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An Overview of Thermal Mass Flowmeters Applicability in Oil and Gas Industry

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Abstract

Measuring and modeling flow has played a central role in predicting its behavior and its effects on the surroundings. Flow measurement is the basis of trade between producers, transporters, process plants, state and public marketers. To improve transactional operation, thermal flowmeters could provide direct mass flow measurement of gases and vapors over a wide range of process conditions without the need for density corrections based on pressure and temperature.
The flow meters are classified according to the domain in which they are used and their operating principle. The goal of this work is to provide an overview of using thermal flow meter in hydrocarbons industries. The applicability of thermal flow meters is discussed by a simulation using one-dimensional mathematical model of thermal flow sensor.

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Keywords: flow, hot wire anemometer, dispersion flowmeter, thermal flowmeter, CTMF, ITMF.

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1. Introduction

New devices for gas metering such vortex, Coriolis, ultrasonic and thermal mass flowmeters have been emerged. Among them, thermal mass flow meters are very promising, because they present many useful characteristics such as the absence of moving parts, direct mass measurement and digital output [1].

A thermal mass flowmeter measures either the local mass velocity of gas flow gas or the total mass flow rate through a channel or pipe [2].

Basically, the thermal mass flow meters are based on the relationship between the output voltage of sensors and heat transfer rate produced by the sensor itself and the gas flow in the pipe [1, 3]. In fact, the output voltage is influenced by the gas composition through its thermos-physical properties such as thermal conductivity, diffusivity, density, specific heat and dynamic viscosity [1].

The fluid mass flow rate is a measure quantity very important in the control or monitoring of most industrial process. A thermal anemometer is used to measure the mass velocity at a point or small area of fluid flow [4].

There are broadly two concepts of thermal flowmeters available for fluid mass flow measurement: thermal dispersion mass flow meters (ITMF) and capillary thermal mass flow (CTMF). The American Society of Mechanical Engineers (ASME) has published separate standers for each one [3, 5, 6]. Both types measure the flow rate using heat transfer from a heated surface to fluid flow [7].

Thermal dispersion mass flow meters are available as both insertion probe and in-line type. These flowmeters measure the fluid flow mass flowrate through a closed conduit [8]. The fluid flows over a surface of a heated velocity sensor immersed in the flow [3, 7].

Generally, the thermal anemometer is referred to an immiscible thermal mass flow meter because it is immersed in a flow stream or channel in contrast to other thermal mass flow meter systems [4]. Its performance is affected by the internal structure of the thermal flow sensor, the installation conditions and the process conditions [9].

The present work deals with dispersion thermal mass flow meters, their theoretical and practical aspects are discussed.

2. Dispersion thermal flowmeter theory

Dispersion Thermal mass flowmeter are devices in which the associated physical quantity measured by them is the mass flow rate measured by the means of the heat convected from a heated surface to surrounding fluid from an electrically heated sensing element or probe [6, 7, 10]. In response to the large acceptance of thermal dispersion mass flow meters for industrial applications, the American Society of Mechanical Engineers (ASME) has published a new national standard for this kind of flowmeters [11, 12]

The figure 1 illustrates the complete transduction process for thermal flow meter with a voltage output signal. As, it is shown, two transduction processes take place, first, the mechanical signal (mass flow) is converted to a thermal signal (heat transfer), the flow induces a temperature difference which is converted into an electrical output signal (current or voltage). The principle of the gas mass-flow measurement is based on the fact that the output voltage of the sensor element is related to the rate of heat transfer deducted between the sensor and the fluid [13, 14].

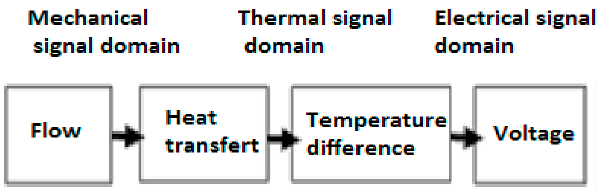

Fig.1. The three signal domains and the signal transfer process of a thermal flow sensor [8].

The composition and the type of the fluid can affect the intensity of the convective heat transfer from the thermal flow sensor to the fluid [7, 13, 15]. The accomplishment of thermal mass flowmeters are attributed to L.V. King [16] who in 1914, published his famous King's Law revealing how a heated wire immersed in a fluid flow measure locally the mass velocity in the flow. King called his instrument "hot-wire anemometer" [17].