Two-Phase Flow Analysis of a Finger-Type Slug Catcher

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Abstract

The two-phase flow in the finger pipe of a finger-type slug catcher is analysed using CFD techniques. The purpose of a finger-type slug catcher is to separate the liquid condensate from the natural gas. In order to design a high performance finger-type slug catcher, it is necessary that the fluid flow in the inlet header manifold is evenly distributed among the different fingers (Figure 1). The open-source framework of OpenFOAM® is used to solve the incompressible Navier-Stokes equations for the different fractions of the natureal gas and the liquid condensate mixture. The distribution of the superficial and actual gas / liquid velocities was used as well as the pressure drop to study the performance of the finger-type slug catcher. In order to model the liquid separation, force equilibrium on a liquid droplet moving in gas is considered:

$$\sum F = \frac{\pi}{4} D_p^3 \rho_g g + C_d A \frac{1}{2} \rho_g v_t^2 - \frac{\pi}{6} D_p^3 \rho_l g$$

Here v_t is the settling velocity of particles of a specified diameter. Different inlet header manifold configurations are defined and compared using the time-averaged mass flow at the finger inlets. A constant and increased pipe diameter was found to promote the mass flow balance. Additionally, by applying an extra split in the main header pipe, the equal flow distribution is significantly increased, see Figure 1.

When the fluid flow in the inlet header manifold is evenly distributed among the different fingers, it is necessary to obtain stratified flow to promote liquid separation. The two-phase flow in the separation section is simulated to study the amount of liquid at the intersection with and through the gas riser, see Figure 2, showing the phase volume fraction of the liquid condensate mixture. Therefore, different particles diameters are studied to identify the amount of liquid particles exiting the gas riser pipe after the separation section. Accurate CFD results will be presented to provide insight in how the interface between the natural gas and the liquid condensate, containing liquid droplets, behaves.

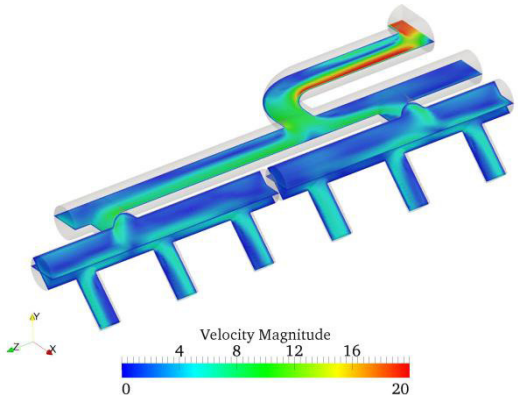

Figure 1: Flow field in the header configuration.

Figure 2: Volume fraction of the liquid mixture in the finger pipe.

Key words: Two-phase flow, Industrial applications, Slug/stratified flows, Slug catcher, OpenFOAM

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