Excercise 4
Pitot tube measurements of the wake behind a circular cylinder

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Chapter 1

Calibration

Pitot's tube calibration has been done using as reference an alcohol manometer. Imposing a set of values of velocity to the wind tunnel, the measure has been recorded with the manometer, and for each the value (in Volt) has been acquired through the acquisition card.

CALIBRATION CURVE			
PITOT		MANOMETER	
[V]	[V] with offset	[mm]	[Pa]
-7,78	0	0	0
-6,29	1,49	25	39,24
-5,46	2,32	39	61,2144
-3,72	4,06	68	106,7328
-1,75	6,03	100	156,96
0,18	7,96	133	208,7568
2,57	10,35	173	271,5408
3,89	11,67	196	307,6416
1,82	9,6	162	254,2752
-0,27	7,51	127	199,3392
-2,15	5,63	95	149,112
-3,88	3,9	67	105,1632
-5,38	2,4	41	64,3536
-6,23	1,55	27	42,3792
-6,93	0,85	15	23,544
-7,73	0,05	7	10,9872

In order not to miss part of the range of measure after amplification has been applied a negative offset of 8V. The correct measure of the offset is $V_0 = -7.78$V. The first part of the set is done with growing values, the second with decreasing values. This was done to consider the influence of the hysteresis.

This set of value has been reported on a graph (1.1) and with Volt on the x-axis and Pa on the y-axis. By interpolation is calculated a constant of calibration $K = 26.372[\frac{Pa}{V}]$

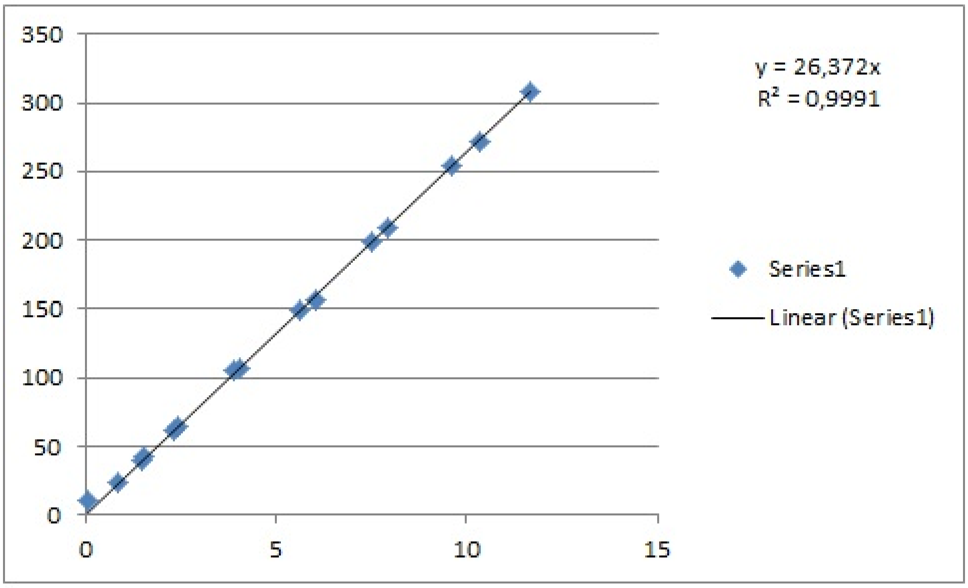

Figure 1.1:

Chapter 2

Measure

After calibrating Pitot's tube the cilinder is inserted in the chamber. The chamber has a section of $46x46$ cm. The instrument is placed at a distance from the upper wall wich is reported in the first column of the following tabular. In the second column is indicated the value in Volt of the tension (considering the offset V_0). In the third the correspond value of velocity.

Distance [cm]	[V] with offset	Velocity [m/s]
6	5,95	16,094
8	6,01	16,175
10	6	16,161
12	6,02	16,188
14	5,94	16,080
16	5,68	15,724
18	5,23	15,089
20	4,47	13,949
22	3,73	12,743
24	3,29	11,967
26	3,26	11,913
28	3,74	12,760
30	4,53	14,043
32	5,27	15,146
34	5,73	15,794
34,9	5,85	15,958
37,5	6	16,161

In the figure2.1 is represented the profile of velocity measured due to the wake of the cylinder

I hereby introduce a semplification. The reference velocity, the one consid-

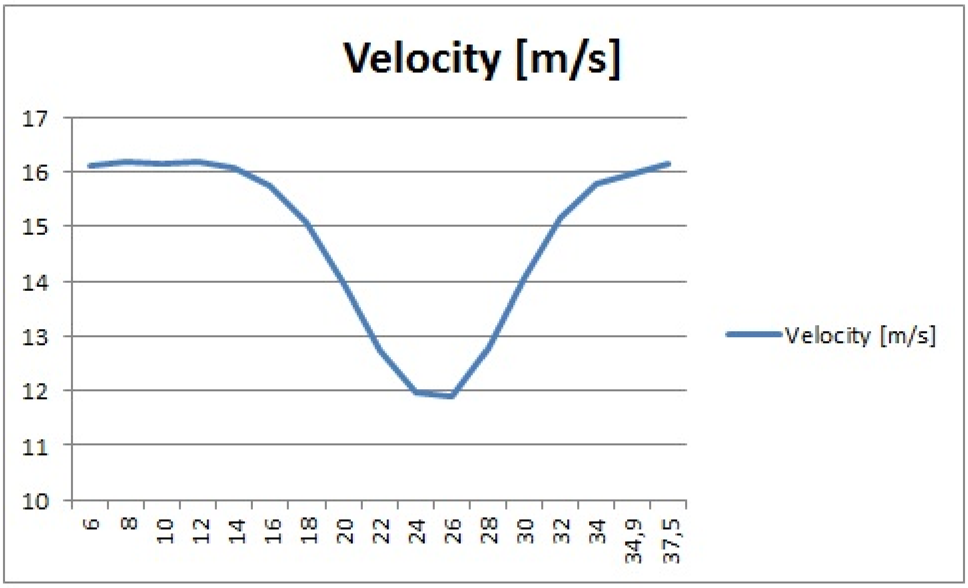

Figure 2.1:

ered undisturbed, is considered $V(6cm) = 16.16\frac{m}{s}$ Fo the integration process I consider the formula

$$\frac{D}{h} = b\rho U_1^2 - \rho \int_{-\frac{b}{2}}^{\frac{b}{2}} U_2^2(y)\, dy \tag{2.1}$$

where b is the extension of the measurement field (vertical distance) and U_1 is the velocity of the indisturbed flow. Applying the Trapezoidal rule for the grephic integration I can state that

$$\int_{-\frac{b}{2}}^{\frac{b}{2}} U_2^2(y)\, dy \sim \frac{b-a}{n}\left(\frac{f(a)+f(b)}{2} + \sum_{k=1}^{n} -1 f\left(a + k\frac{b-a}{n}\right)\right) \tag{2.2}$$

where a and b are the extreme of each interval.

After the calculation I found a value of $\frac{D}{h}$ of 23.255 $\frac{kg}{s}$. Inserting this in the formula of the Drag coefficient

$$C_d = \frac{D}{\frac{1}{2}\rho_{air} v^2 A} \tag{2.3}$$

I obtain

$$C_d = 0.47 \tag{2.4}$$

In order to compare the obtained value the Reynolds number of the experiment has to be considered. In the experimental apparatus there was not a termometer, so the dynamic viscosity of air is considered at 20°C which is $\mu = 1.81 \cdot 10^{-}5\frac{Pa}{s}$. Hence the Reynolds calculated is $Re = 336232$. It follows Figure2.2 taken from the section "Drag of Blunt Bodies and Streamlined Bodies" of the website www.princeton.edu.

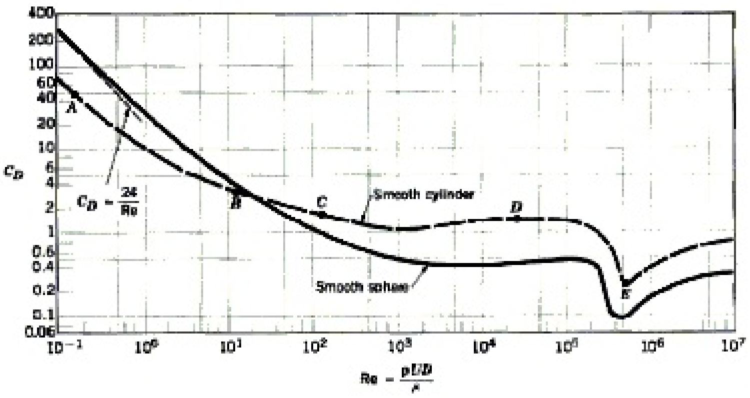

Figure 2.2:

From the figure we can see that the C_d calculated is close to the smooth cylinder one, but even closer to the one of a smooth sphere. The error is consequent to a series of causes. We can divide them in measure errors and calculation errors. Concerning the measure error I must say that I cannot completely trust the Pitot's tube. In fact it was held by a pole which for opportunity reasons was not embedded in the wind tunnel, so, especially at the speed the experiment was conducted, was interested by a visible vibration. Furthermore it didn't let Pitot's tube to placed close enough to the wall, so the undisturbed velocity was taken a little too far from it. A problem in the same device caused the last two intervals of measure to be slightly different from the others and this, together with the approximated integration formula which was used, lead to uncertainty in the calculation.