23^{rd} International North Sea Flow Measurement Workshop
18-21 October 2005 Tonsberg Norway

Wet Gas Metering with the V-Cone and Neural Nets

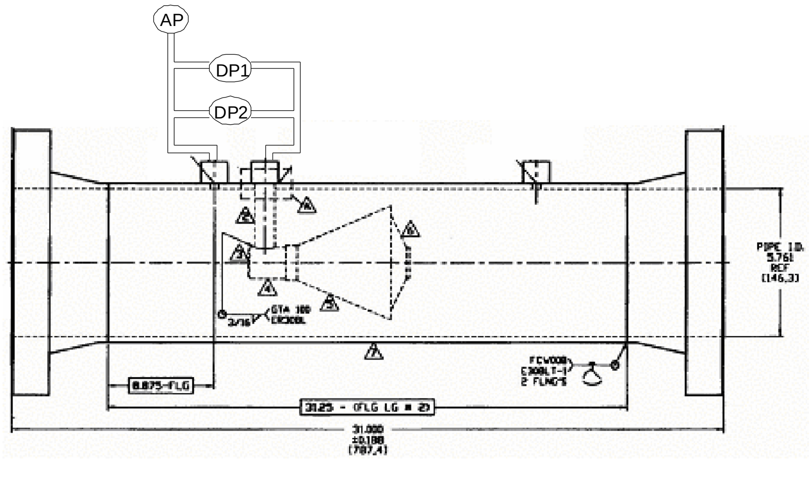
Haluk Toral and Shiqian Cai
Petroleum Software Ltd.
Robert Peters
McCrometer

Abstract

The paper presents analysis of extensive measurements taken at NEL, K-Lab and CEESI wet gas test loops. Differential and absolute pressure signals were sampled at high frequency across V-Cone meters. Turbulence characteristics of the flow captured in the sampled signals were characterized by pattern recognition techniques and related to the fractions and flow rates of individual phases. The sensitivity of over-reading to first and higher order features of the high frequency signals were investigated qualitatively. The sensitivities were quantified by means of the saliency test based on back propagating neural nets. A self contained wet gas meter based on neural net characterization of first and higher order features of the pressure, differential pressure and capacitance signals was proposed. Alternatively, a wet gas meter based on a neural net model of just pressure sensor inputs (based on currently available data) and liquid Froude number was shown to offer an accuracy of under 5% if the Froude number could be estimated with 25% accuracy.

Introduction

Wet gas measurements were conducted under a wide range of conditions with a V-cone meter in the test loops at NEL, K-Lab and CEESI. Measurements, comprising high frequency signals from pressure and differential pressure sensors, were analysed by characterisation of the turbulence properties of the flow by means of a pattern recognition / neural net methodology described in previous publications [1,2]



DP1: Standard DP
DP2: ESMER Fast DP
AP: ESMER Fast AP

Figure 1. Schematic Diagram of V-Cone

The V-cone was connected to high frequency absolute and differential pressure gauges and a portable PC as the data acquisition system. The signals were sampled and analysed by extracting characteristic features from fluctuating differential and pressure signals sampled at high frequencies. Examples of such features can be given as standard deviation in the amplitude domain and linear prediction coefficients in the frequency domain. The efficiency of the features for discriminating between different flow conditions is assessed by means of the Saliency test. The features were then related to the superficial velocities of individual phases by means of a back-propagating neural net. A data flow diagram of the concept is shown in figure below.

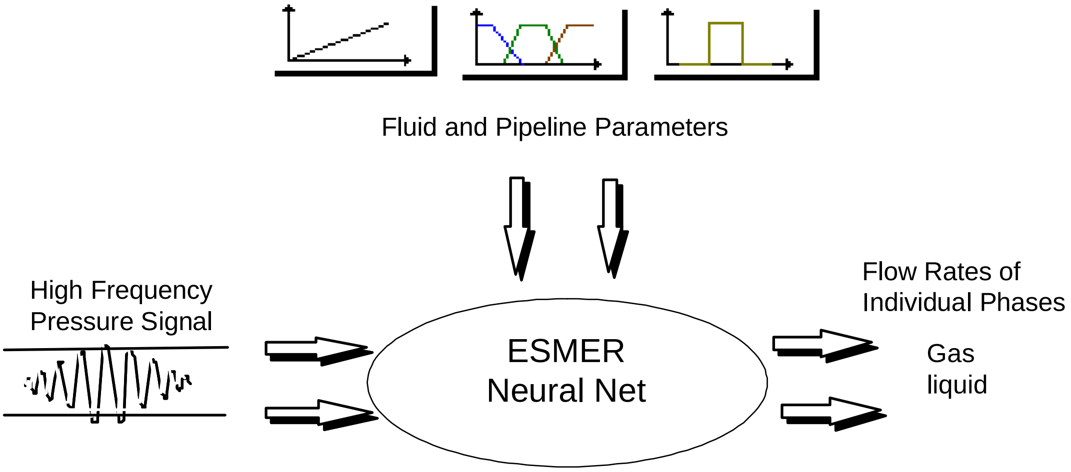


Figure 2. Schematic diagram of the ESMER concept

Test matrices covered a range of flow conditions up to 15% liquid volume fraction, operating pressure up to 90 bar; gas actual volumetric flow of 1000 m3/hr. Kerosene, condensate, field gas and nitrogen was used in different labs in 4” and 6” lines. The chart below gives a graphic summary of the flow conditions.

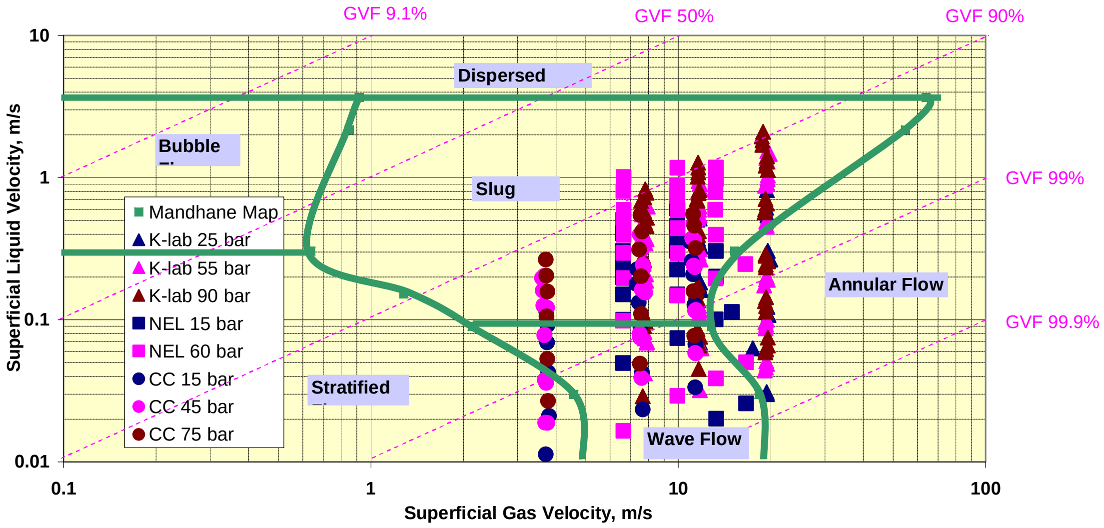


Figure 3. Operating envelope of NEL, K-lab and CEESI test data