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Experimental Study and CFD Simulation of Two-phase Flow Measurement Using Orifice Flow Meter

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INTRODUCTION

Due to increased importance of multiphase flow metering in oil and gas industry, many researchers have studied in this area. In the research carried out by Ferreira et al [1], two-phase flow of air and water has been investigated. Moreover, the two-phase flow passing through the orifice plate has been investigated by Fossa et al [2]. Between 2008 and 2012, many scientists such as Bertola et al [3], Jones [4] and Manmatha et al [5] have measured the pressure drop and the characteristics of the two-phase flow passing through the orifice plate. In 2010, the characteristics of the two-phase flow passing through the orifice plate were studied by Alimonti et al [6]. In 2010, more comprehensive studies on measuring two-phase flow using venturi and electrical resistive sensors were proposed by Meng et al [7]. In 2011, performance and discharge coefficients of orifice plates and venture meters for low rates of two-phase flow were investigated by Hollingshead et al [8]. In 2015, a new type of orifice plates was investigated by Cioncolini et al [9] called micro orifice. In 2017, the performance of the orifice plate for two-phase flow was studied by machine learning methods by Tareq Aziz et al [10]. In this study, two-phase flow under various operational conditions such as pressure, air and water flow rates and volume fraction of the air was passing through the orifice plate flow meter and the total mass flow rate which was equal to the measured flow rates of electromagnetic and turbine flow meters were used to determine the orifice discharge coefficient versus Reynolds number of two-phase flow. Then the orifice plate flow meter was simulated by CFD approach. The pressure drop of the CFD simulation was compared to the empirical results, and the best turbulent model for simulation of flow through orifice plate was reported.

EXPERIMENTAL PROCEDURE

Air and water flow were measured separately before entering the two-phase flow loop with a turbine and an electromagnetic flow meters. Then, the two-phase flow with various volumetric fractions of the air phase is entered to the orifice plate flow meter, and its performance was investigated.

RESULTS AND DISCUSSION

Two-phase flow pressure is reduced in the orifice throat due to reduction of cross sectional area, on the other hand, velocity magnitude of the two-phase flow is increased in the orifice throat. Moreover, performances of various turbulence models were compared together. Calculated values of discharge coefficients for orifice plate were compared to those of experimental values. Mean absolute error for discharge coefficients of orifice plate using various turbulent models of standard k-ξ, RNG k-ξ, SST k-omega and STN k-omega were 2, 3, 8 and 10 percent respectively. Therefore, the standard k-ξ turbulence model was the best model to simulate the turbulent flow in orifice plate. Comparison between the turbulence models based on the obtained discharge coefficient of the orifice plate is shown in Table 1.

Table1: performance comparing between the turbulent models.

Turbulent model	Mean difference between simulation and empirical results [%]
Standard k-epsilon	۲
RNG k-epsilon	3
Standard k-omega	8
STN k-omega	10

CONCLUSIONS

In this study, the method of measuring two-phase flow of air and water using the orifice plate flow meter was investigated. Moreover, effects of air volume fraction and Reynolds number of two-phase flow were investigated on the orifice plate flow meter performance in order to determine the flow rate of the two-phase flow. It was observed that with an increase in air volume fraction and Reynolds number of two-phase flow, discharge coefficient of the orifice plate was increased. The standard K-Epsilon turbulence model led to better results in comparison to other turbulence models. Also, the achievement of this study is to provide the suitable approach in order to manufacture the two-phase flow for two-phase flow measurement in oil and industries.

REFERENCES

[1]. Ferreira, V., *“Differential pressure spectral analysis for two-phase flow through an orifice plate,”* International journal of pressure vessels and piping, 1997. 73(1): pp. 19-23.

[2]. Fossa, M. and G. Guglielmini, *“Pressure drop and void fraction profiles during horizontal flow through thin and thick orifices,”* Experimental

Thermal and Fluid Science, 2002. 26(5): pp. 513-523. Fluid Science, 2002. 26(5): pp. 513-523.

[4]. Bertola, V., *"The structure of gas–liquid flow in a horizontal pipe with abrupt area contraction,"* Experimental thermal and fluid science, 2004. 28(6): pp. 505-512.

[5]. Jones Jr, O.C. and N. Zuber, *"The interrelation between void fraction fluctuations and flow patterns in two-phase flow,"* International Journal of Multiphase Flow, 1975. 2(3): pp. 273-306.

[6]. Roul, M.K. and S.K. Dash, *"Single-phase and two-phase flow through thin and thick orifices in horizontal pipes,"* Journal of Fluids Engineering, 2012. 134(9): pp. 091301.

[7]. Alimonti, C., G. Falcone, and O. Bello, *"Two-phase flow characteristics in multiple orifice valves,"* Experimental Thermal and Fluid Science, 2010. 34(8): pp. 1324-1333.

[8]. Meng, Z., et al., *"Air–water two-phase flow measurement using a Venturi meter and an electrical resistance tomography sensor,"* Flow Measurement and Instrumentation, 2010. 21(3): pp. 268-276.

[9]. Hollingshead, C.L., et al., *"Discharge coefficient performance of Venturi, standard concentric orifice plate, V-cone and wedge flow meters at low Reynolds numbers,"* Journal of Petroleum Science and Engineering, 2011. 78(3-4): pp. 559-566.

[11]. Cioncolini, A., F. Scenini, and J. Duff, *"Micro-orifice single-phase liquid flow: Pressure drop measurements and prediction,"* Experimental Thermal and Fluid Science, 2015. 65: pp. 33-40.

[12]. Al-Qutami, T.A., et al., *"DEVELOPMENT OF SOFT SENSOR TO ESTIMATE MULTIPHASE FLOW RATES USING NEURAL NETWORKS AND EARLY STOPPING,"* International Journal on Smart Sensing & Intelligent Systems, 2017. 10(1).