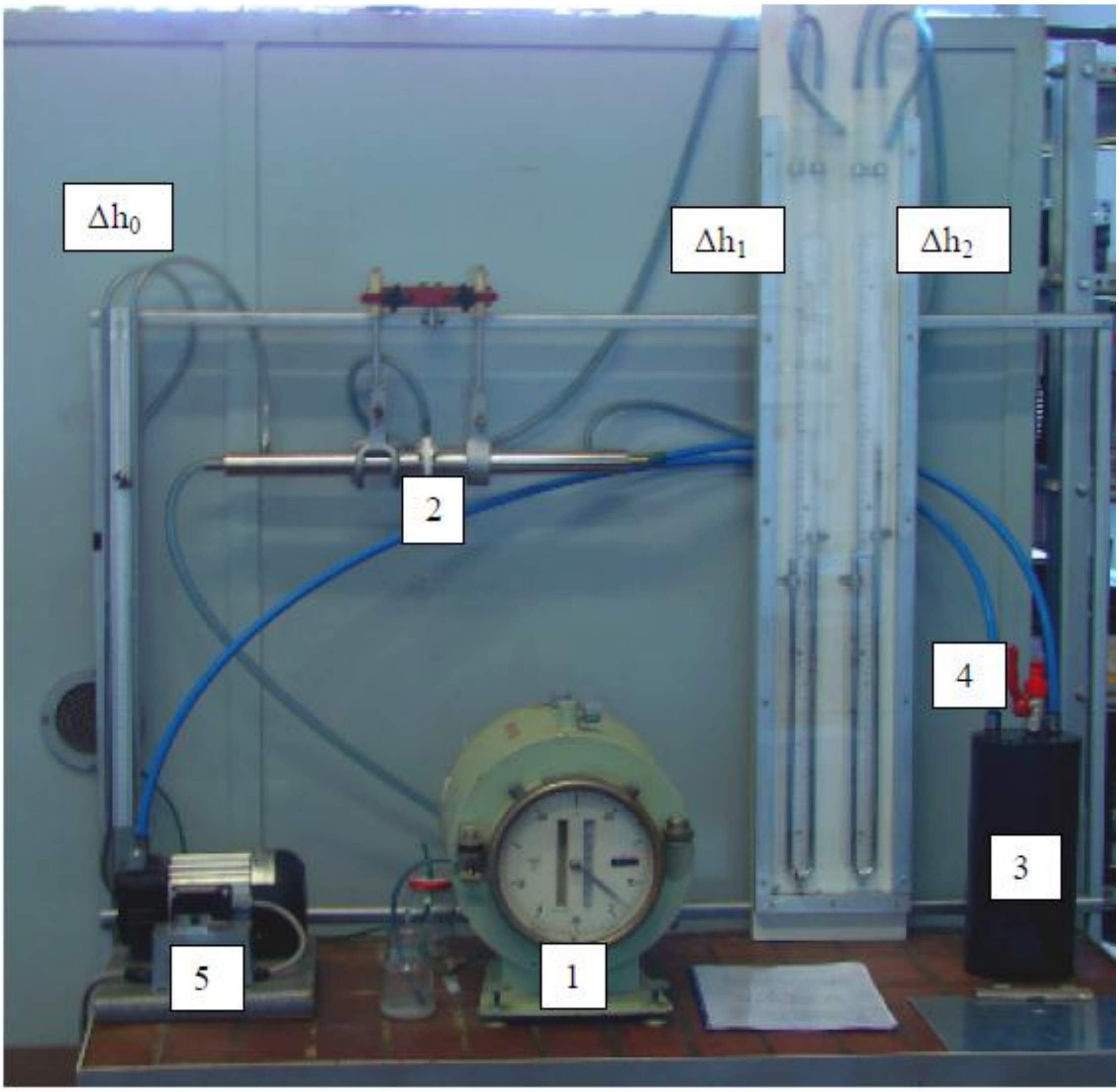
4.2 Experiment description

Necessary steps to carry out a test:

1. turn the vacuum pump (5) on,
2. open minimally the valve (4) so the Δh_2 reaches 40 mmHg,
3. be sure that pressure is stabilized and record drops of pressure Δh_1 and Δh_2k
4. then, measure air flow using flow-meter (1) and stop watch (flow per 1 minute),
5. repeat measurement approximately 10 times, increasing drop of pressure Δh_2 for around 40 mmHg,

To pass a remark when $\beta = {}^{p_2}/_{p_0}$will reach $\beta_{cr} \approx 0{,}5$

β_{cr} is called critical (threshold) value of flow. Around that point outflow should be steady as well as pressure “p_1“ independent on decreasing “p_2“.



When the critical parameter (i.e. $\beta_{cr} \approx 0{,}5$) are obtained at the narrowest point in the nozzle, the mass flow $(\dot{m})$ exiting the nozzle should exhibit a constant value. the pressure p_1 is also constant, regardless to farther decrease of the pressure behind the nozzle p_2

4.3 Elaboration of test data

4.3.1 The measured pressure drop ($\Delta h_{0,1,2}$) shall be converted using following equations:

$$\Delta p_0 = \Delta h_0 \cdot 9{,}81 \cdot 13{,}6 \ {}^{N}/_{m^2}$$

$$\Delta p_1 = \Delta h_1 \cdot 9{,}81 \cdot 13{,}6 \ {}^{N}/_{m^2}$$

$$\Delta p_2 = \Delta h_2 \cdot 9{,}81 \cdot 13{,}6 \ {}^{N}/_{m^2}$$

*Note that the pressure drop $\Delta h_{0,1,2}$ are expressed in **mmHg** unit.*

4.3.2. Calculate the air pressures p_1 and p_2 i.e. at the narrowest point of the nozzle and behind the nozzle respectively . Following equations shall be used for this purpose:

$$p_0 = p_0 - \Delta p_0$$

$$p_1 = p_1 - \Delta p_1$$

$$p_2 = p_2 - \Delta p_2$$

4.3.2 Compute factor β for each measurement:

$$\beta = \frac{p_2}{p_0}$$

and critical value of β_{cr}

$$\beta_{cr} = \left(\frac{2}{k+1}\right)^{\frac{k}{k+1}}$$

Where: k is the exponent of adiabatic. For air the; k=1,4

4.3.3 Using Clapeyron formula calculate mass air flow $\dot{m}$, ${}^{kg}/_{s}$:

$$\dot{m} = \frac{p_0 \dot{V}}{RT_0}$$

Wherer:

$p_o, T_o\ [N/m2;\ K]$ – pressure and temperature of ambient air,

$\dot{V}\ [\ m^3/s]$ – volumetric air flow,

$R\ [J\ /\ kg\ K]$ – individual gas constant for ambient air.

4.3.4 Draw diagram $\dot{m} = f(\beta)$ and show on it β_{cr}

An example of test table

Lab_4 Recognition of adiabatic process of outflow from nozzle in range β(-1)

Group …………………..date: …………………. hour:…………………….

p_0 = ... t_0 = ... T_0 = ………………………										
lp	Δh_0 mm Hg	Δh_1 mm Hg	Δh_2 mm Hg	$\dot{V}$ dm^3/min	$\dot{V}$ m^3/s	p_0 Pa	p_1 Pa	p_2 Pa	B -	$\dot{m}$ kg/s
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										