THE EXPERIMENTAL STUDY OF ENERGY LOSSES FLOW MEASURING MEANS

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Abstract— **This work aims to describe, for flow measurement devices most commonly used in laboratories and industrial facilities, an important factor often overlooked within the range of flow meters: The cost service. We will present firstly a classification of methods for measuring flow, a theoretical reminder explaining the operation without abusing the mathematical background. On the other hand, a study of the energy cost of some methods of flow measurement. The experiment was done on a bench comprising five flow measuring devices.**

Index Terms— **Flow, flow meter, pressure drop, power consumption and economical choice.**

I. INTRODUCTION

Measurement plays an increasingly fundamental in the development of industrial activities with the sophistication of automation, robotics, quality control, energy conservation, the fight against pollution, etc. The measure is a key factor in the economy; it must be treated with particular and sustained attention.

In particular, the flow measurement is of importance in the fluid transporting network (pipeline, oil, ...), and in any industrial facility to be controlled where the amount of the fluid involved in the process: the chemical reactions, production plants of energy, internal combustion engines, water supply, wastewater treatment, washing circuit in the food industry, water supply, ...

At first an unexpected user may have some difficulty choosing between units of flow measurement. The selection criteria are:

- Congestion and installation conditions,
- The cost of the equipment installed,
- Losses of residual charge
- The nature of the pumped fluid.

The choice of a meter is a compromise between price, performance of the device and its implantation site. The cost of the equipment installed is related to congestion and installation conditions. Indeed, over the unit and bigger, it is expensive, and the more a problem of installation. But we often forget that there are variable costs or consumption (costs after service) that only appears after use. These variable costs are the direct result of energy losses in the unit that are inevitable in most cases. According to their shape, flow meters in general and in particular pressure devices create more or less losses.

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II. MEASUREMENT OF FLOW

1. Flow measurement device Compact Orifice:

The Overfall orifices are primary measurement. Their operating principle is a direct consequence of the Bernoulli applied to real fluids. They are completely static devices. In primary device, it creates a narrowing of the duct which causes an increase in the average flow velocity, so an increase in kinetic energy. Under the principle of conservation of energy, potential energy must decrease. The primary device therefore causes a drop in pressure. The difference between the measured upstream pressure of the narrowed section and the measured level of this segment is proportional to the square of the flow Q. The relationship between the volume flow rate and differential pressure .DELTA.P is given by the formula:

$$Q = \alpha \frac{\Pi}{4} d^2 \sqrt{\frac{2\Delta P}{\rho_1}} \quad (1)$$

Where: α is the flow coefficient which depends on the shape of the orifice and the flow conditions, is the diameter of the tapered section, and is the density of water differential pressure.

Several types and various forms of Overfall orifices exist:- diaphragms (fig. 1) : single diaphragm plate "vena contracta" single diaphragm pressure tapping sheet flanged diaphragm pressure tap in the corners to annular chambers). They are just pre equivalent and their main advantages are the low cost and small footprint. The main disadvantages are the straight inlet very important that there should be up to 80 times the nominal and the losses diameter.

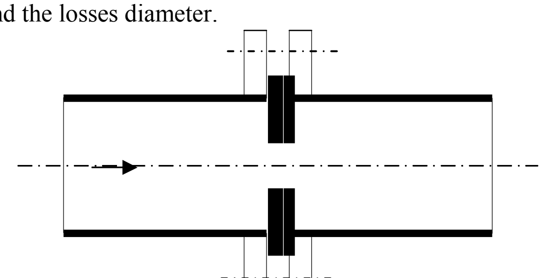

Fig. 1 : Diaphragm single sheet

- Nozzles: the nozzle is a shaped orifice whose characteristics are close to the diaphragm. It is normalized for diameters from 50 mm to 500 mm. It creates a little less pressure drop as diaphragms. It has significantly higher than the same ratio for the diaphragms opening flow coefficients. This is more expensive than the diaphragm device.

- The classic venturi nozzle (fig 2.): This is a profile tube. It can be constructed of welded sheet steel. In this case, it is normalized for comers diameters of 200 mm to 1000 mm. These advantages are the low right length required upstream and relatively low pressure loss created compared to that created by other pressure reducing sail. As against its size is very important and its installation cost is high.

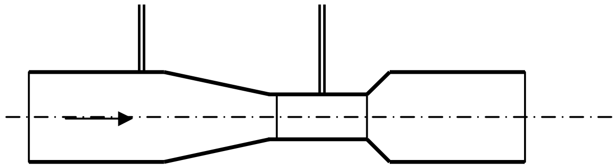

Fig. 2 : Classical Venturi outlet pressure water column

- The venturi nozzle (venturi short) is extended by a diverging nozzle. It is normalized for diameters from 75 mm to 500 mm. It can compromise made between the diaphragm and the conventional venture
- The half-moon aperture: these are variants of diaphragms "single sheet" used to measure the rate charged.
- The special venturi: they are devices developed by some manufacturers to compromise achieved low footprint, low pressure drop. The best known is the Dall tube. These devices are usually very expensive.

2. **Woltman meters or propellers**

Ce sont des compteurs à hélice. Celle-ci peut être horizontale ou verticale. La vitesse de rotation de l'hélice est proportionnelle au débit. Ces appareils sont surtout fait pour compter des volumes d'eau. Cependant, on peut les équiper d'horlogeries émettrices d'impulsions. La cadence des impulsions est proportionnelle au débit. Un convertisseur cadence/courant permet d'obtenir un signal de mesure en courant continu proportionnel au débit moyen sur la période d'intégration (de l'ordre de quelques minutes) et non au débit instantané. On ne peut donc pas utilisé ce genre d'appareillage pour la mesure dans une chaîne de régulation ou d'automatisme (systèmes bouclés).

3. **Vortex Flowmeters (fig. 3)**

A diffuser sharp edges placed perpendicularly to the flow vortex causes eddies which are driven or one side of the diffuser and then the other. These vortex send a push to the diffuser which transmits the thrust to a piezoelectric sensor. The frequency of detachment Vortex either side of the diffuser is directly proportional to the speed and thus the flow rate consistent with rules for the ranges limited of 1 to 15. These devices allow static sensors and a small footprint. However, their use is limited to clean fluids and low span.

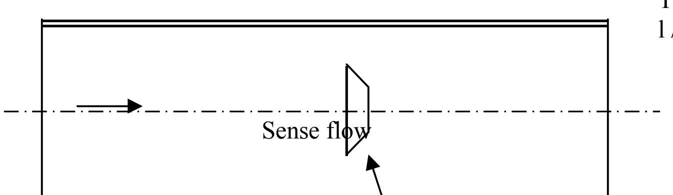

fig. 3 : Vortex flowmeter

4. **The point measurement systems,**
5. **Electromagnetic flowmeters,**
6. **Ultrasonic flowmeters,**

Ces derniers consomment moins de pertes de charge que les premiers.

III. STUDY OF THE PRESSURE LOSS COST

The pressure loss creates a flow meter is made on parameters that allows us to have the pressure drop and subsequently the discharge relationship / signal out. However, this pressure loss can be, in case a real waste of energy and can give rise to significant costs after the flowmeter. This pressure drop is given by the Bernoulli relationship for adiabatic flow of an incompressible fluid:

$$\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+Z_2+\Delta H_{12} \quad (2)$$

Where: : P_i : pressure at point i, V_i : i average speed, ρ : density, g is the gravity and the Z_i piezometric coast.

The term $P/\rho g$ represents the hydrostatic and $P/\rho g + V^2/2g + Z$ being the total load.

The pressure drop is a direct result of contact between the fluid and the inner wall. The fluid must experienced some resistance so it can opposed to internal friction. Relation (2) shows that the energy and speed of the pressure energy may be converted progressively as the fluid moves. This energy transformation is obviously not perfect. Hydraulic engineers often translated in water, the energy loss column meter for ease of interpretation. For water, the equivalent power is given by [1]:

$$PU_{12}(KW)=\frac{Q(m^3/h)\cdot\Delta H_{12}(mce)}{387} \quad (3)$$

387 coefficient is the result of changes made in SI units to the hydraulic units.

IV. EXPERIENCE AND RESULTS

The experiment is done on the tester pressure drop and flow calculation, available in the laboratory MDF - Hydraulics of FST Tangier. It includes: an electric pump to supply (30 liters / min at 15 mce), a rotameter (Φ30 mm), an ultrasonic flow meter, diaphragm (Φ50 mm), a conventional venturi mercury (Φ80 mm), a conventional venturi water (Φ25 mm), a float (Φ50 mm) and a weir (capacity 100 l). The set is accompanied by two other benches for power flow and higher pressures. The experience is made for a range of flow going from 0 to 30 l / min. identified of the measurements are shown in Table 1:

Trial	Q_u	Q_d	Q_r	Q_{v1}	Q_{v2}	Q_f
0	0,040	0,043	0,042	0,080	0,071	0,05
1	0,063	0,067	0,073	0,113	0,100	0,07
2	0,080	0,085	0,099	0,138	0,123	0,09

3	0,097	0,103	0,116	0,138	0,123	0,11
4	0,119	0,126	0,220	0,138	0,123	0,13
5	0,137	0,146	0,150	0,178	0,159	0,15
6	0,157	0,167	0,172	0,211	0,188	0,17
7	0,174	0,185	0,185	0,211	0,188	0,19
8	0,190	0,202	0,203	0,226	0,201	0,21
9	0,216	0,230	0,230	0,252	0,225	0,23
10	0,233	0,248	0,253	0,239	0,213	0,26
11	0,255	0,271	0,272	0,288	0,256	0,28
12	0,272	0,289	0,294	0,319	0,284	0,30
13	0,280	0,309	0,306	0,339	0,301	0,32
14	0,300	0,336	0,341	0,329	0,293	0,34
15	33,80	33,73	33,74	33,57	33,67	33,7
16	35,86	35,78	35,80	35,62	35,72	35,8
17	37,91	37,83	37,85	37,66	37,77	37,8
18	39,97	39,88	39,90	39,70	39,82	39,9
19	42,03	41,94	41,95	41,74	41,86	41,9
20	44,08	43,99	44,01	43,78	43,91	44,0

Tab 1 : Raised rates by 10-2 1 / s for 21 trials; Qr: rotameter, Qu: ultrasound, Qd diaphragm Qv1: mercury venturi, QV2: Venturi water and Qf: float.

The corresponding load losses are shown in Table 2:

Trial	ΔH_r	ΔH_u	ΔH_d	ΔH_{v1}	ΔH_{v2}	ΔH_f
1	195,0	0,0	2,0	0,5	1,0	97,0
2	191,0	0,0	6,0	1,1	2,0	101,0
3	187,0	0,0	11,0	1,6	3,0	104,0
4	179,0	0,0	15,0	1,6	3,0	104,0
5	165,0	0,0	54,0	1,6	3,0	105,0
6	141,0	0,0	25,0	2,6	5,0	105,0
7	123,0	0,0	33,0	3,7	7,0	105,0
8	104,0	0,0	38,0	3,7	7,0	106,0
9	81,0	0,0	46,0	4,2	8,0	107,0
10	62,0	0,0	59,0	5,3	10,0	110,0
11	45,0	0,0	71,0	4,7	9,0	110,0
12	30,0	0,0	82,0	6,8	13,0	111,0
13	21,0	0,0	96,0	8,4	16,0	112,0
14	17,0	0,0	104,0	9,5	18,0	113,0
15	15,0	0,0	129,0	8,9	17,0	115,0
16	14,0	0,0	143,0	11,1	21,0	115,0
17	13,8	0,0	165,0	11,6	22,0	115,0
18	13,7	0,0	193,0	12,6	24,0	115,0
19	13,5	0,0	213,0	14,2	27,0	115,0
20	13,4	0,0	240,0	15,3	29,0	115,0

Tab 2 : Each loss in mm water column measured at each flowmeter: ΔHr: rotameter ΔHu: ultrasound ΔHd: diaphragm ΔHv1: mercury venturi ΔHv2 venturi to water and ΔHf: float.

Values will allow us later to study the evolution of the power consumed at each meter using equation (3). In Figure 4 are shown the values of the power consumed at each flowmeter and for different values of speed.

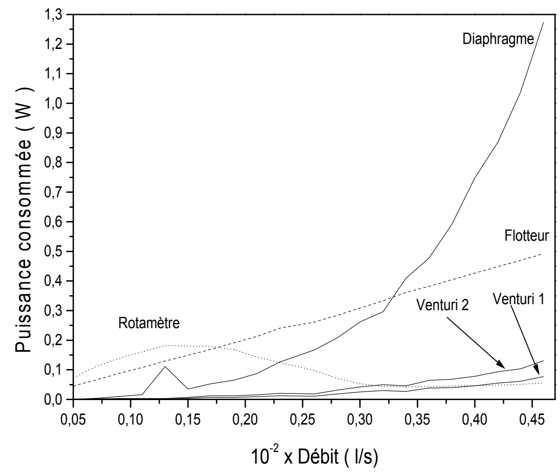

Figure 4: power consumption depending on the flow meter for different

INTERPRETATION AND CONCLUSION

The experience on the flow rate measuring apparatus shows that the power consumption can reach very high values. For a flow rate of 0.46 10-2 l / s, the power consumed in the diaphragm is 15 times greater than that consumed in the venturi mercury. What is very significant for a user and especially for large flows and high pressures. Considering this parameter choosing a flowmeter can be enormously oriented.

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