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Wet Gas Flow Metering Technique
Using a Venturi With Conductance Sensors

OVERVIEW AND RESEARCH OBJECTIVES

Wet gas metering is becoming an increasingly important problem to the oil and gas industry. The aim of the research is to design a novel wet gas flow metering technique, which combines a Venturi with conductance sensors at the inlet and throat. The objectives, providing the solution to achieve the aims, are outlined below:

- Design and build a Venturi meter to measure the liquid film thickness at the inlet of the Venturi in annular flow.
- Design and build three separate conductance electronic circuits for:
  - Measuring the liquid film thickness at the inlet of the Venturi using electrical conductance techniques.
  - Measuring the liquid film thickness at the inlet of the Venturi in annular flow.
  - Measuring the liquid film thickness at the throat using electrical conductance techniques.

THE MEASUREMENTS

What measurements we need to make and how these measurements will be integrated into mathematical model to give the liquid and gas flow rates.

- Measuring the film velocity in wet gas flow.
- Measuring the film thickness.
- Measuring the gas volume fraction at inlet.
- Measuring the film velocity in wet gas flow.
- Measuring the gas volume fraction at the throat.
- Measuring the liquid conductivity under actual flow conditions.
- Measuring the gas volume fraction at inlet.
- Measuring the liquid conductivity under actual flow conditions.
- Measuring the gas volume fraction at the throat.

DESIGN OF THE CONDUITANCE VENTURI METER

A new Venturi with conductance sensors was designed and constructed to determine the gas flow rate.

TECHNIQUE

Measuring the film velocity in wet gas flow

Measured by cross-correlating the conductance signals between two sensors at the inlet of the Venturi, using the conductance electronic circuits of the upstream ring sensors.

The film thickness measurements

Measured using a digital level sensor at the inlet of the Venturi (upstream)

The gas volume fraction measurement

From the conductance circuit we know feedback resistance and the excitation voltage.

The measurement voltage equation is

\[ V(t) = V_0 R_p \sigma \alpha_2 \]  

We therefore have

\[ K(\alpha_1) = \frac{V_{in}}{V(t)} \]  

The cell constant

\[ K(\alpha_1) \propto \alpha_1 \]  

The gas volume fraction measurement at the throat

The measurement of the gas volume fraction at the throat relies upon knowing the liquid conductivity under actual flowing conditions.

we have

\[ K(\alpha_2) \propto \alpha_2 \]  

\[ K(\alpha_2) = \frac{V(t)}{V_{off}} \]  

\[ \alpha_{w, w} = \frac{[V(t)]_{\alpha=1}}{K(\alpha_1)} = \frac{[V(t)]_{\alpha=1}}{K(\alpha_1)} \]  

Differential pressure in wet gas flow

As in the figure the differential pressure will be measured by the dP cell.

\[ \Delta P_{dP, w} = (P_1 - P_2) \]  

Measuring the gas flow rate in annular flow

We make the above measurements to enable the gas flow rate in annular to be determined and the mass flow rate of water in the film using the equation 1 and 2 respectively.

\[ \dot{m}_w = C_{w} \left( \frac{\Delta P_{dP, w}}{\Delta \sigma_p} \right) \frac{\dot{m}_A \dot{V}}{A_p \left( \frac{A_p}{A} \right)^{1/2}} \]  

Measuring the gas flow rate in annular flow

The mass flow rate of water in film can be obtained from the following equation.

\[ \dot{m}_g = \frac{Q_g}{P_m} \]