34th International North Sea Flow Measurement Workshop
25-28 October 2016

Extended Abstract

Investigation of Multiphase Flow-Regimes After a Blind-T Mixer and at the Throat of the Venturi – Using Gamma-Ray Tomography and CFD Modelling

Stein-Arild Tjugum and Teerachai Leeungculsatien, Roxar - Emerson Process Management
Bjørn Tore Hjertaker and Rachid Maad, University of Bergen – Dept. of Physics and Tech.
Anders Hallanger, Cristian Michelsen Research AS

---

1 INTRODUCTION

Multiphase flow meters (MPFMs) are often installed in a vertical section at a given distance downstream of a blind-T to provide a more predictable flow regime. Placing the measurement section at the throat of a venturi or downstream of a venturi is another method used in some MPFM designs to condition the flow regime. In this work the multiphase flow has been studied at different distances from the blind-T, at the throat and downstream of the venturi using gamma-ray tomography. The objective was to investigate the flow-regime and flow mixing quality at different locations required to optimize MPFM performance. This was done using high-speed gamma-ray tomography and CFD flow simulations. This work was a collaboration between the University of Bergen, CMR and Roxar - Emerson Process Management.

2 DESCRIPTION OF THE TEST SETUP

The tests were done in the CMR flow loop [1] using the measurement setup shown in figure 1. It was of interest to investigate how the flow regime develops after the blind-T and how the venturi influences the flow regime. Thus, the gamma-ray tomograph was installed in a number of positions along the vertical pipe at different distance downstream the blind-T, and close upstream, downstream and in the throat of the venturi. The measurement-positions are shown in figure 1. Positions 1, 2 and 5 were tested with no venturi, and positions 1, 3, 4 and 5 were tested with the venturi installed.

A drawing of the gamma-ray tomograph is shown in figure 2. This instrument enables tomographic images of the flow cross-section with a 10ms time resolution [2]. The time-average tomograph measurements are used to find a gas fraction profile of the multiphase flow at each measurement position.

Extended Abstract

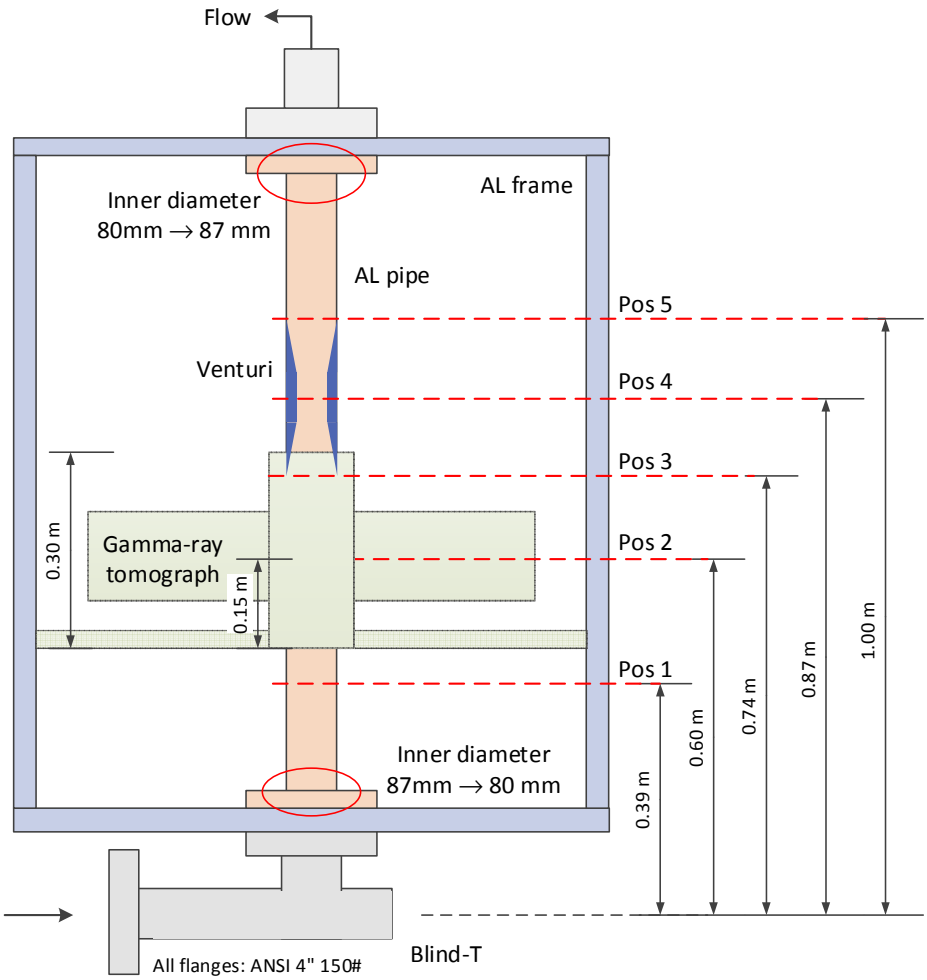

Figure 1 - The measurement section.

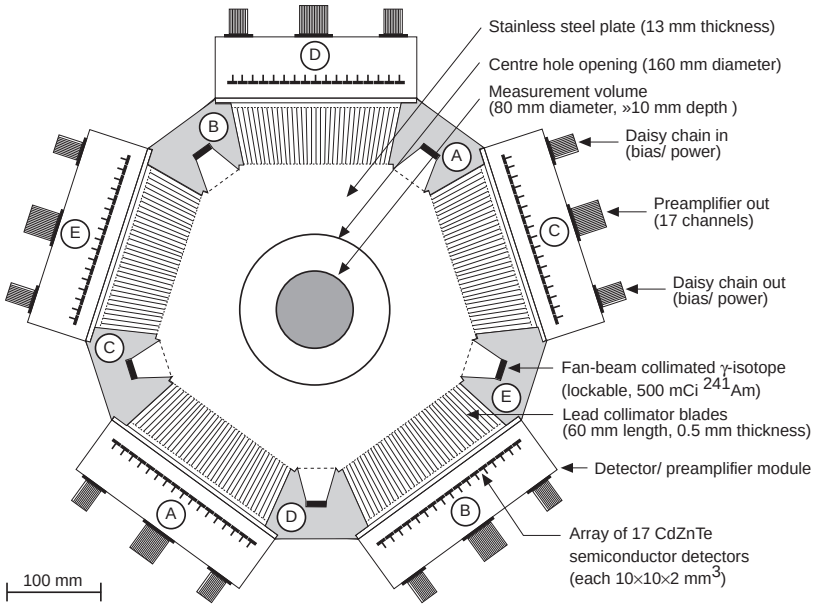

Figure 2 - The geometrical design of the high speed gamma-ray tomograph.

3 RESULTS

In full developed vertical multiphase flow, there is often an axis-symmetric time averaged gas fraction profile with more gas in the center of the flow. This is not always the circumstance closely downstream to the blind-T, where it is expected to have some deviation from axis-symmetry due to the fluid mechanics of the multiphase flow. This distribution of the gas fraction profile and deviation from axis-symmetric flow has been investigated. Figure 3 show gas fraction profiles and time-series plots of gas fraction obtained with the gamma-ray tomograph. The profile plots show that there is larger deviation from axis-symmetry close to the blind-T, and increasing symmetry with increasing distance downstream from the blind-T. The time average gas profile is close to symmetric at the position about a meter or 10 pipe diameters downstream from the Blind-T.

Measurements inside the venturi throat (pos. 4) also show a higher gas fraction in the center of the flow and some deviation from axis-symmetry. Measurements downstream of the venturi (pos. 5) show a more homogenous flow caused by the mixing effect of the venturi geometry. However, this venturi mixing effect is dependent on the flow velocity and the fluid properties and is therefore difficult to predict.

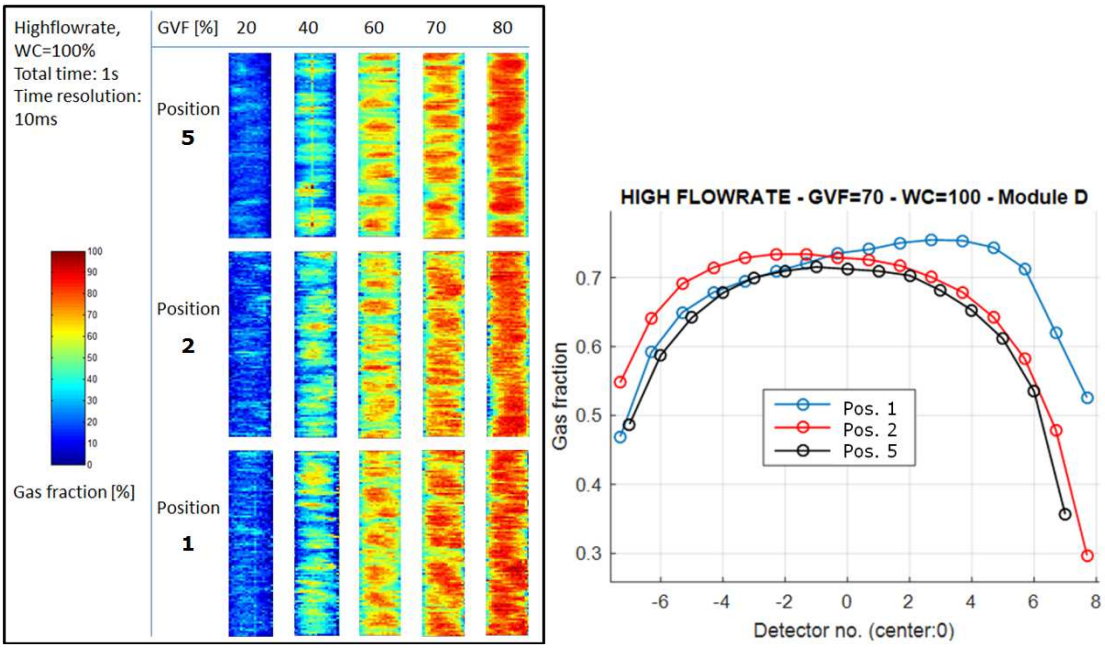

Figure 3 - Left: time-series plots of liquid/gas distribution, Rigth:Gas fraction plots from the gamma-ray tomograph.

The theoretical gas fraction profiles from the CFD simulations [3] show a more axis-symmetric flow with increasing distance from the blind-T in agreement with the measurements. The CFD simulations also provide a more detailed picture of the liquid gas distribution in the measurement-section as shown in figure 4.

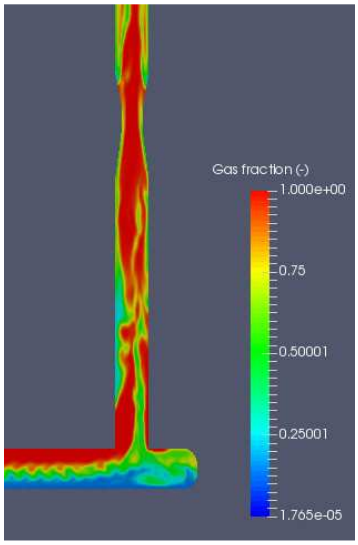

Figure 1 - Gas/liquid distribution found from CFD simulations

4 STRATEGIES FOR OBTAINING FLOW REGIME INDEPENDENT MEASUREMENTS

Multiphase flow meters are normally installed in the vertical section downstream of the blind-T, the possible positions for the fraction measurements are upstream, at the throat or downstream of the venturi [4]. It is preferrable to do the measurements where the flow-regime is predictable and where the time-average of the gas fraction profile is axis-symmetric.

The Roxar measurent strategy is to do the fraction measurements on a well developed vertical flow downstream of the blind-T and before the venturi. By the use of six-electorde tomometric impedance measurements flow-regime effects are captured and compensated for, this technique can also handle deviation from axis symmetric flow.

5 REFERENCES

[1] CMR (2014), Web page [online], Available: www.cmr.no (visited on 06/06/2016).

[2] G.A. JOHANSEN, T. FRØYSTEIN, B.T. HJERTAKER, Ø. OLSEN (1996), A dual sensor flow imaging tomographic system. Measurement Science and Technology, Vol 7, pp. 297-307.

[3] OpenFoam (2016), Web page [online], Available: http://www.openfoam.com/ (visited 06/06/2016).

[4] R. THORN, G.A. JOHANSEN, B.T. HJERTAKER (2013), Three-phase flow measurement in the petroleum industry, Measurement Science and Technology, Vol 24 (17 pp).