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Study of Hydrocarbons Metering Issues in Algerian Fields under the New Law Context

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Abstract**—**Since the advent of the law 86/14 concerning the exploitation of the national territory by foreign companies in partnership with the Algerian oil and gas company, the problem of hydrocarbons metering in the sharing production come out.

More generally, good management counting hydrocarbons can provide data on the production wells, the field and the reservoir for medium and long term planning, particularly in the context of the management and field development.

In this work, we are interested in the transactional metering which is a very delicate and crucial period in the current context of the new hydrocarbon's law characterized by assets system between the various activities of Sonatrach and its foreign partners.

After a state of the art on hydrocarbons metering devices in Algeria and elsewhere, we will decline the advantages and disadvantages of each system, and then we describe the problem to try to reach an optimal solution.

Keywords**—**Flowmeter orifice, heat flow, Sonatrach, Transactional metering.

I. Introduction

UNDER the undisputed production sharing with its partners, the Algerian Oil and Gas Company (Sonatrach) faces a challenging complication which consists in the appropriate choice technology to ensure the best possible measurement accuracy regardless the nature of the product crude or gas. In addition to the partner judgment, the context of the new hydrocarbons law involves other actors like the ONML (National Office of Legal Metrology) approval for the technology question and its adaptation by the Customs department which ensures the calculation of public charges.

A deep literature search allowed us to realize that there are basically three types of meters (flowmeters) used in the industry which are velocity, vortex and turbines meters. More recently, there's the introduction of ultrasonic and electromagnetic flowmeters.

In Algeria, there are two types of flowmeters used in the oil and gas fields;

- The flowmeter DANIEL (orifice flowmeter)
- The flowmeter MECI (turbine flowmeter)

We are interested in this work to the gas transactional metering which is a very delicate exercise in this crucial period and the current context of the new hydrocarbons law, characterized by the system of assets between the various activities of Sonatrach and its foreigner's partners. In our present study, we will take as an example the field of GTFT (Gas Tin Fouye Tabankort), exploited by Sonatrach and the French company Total.

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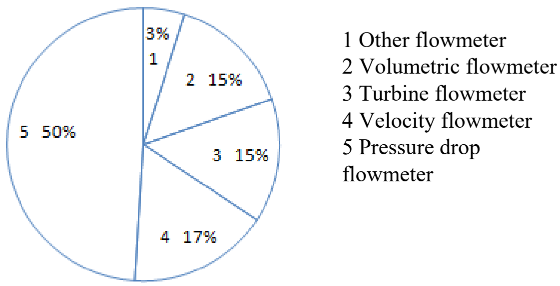

Fig. 1 Distribution of flowmeters in the industry [1]

II. Principle of Industrial Fluids Flow Rate Measurement

In the context of this paper, we will present the two most widely used flowmeters, drop pressure (orifice) and turbines flowmeters, others types are described in [1].

A. Definition

The flow rate is the amount of material or fluid, liquid or gaseous, which flows per unit of time in a defined channel section.

In practice there are two rates:

- Mass flow rate Q expressed in kg/s
- Volume flow rate V expressed in m^3/s

If ρ is the fluid density (kg/m^3), we have the following relation between the mass flow rate volume:

$$M = \rho V \tag{1}$$

Flow measuring devices are called flowmeters.

Fluid volume measuring devices (regardless the duration or the flow mass) are called counters.

B. Orifices Flowmeters

We will see in this subsection some of the most used ones;

1. Orifices Flowmeters

Their operating principle is based on a static disrupter system including a throttle or orifice causing a pressure drop which is a function of the value of the flow rate and thermodynamic properties of the fluid to be measured.

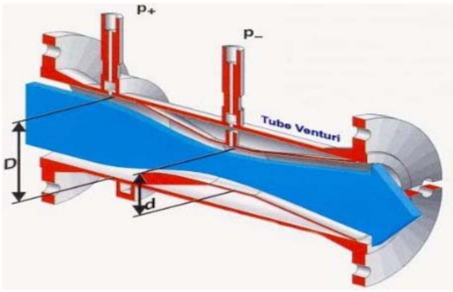

Fig. 2 Principle of orifice flowmeter

Unlike incompressible fluids, here the fluid is compressible, such as gas and water vapor in the portion of the throttle increasing speed is accompanied by a decrease in density with pressure. It is assumed that the fluid flowing through the constriction (point 1 to 2) undergoes an adiabatic transformation, i.e. without significant heat exchange with the external environment; this result is expressed with the relationship below:

$$\left(\frac{P}{\rho}\right)^{\gamma} = \text{cte} \quad (2)$$

γ the isentropic coefficient being defined as the ratio of the relative variations of pressure and density in a primary reversible adiabatic change (ISO 5167). For ideal gas γ is the ratio of the mass heat capacity pressure and at constant volume, $\gamma = Cp / Cv$.

The volume flow is adjusted by an expansion coefficient called ε:

$$V = C\frac{1}{\sqrt{1-v_1^2/v_2^2}} = \varepsilon A\sqrt{\frac{2(P_1-P_2)}{\rho}} \quad (3)$$

And the mass flow rate by the equation:

$$M = CE\varepsilon(\pi d^2/4)\sqrt{2\Delta P\rho_1} \quad (4)$$

with A: the orifice sectional area; C: the discharge coefficient of the flowmeter which is dependent on the pipe geometry; E: the approach speed coefficient,

$$E = \sqrt{1-(v_1^2/v_2^2)^4} = 1/\sqrt{1-\beta^4} \quad (5)$$

where β is the aperture ratio = diameter ratio d/D

The values of the discharge coefficient *C* of the various primary elements were obtained by testing on a test bench and are available in the ISO 5167 norm. Empirical formulas such as Stolz formula or Reader-Harris/Galagher formula allow the calculation of the coefficient C.

International standards ISO 5167 and ISO 5168 specifications define the construction and conditions of use of these flowmeters and calculation procedures.

The main types of orifices described by the standard are:

– The diaphragm or orifice plate concentrically
– The profiles holes (nozzles, Venturi tubes and Venturi nozzles)

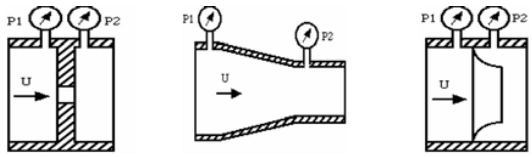

Fig. 3 Main orifice flowmeters

Measurement Uncertainty: The used standards to determine the uncertainties or errors of measurement for pressure devices are in the order of:

± 2% for the diaphragm and the standard nozzle

± 1.5% for the standard venturi

It is important to note here that these limits of error permitted by the standard values are obtained under the conditions flow (flow state) and geometry (clean).

Application: Orifices flowmeters are used for the measurement of gases and liquids. These flowmeters have been widely used in the field of oil and gas industry as well as for measuring water. It is estimated that over 50 % of the flowmeters installed in the world are of orifice type. The diaphragm is the most used;

Advantages: Inexpensive, easy to install and operate, measure the large amounts of fluids at high pressure

Disadvantages: Pressure loss or significant loss of mass energy: It can go up to 90% of the measured differential pressure on a diaphragm: dynamics of small extent; sensitive to flow disturbances.

2. Turbine Meter

Their operating principle is shown schematically (figure below) by a free rotation axis which carries a turbine (for liquids) or propeller (for gases), at the center of the line where you want to measure the flow. Under the action of the pressure forces exerted on the viscosity and the blades, the propeller of the turbine starts rotating at a speed ω of which depends on the flow rate.

The instantaneous flow rate Q is proportional to the instantaneous speed ω, as:

$$Q = k\omega \quad (6)$$

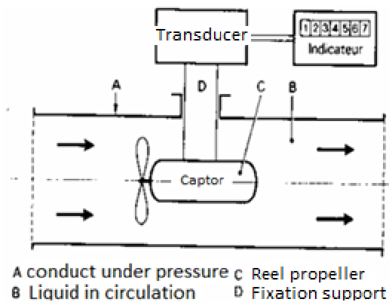

Fig. 4 Schematic diagram of a turbine flowmeter

Coefficient k is called coefficient of measurement, it is one of the most important characteristics for a turbine flowmeter. It must be kept constant for the entire range of the flowmeter use. This coefficient that determines the measurement accuracy of the flow rate Q is influenced by:

- The flow,
- The viscosity of the fluid,
- The temperature.

Applications: The turbines can cover measures in a flow rate range of:

- Speeds up to 0.3 m^3/h to 15000 m^3/h Liquid and 30000 m^3/h Gas;
- Absolute pressures of from 1 to 70 bar ;
- Fluid temperatures ranging from -20 to + 50 °C ;
- The covered diameters can range from 5 mm to 660 mm;

Standardization: The ISO2715 standard recommends that the absolute pressure (Pa), downstream of the turbine (at a distance of four times the diameter of the pipe) is:

$$Pa > 2\Delta P + 1.25Pv \quad (7)$$

where ΔP is the pressure drop; Pv is the saturation vapor pressure of the liquid at the maximum operating temperature.

The pressure drop caused by the turbine flowmeter is considered quite low. It usually reaches 0.2 to 0.5 bars at maximum flow rate.

III. Different Manufacturers

Among the major manufacturers of counters, there are

- EMERSON offers a wide range of flow measurement technologies, including:
- DANIEL: orifice plates, ultrasonic meters and turbine MICRO MOTION: Flowmeters coriolis and density
- ROSEMOUNT: differential pressure, pressure differential elements
- ROSEMOUNT: Electromagnetic flowmeters and vortex
- ROXAR: Multiphase Flow
- METI
- SAGE
- BROOKS

IV. Example: Counting System of Gas, Gas Field Group Tft (Gtft)

At the beginning of GTFT field exploitation, counting the dry gas was done using a counting system provided by the company DANIEL (company later bought by EMERSON). The update made on this unit during the periodic decennial stop 2009 led to the replacement of this system with another provided by the company MECI (chosen by the French company TOTAL partners). It is noted that the update of this system has not affected the orifice plates and the chromatogram initially provided by DANIEL company.

A. Description of the Counting Unit Daniel

The counting unit of gas supplied by DANIEL is consisted of:

- Two lines count 24 inches x 30 inches. In normal operation, a line is in operation and the other in reserve.
- An orifice plate DANIEL on each line. In normal conditions, only one plate is capable of all steps, while the other is in reserve. (The plates are installed on the sides 30 inches).
- A common pressure transmitter PT 40110 both lines installed on the portion 24 inches.
- A temperature transmitter TT 40111 A & B for each installed on the plate portions 24 inches.
- Two computers speeds DANIEL Model 2512R, FQY 40109 - A & B (master and slave) for the correction of the gas flow to normal conditions through the method P, T, Z
- A totalizer gas shipped with print a tax receipt.
- A model 500 chromatograph for analysis of the composition of the gas shipped and the calculation of PCS (Gross Calorific Value).
- A moisture analyzer PANAMETRICS

B. Description of the Counting Unit MECI

The system is composed of:

- Two line count of 24 inches x 30 inches. In normal mode, a line is in operation and the other in reserve. In degraded mode, the two rows may be used simultaneously.
- Two temperature transmitters, two low level pressure transmitters, two high level pressure transmitters and two pressure transmitters for each line counting. These transmitters are installed in insulated boxes to avoid temperature gradients, totaling four boxes are installed.
- A computer count for each set of transmitters, two -by-line computers. (Master and back up)
- Two supervisors (Master & back up) for the visualization of all the data storage and data editing counting every 24 hours.
- A chromatograph model 500 previously installed.
- A humidity sensor installed previously.

C. Comment

In total there are 4 computers. Redundancy on both lines eliminates the potential excesses of a transmitter (for contradictory measurement), and failure of a transmitter, to get the information through his transmitter back up. Each sub metering system (transmitter + calculator) is autonomous and the count is permanent. A selection is made from a supervisor state of the assembly to the reference computer

D. Discussion

At the beginning of our work, we had planned with our economic partner to visit some production fields, and to investigate the specificity of each deposit. But during our work, we have changed our minds and opted for a direct study of metering technologies used by a pilot region, GTFT (Gas Tin Fouyé Tabankourt). We will analyze and then choose the most suitable for this region.

This change of plan due to various reasons that will list below;

– The complexity of the work due to the composition and type of gas fluid at each field.
– The short duration of the project and in order to do a useful work for our business partner, we chose the method that will allow us to recommend the best solution.

What can be remembered is that the two metering systems are used at Sonatrach and its partners; one is American and the other French. One or the other of the two systems is used in the production sharing by the sealed contract type between the two partners.

Both technologies DANIEL and MECI are using techniques of orifice and regarding our preliminary results there are not appropriate, as noted previously, there's a significant loss of mass energy of up to 90% of the measured differential pressure, especially during the summer period.

Regarding the fluids aspects, they could be as follows;

– In addition to the properties of a real hydrocarbon fluid pressure, volume, temperature, viscosity, PCS, we must understand the effect of the components, presence such as sulfur, carbon dioxide and water.
- A compressible gas may be considered if the Mach number "Ma" of the gas flow in a pipeline is lower than 0.3. We consider the correction terms that must be introduced if the fluid velocities reach values of 200 m/s.
- The introduction of a counting system disrupts the flow of the fluid. We must minimize their impact by imposing conditions on the positions, shapes and dimensions of the elements that constitute (valves, converge, diverge ...).
- In terms of fluid-structure interaction, it is interesting to highlight the flow disturbance and propose solutions to change the profile of the flow components to mitigate its effects (Venturi divergent and convergent exponential profiles).

V. Proposed Solution

We studied the option of replacement the velocity by ultrasonic flowmeter as a new technology that is beginning to come out in the transactional metering industrial fluids [2]., but we do not recommend using this technology because of its two operating principles based on;

– The use of acoustic waves to measure the flow velocity.
– The Doppler Effect is used to measure the flow that requires a very high sensibility,

And since our fields are regularly subjected to sandstorms, it can alter the measures.

We also know that during the summer period, a fall production is observed without clearly identify the reasons and since the temperature gradient between winter and summer is great in the area, we strongly recommend the use of technologies based on the meter heat. Because, given the complex composition of the gas, it can change through the day as a result of seasonal and drastic temperature change. So we choose the heat meter, which is based on the King's law to take into account all the parameters that can affect the result [2]-[7].

A. Principle of Operation

The mass flow rate (m) of a gas is a function of the specific heat (C_p of the gas and the temperature difference AT) measured across the sensor.

$$AT = km \quad (8)$$

Knowing the value of C_p, a technical solution to deduce the mass flow is illustrated by the figure below.

The measurement tube includes two temperature sensors disposed one upstream (T_1) and the other downstream (T_2) of a heating element which causes the fluid to a temperature set by the supplier.

When the flow is zero, T_2=T_1 and when the flow increases, T_1 decreases with the flow linearly

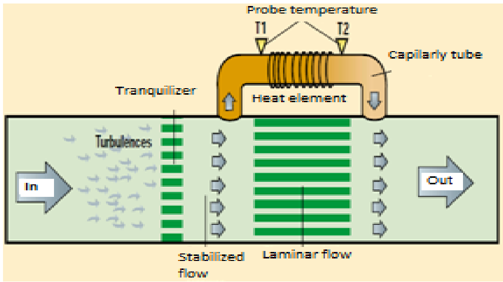

Fig. 5 Description of thermal flowmeter

VI. Conclusion

We propose the Thermal Mass flowmeter that has made a specialty of low gas flow rates where all other technologies have failed.

But recently, it has also been used in other applications such as liquid or gas flows stronger. We started making a flowmeter as academic character within our team and we would like to get one industrial type in order to compare it with other types of meters.

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