4. Examination of adiabatic outflow from the nozzle in the range β(0-1)

1 Aim of the experiment.

The aim of the experiment is to determine the maximum flow through the nozzle.

2 Introduction

The schematic representation of the test station is shown in fig. 1. Ambient air, with pressure p_0 and temperature T_0 flows through the gasometer (1) to the nozzle (2). The air flow is forced using a vacuum pump (5) that produces a sufficiently low (regulated) pressure p_2 behind the nozzle. This pressure is regulated by the valve (4) on the bladder tank (3). Pressure drops are measured using differential pressure manometers (U-tubes); where Δh_0 is the pressure drop before the nozzle, Δh_1 is the pressure drop at the nozzle, and Δh_2 - the pressure drop behind the nozzle. To measure the air flow rate, a gas meter and stopwatch are used.

1

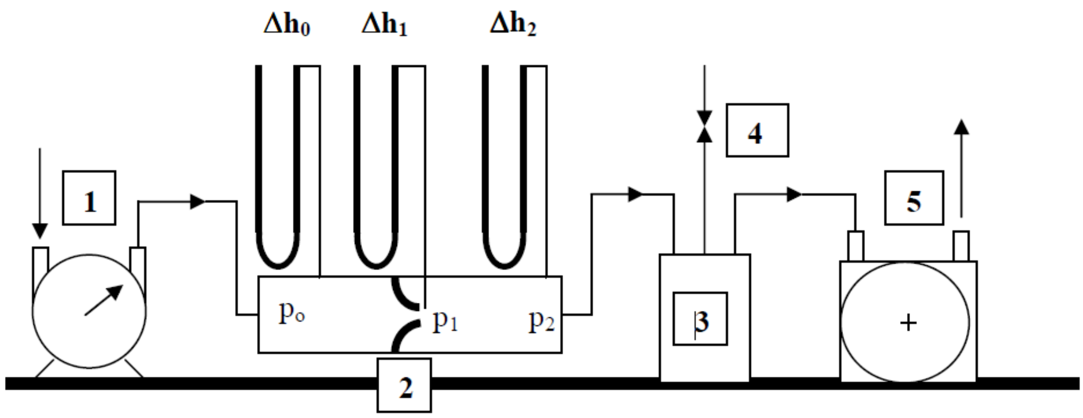

Fig. 1. Schematic representation of the test station

3 Experiment description

The following steps should be performed (see fig. 2)

a. turn on the vacuum pump (5),
b. open the valve (4) so the Δh_2 reaches 40 mmHg,
c. be sure that pressure is stabilized and record drops of pressure Δh_0, Δh_1 and Δh_2
d. measure the volumetric air flow using gasometer (1) and stopwatch. Other words measure how many litres of air went through the nozzle within 1 minute
e. repeat measurement **10 times (!)**, increasing the drop of pressure Δh_2 until the valve (4) is fully closed.

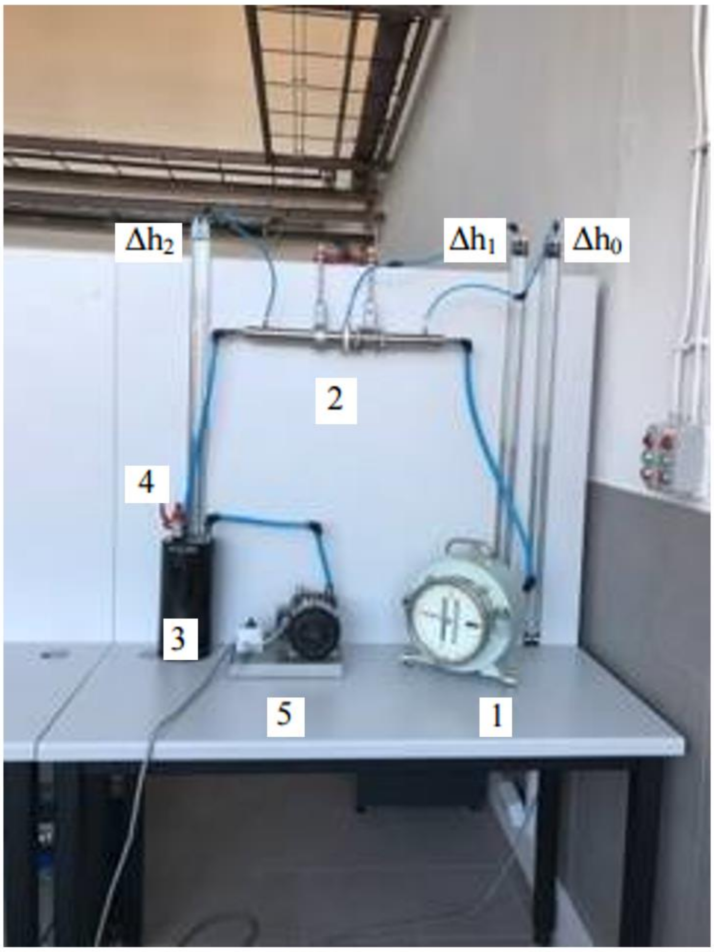

Fig. 2. The picture of the test station

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

4 Elaboration of the results

1. ***The pressure drops ($\Delta h_{0,1,2}$) are to be converted into the unit of Pa using follothe wing equations:***

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

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

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

2. ***Calculate the absolute 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:***

$$p_0 = p_0 - \Delta p_0$$

$$p_1 = p_0 - \Delta p_1$$

$$p_2 = p_0 - \Delta p_2$$

3. ***Compute factor $\boldsymbol{\beta}$ for each measurement:***

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

and the critical value of β_{cr}

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

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

4. ***Using perfect gas equation calculate mass air flow $\dot{m}$, $\boldsymbol{{}^{kg}/_{s}}$:***

$$\dot{m} = \frac{p_0 \dot{V}}{R T_0}$$

Where:

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

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

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

5. ***Draw diagram $\dot{\boldsymbol{m}} = \boldsymbol{f}(\boldsymbol{\beta})$ and show on it $\boldsymbol{\beta_{cr}}$***

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

p_0 = ... t_0 = ... T_0 = ………………………										
no	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	β -	$\dot{m}$ kg/s
1										
2										
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