

Coanda Flowmeter with ADXL105 acceleration sensor

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Abstract- The geometric shape of the Coanda flowmeter produces a continuous, self-induced oscillation at a frequency that is linearly proportional to flow rate. As fluid passes through the meter, it will attach itself to one of the side walls as a result of the Coanda effect. A small portion of the flow is diverted through the feedback passage and travels around to the control port. This feedback flow disrupts the attachment of the main jet to the side wall. The main jet is now free and will attach itself to the other side wall due to the Coanda effect. The feedback action will repeat itself, and in the manner the meter body produces a sustained oscillation. As the main fluid stream oscillates between the two side walls, the flow in the feedback passages cycles between zero and maximum. The cycling of the flow in the feedback passages is detected by a sensor located in one of the feedback passages, while the sensor signal is conditioned by a signal conditioner.

1. Introduction

The oscillating flowmeters have as basic principle the periodic interruption of the flow regime, that phenomenon generates pressure waves whose frequency is proportional with the flow velocity. Two categories of oscillating flowmeters without moving parts can be identified: the vortex and the Coanda. Although the „Coanda effect” concept is not mentioned in the *Smartmeter flowmeter* documentation (Fig.1), from its functional description it results clearly that the fluid movement is controlled by the Coanda effect. Water enters the fluidic oscillator through a nozzle that forms an accelerated jet. When the jet enters the flow chamber, it will initially be drawn to one of the two diffuser walls. The jet will travel along the wall and then exit the flow chamber. At this point, a small portion of the flow will be caught in the feedback channel and be returned to the base of the incoming jet. This causes the jet to flip to the other side of the chamber, where it will travel along the other diffuser wall, and a small amount of water will be returned via the other feedback channel to repeat the process.



Fig.1

This oscillation between the diffuser walls continues while flow is present and its frequency is related to the rate of flow through the chamber. The oscillation is monitored by electrodes placed next to each diffuser wall. An electrical current is induced in the jet by a pair of powerful magnets within the flow chamber. The

electrodes sense the induced current, from which the rate of oscillation is calculated and thus, over time, a measure of total flow is derived.

From the above specifications, it results that the fluid has the same behavior for both situations (Microsensor respectively Smartmeter), the mechanical signal conversion kinds are different. The Smartmeter flowmeter would be called „electromagnetic oscillating flowmeters” being a hybrid circuit based on both types already well known (electromagnetic and oscillating). The Microsensor transducer has in its structure a vibration sensor. Which is placed on one feedback channel, taking over the pressure waves, which occurred in that region. The fluid nature, that can be measured by both kinds of instruments, issued from the difference described above. While the Smartmeter doesn't measure air, this being however a property, which improves the measurement accuracy for liquid flow, using a vibration transducer as in the Microsensor case, the gases flow can be determined as well. Being a jet impulse variation, which is converted into an electrical signal, we can say that this kind of instrument is sensitive to mass flow. Other fluid characteristics matter of course, such as viscosity.

For the experimental study we have used the Smartmeter geometrical structure, the pressure wave being converted into electrical signal using an acceleration sensor.

The fluidic oscillator described in this paper represents a bistable fluidic amplifier, which is made to oscillate, connecting the control ports to output ports. This is provided with a feedback, from each output port to each proper input port.

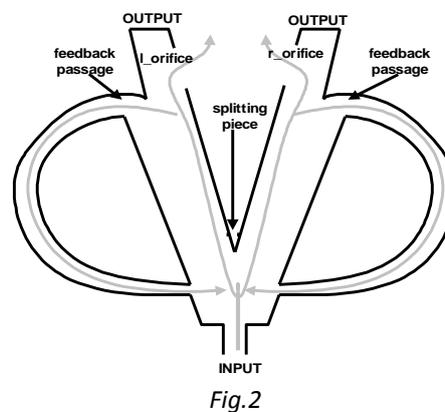


Fig.2

Thus, this type of device, usually known as “feedback fluidic oscillator”, can be used for the direct flow measurement of Newtonian fluids.

The period of oscillation, T , is given in the expression as(1):

$$T = T = 2(\tau_t + \tau_s) = 2[(l/c) + (\zeta * L)/u] \quad (1)$$

Where: τ_t is the transmission time, τ_s is the switching time, l is the length of one loop; c is the speed of wave propagation; L is the nozzle to splitter distance; u is the stream velocity, and ζ is an empirical constant.

The performances for such an instrument depend on the placement of the transducer. This can be a vibration sensor that generates an electrical signal, that is proportional with the intensity and frequency of oscillations.

I assumed two location solutions:

- a) the placement of the transducer in the output region, where it has influenced alternatively by the changing of the evacuation passages ($l_orifice$, respectively $r_orifice$)
- b) the placement of the transducer in input region, where it is influenced by the changing of high energy stream direction.

For case a, the transducer reaction force is small, this moves under alternative r_force , respectively l_force influence (Fig.2). The acceleration sensor is attached to a mobile support that is mounted on a lamellar spring, with a small elasticity coefficient, so the resonant frequency of the transducer – spring aggregate is small.

The fluidic jet is divided by a splitting piece in whose walls two orifices were made ($l_orifice$ and $r_orifice$). At the change of fluid directions, the fluid is evacuated through one orifice or the another, alternatively. It acts on the walls of the mobile support, on which the acceleration sensor is mounted. When the fluid passes through channel A, due to the Coanda effect it is attached to the wall of obstacle P_A , and at the exit, it branches away, most of it is evacuated, and through the feedback channel a, a pressure wave is formed, which is reoriented to the input.

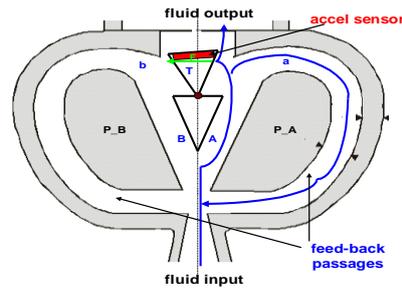


Fig.3

According to the function principle of the Coanda fluidic amplifier, this pressure wave of low energy, will determine the change the direction of the flow, of high energy jet to channel B. The circuit being simetrical, most of the fluid will be evacuated, and through feedback channel b, a pressure wave will be created, that reorienteted towards the input, will determine the change of direction of jet to shift to channel A.

The oscillating frequency of the jet between the two channels is proportional to the fluid velocity and implicitly to its flow. The change of fluid movement direction means velocity variations, i.e. acceleration.

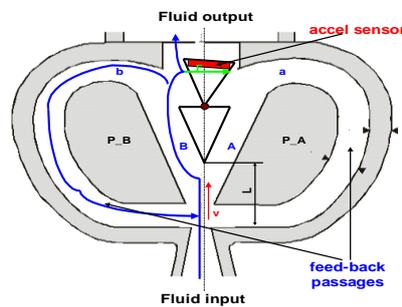


Fig. 4

The fluid energy variations, caused by sudden changes of the jet direction, lead to accelerations and brakes in the output part, where the acceleration transducer is placed, respectively when the jet is orientated through channel A it will be accelerated, and the fluid from channel B will be braked. Therefore, a force F will act on the transducer in the sense indicated in(Fig.3). When the jet is orientated through channel B, the fluid from channel A will lose part of its energy, therefore it will be braked, and the sense of force F will change(Fig.4).

Circuit ADXL105 was used as acceleration transducer. Thus, from the data above, the voltage generated by this device, is a signal variable in frequency (variation imposed by the oscillating frequency), and in amplitude (by the inertian force).

Experimental determination

For the experimental study we conceived a stand whose configuration is shown in figure 5. Making an analogy between hydraulic and electrical values, we could state that the voltage coresponds to pressure, and electrical current to flow.

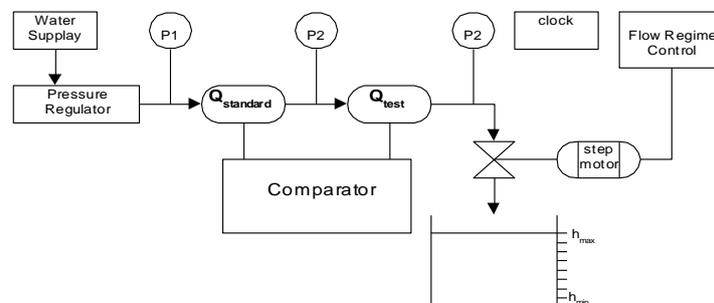


Fig.5

Hydraulic resistance is made up of two components : a constant determinated by fluid frections against hydraulic circuit walls and by its inflection regions, and by a variable whose value is controled by electric valve, a certain flow regim being establishable.

From the above, we conclude that, to impose a constant flow, it is necessary to introduce a pressure regulator at input circuit (for $P = \text{constant}$) and stabilisation of hydraulic resistance by adjusting the electric valve into a fix position (for $R_h = \text{constant}$). Theoretically, any element introduced into the circuit causes pressure losses. Thus, these pressure losses must be monitored (by manometres P1, P1 and P3) being part of flowmeter basic characteristics.

Electric valve positioning is done by stepping motor, by its control we can establish variace functional regime. Values resulting from the standard flowmeters, and the test flowmeter are monitored and compared through Comparator and Deviation Detector, thus tracking errors.

The hydraulic circuit is realised at an increased scale by a model made to Smartmeter Company, in this circuit is mounted an acceleration sensor as is shown in Fig. 3 and Fig.4.

In figure6, the block scheme of the system is presented, realized for experiments. The signal generated by the acceleration sensor, is converted into a digital and then, using UART protocol it is transmitted through port COM1 to the PC. For its graphical display, the MatLAB software was used.

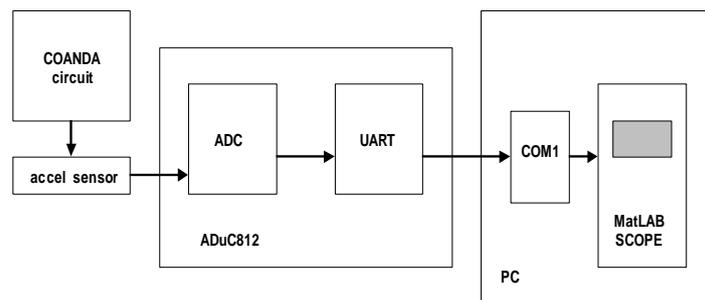
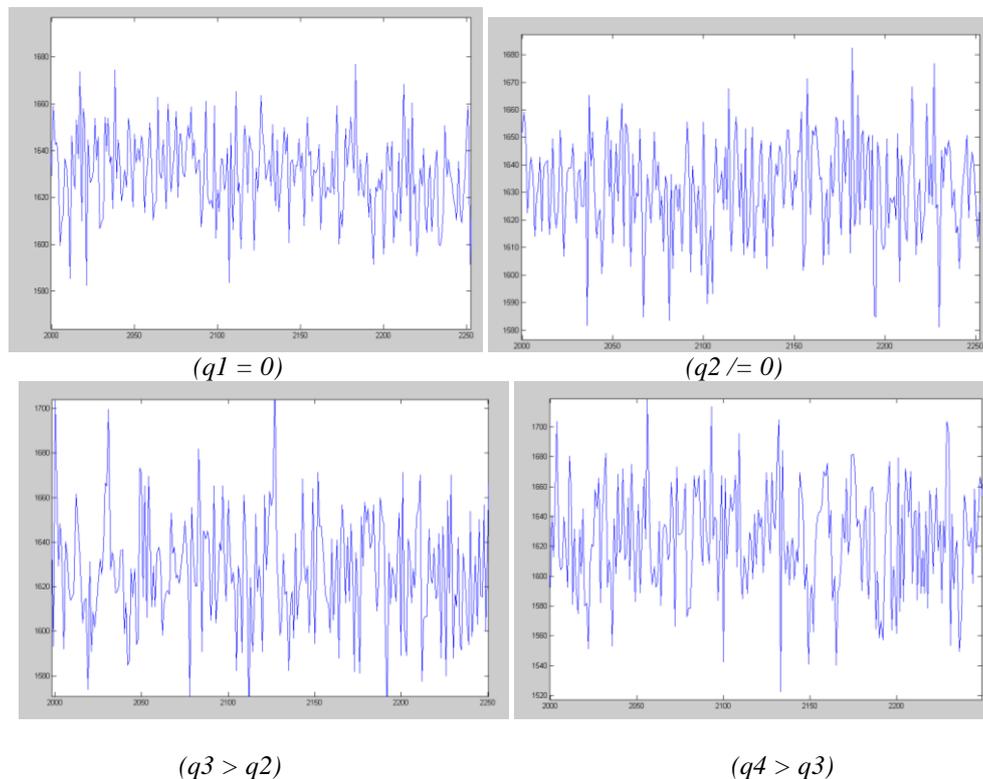
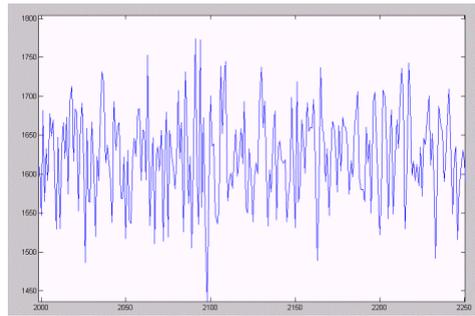


Fig. 6

Data acquisitions was performed for five different situations: the null flow, and four succesively increasing values of the flow. Their graphics are presented , on axis x the time being represented, and on axis y the voltage variations





$$(q5 > q4)$$

II. Conclusions

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According to the function principle of the Coanda fluidic amplifier, this pressure wave of low energy, will determine the change the direction of the flow, of high energy jet . The circuit being simetrical, most of the fluid will be evacuated, and through feedback channel (a,b), a pressure wave will be created, that reorientedet towards the input, will determine the change of direction of jet to shift to channel (A,B).

The oscillating frequency of the jet between the two channels is proportional to the fluid velocity and implicitly to its flow. For the experimental study we have used the Smartmeter geometrical structure, the pressure wave being converted into electrical signal using an acceleration sensor.

The hydraulic circuit is realised at an increased scale by a model made to Smartmeter Company, in this circuit is mounted an acceleration sensor. Circuit ADXL105 was used as acceleration transducer.

For the experimental study we conceived a stand , making an analogy between hydraulic and electrical values, we could state that the voltage coresponds to pressure, and electrical current to flow.

Data acquisitions was performed for five different situations.

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