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Wet Gas Flow Metering Technique Using a Venturi With Conductance Sensors

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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 enable measurement of the gas volume fraction at the inlet and the throat of the Venturi using electrical conductance techniques.
- Design and build a digital liquid level sensor to measure the liquid film thickness at the inlet of the Venturi in annular flow.
- Design and build three separate conductance electronic circuits for:-
  - Two upstream ring sensors, designed to measure the film velocity by cross correlating signals between two sensors at the inlet.
  - The digital level sensor, designed to measure the liquid film thickness in annular flow.
  - The throat ring sensor, designed to measure the gas volume fraction at the throat.

To use a data acquisition device to integrate the system measurements and to control the operation of the device :
- The throat conductance sensor.
- The digital level sensor.
- The inlet conductance sensors.
- The differential pressure sensor.

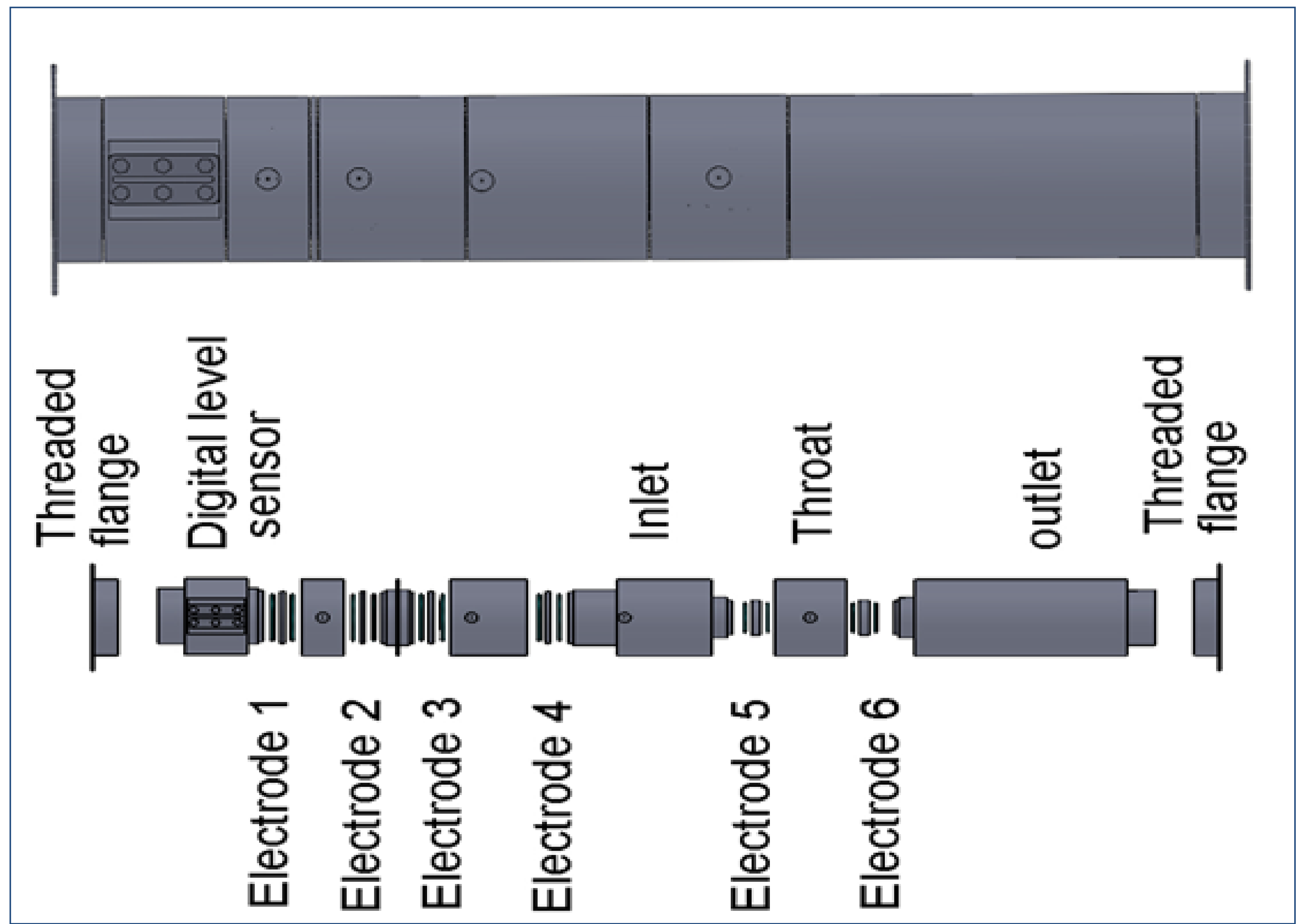
THE MEASUREMENTS

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 U_f
- Measuring the film thickness δ
- Measuring the gas volume fraction at inlet α_1
- Measuring the water conductivity σ_w
- Measuring the gas volume fraction at the throat α_2
- Differential pressure in wet gas flow ΔP

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

DESIGN OF THE CONDUATANCE 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

$$V(\alpha_1)=V_{in}R_{fb}\sigma_{w,ref}K(\alpha_1)$$ We therefore have $$\therefore K(\alpha_1)=\frac{V(\alpha_1)}{V_{in}R_{fb}\sigma_{w,ref}}$$ and $$\bar{K}(\alpha_1)=\frac{\{V(\alpha_1)\}_p-V_{off}}{\sigma_{w,ref}}$$

The cell constant $\bar{K}(\alpha_1)$ **vs** α_1 gas volume faction at the inlet

The water conductivity measurements

We now need to know how the conductivity sensor will be used with the digital level sensor in a real application to find the water conductivity.

$$\sigma_{w,m}=\frac{\{V(\alpha_1)\}_p-V_{off}}{\bar{K}(\alpha_1)}$$

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.

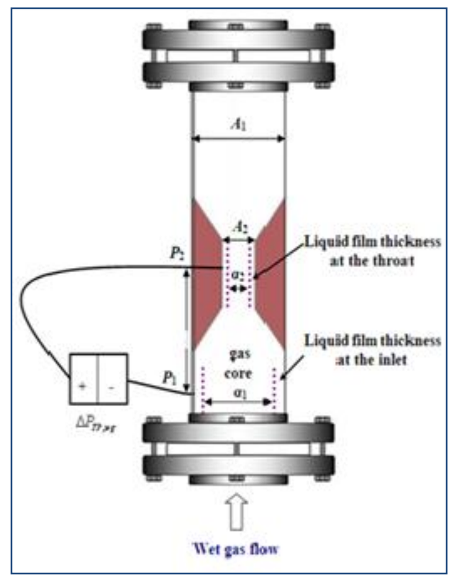
we have $\bar{K}^t(\alpha_2)$ **vs** α_2

$$\bar{K}^t(\alpha_2)=\frac{\{V_m^t(\alpha_2)\}_p-V^t{}_{off}}{\sigma_{w,m}}$$

Differential pressure in wet gas flow

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

$$\Delta P_{TP.wg}=(P_1-P_2)$$



Measuring the gas flow rate in annular flow

We make the above measurements , to combined them to enable the gas flow rate in annular to be determined using the equation

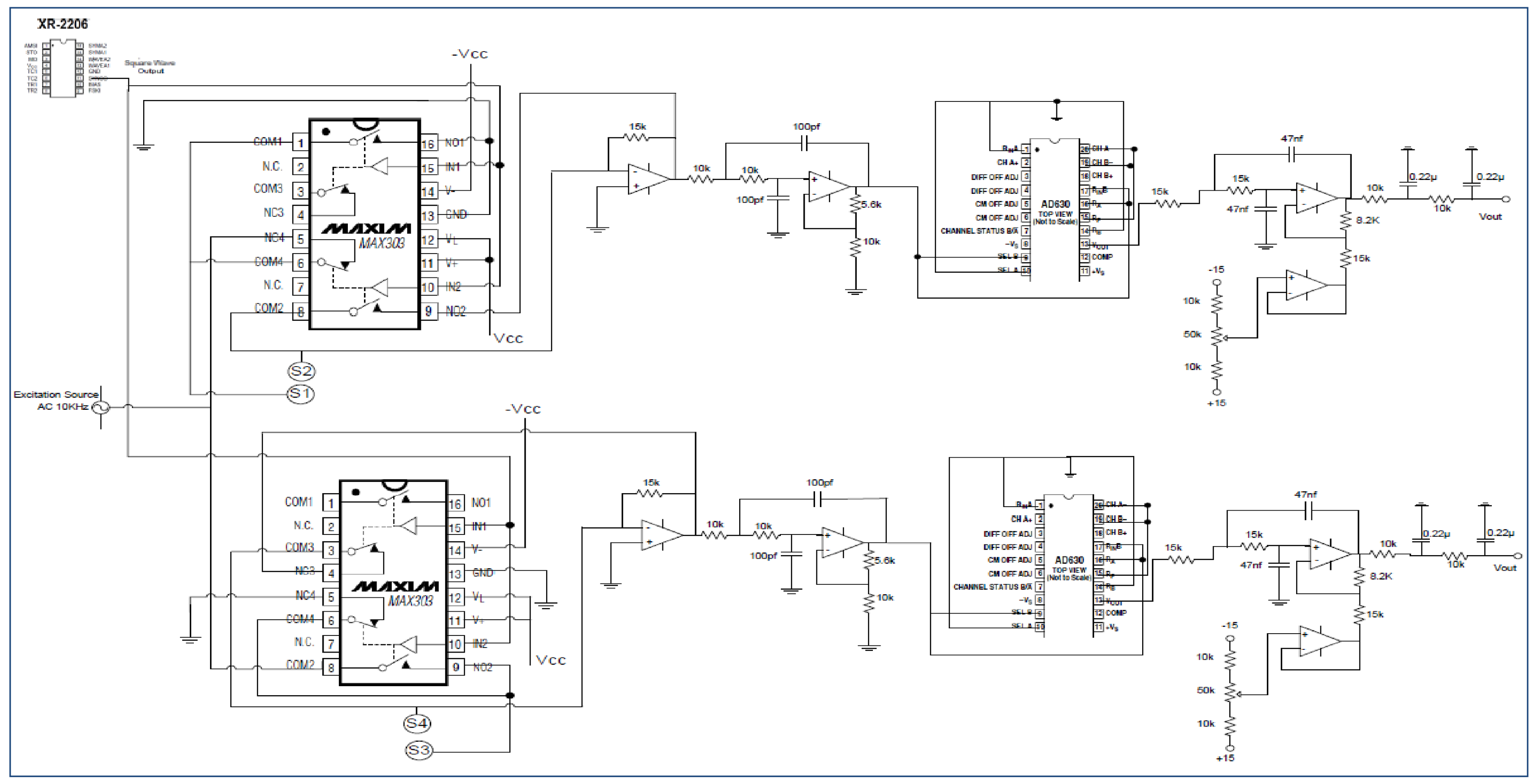
$$\dot{m}_g=C_{dg,wg}\frac{\left(2\rho_{g1}\{\Delta P_{TP,wg}-\Delta P_H\}\right)^{\frac{1}{2}}A_1A_2\alpha_1\alpha_2}{\left\{(\alpha_1A_1)^2(\hat{P})^{\frac{-1}{\gamma}}-(\alpha_2A_2)^2\right\}^{\frac{1}{2}}}$$

Measuring the gas flow rate in annular flow

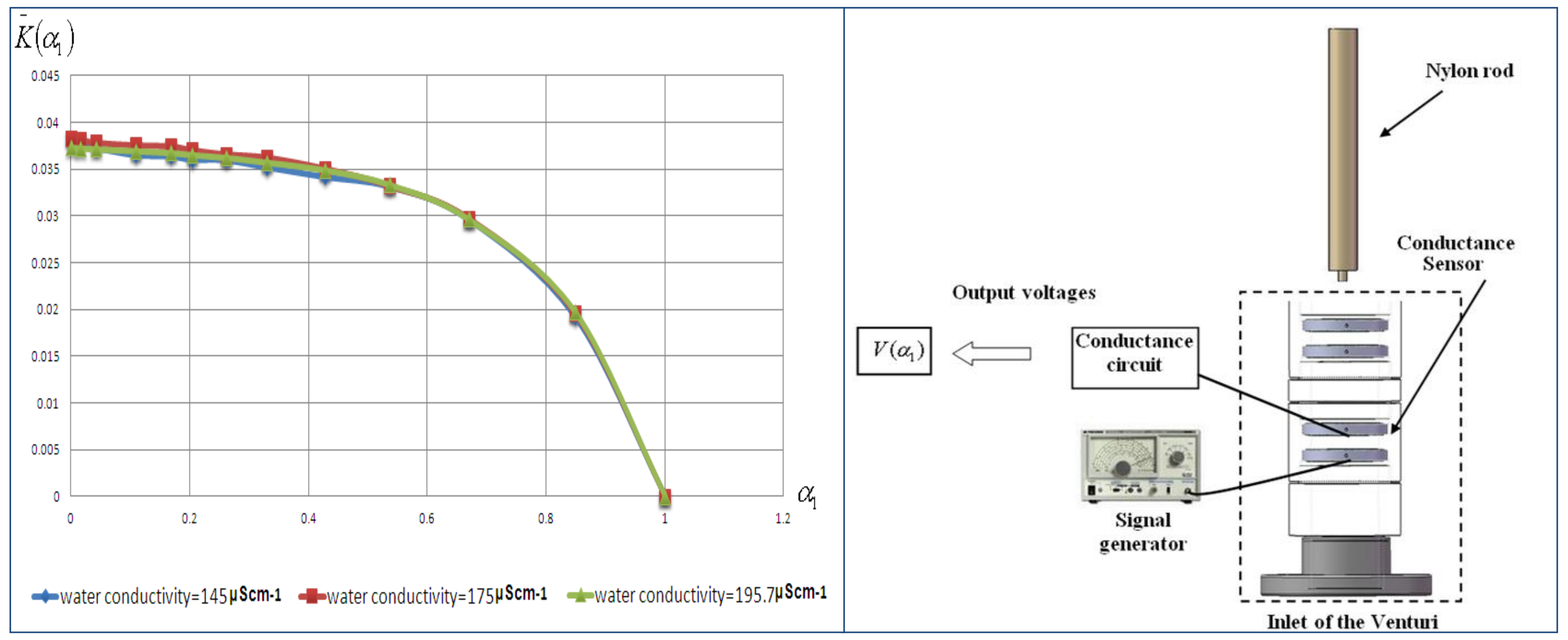
The mass flow rate of water in film can be obtained from the following equation

$$\dot{m}_f=\frac{Q_f}{\rho_w}$$

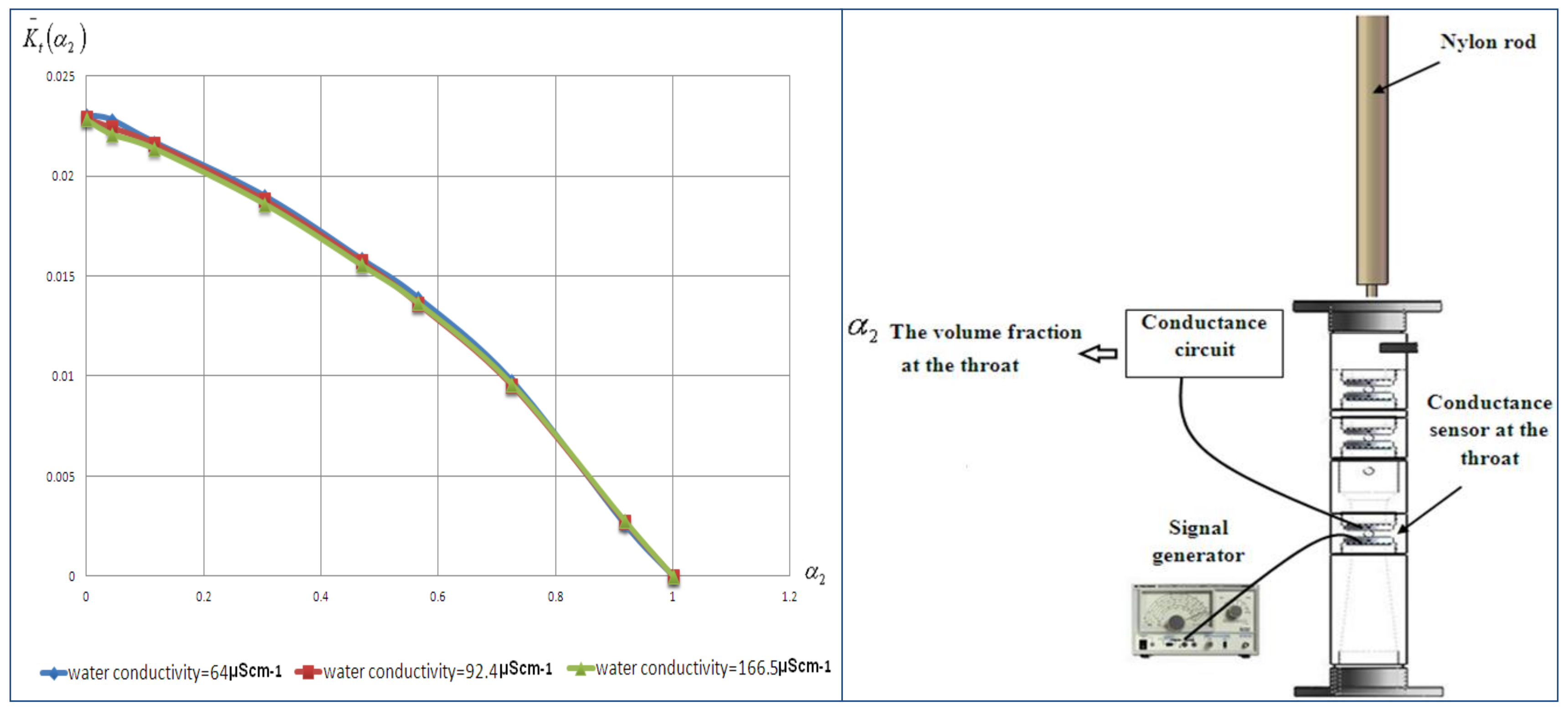
CONDUCTANCE ELECTRONIC CIRCUITS



Experimental result of the Gas volume fraction measurement at the inlet



Experimental result of the Gas volume fraction measurement at the inlet



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