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CFD Modelling of Multiphase Flow through T Junction

Athulya A.S[a], Miji Cherian R[b]*

[a]*Student, Govt. Engineering College, Trichur, 680009, India*
[b]*Assisstant Professor,Govt. Engineering College, Trichur, 680009, India*

Abstract

Multiphase flow is a common phenomenon in many industrial process and energy related industries. Pipelines are widely used in industrial applications for the transport of multiphase mixtures of liquid phases or gas and liquid phases. T junction is an important component of pipeline systems. The numerical study of multiphase flow through T junction have been started a long back. This paper presents a model of multiphase flow through T junction and the redistribution phenomenon of phases at the junction using ANSYS FLUENT Software

Keywords: Compuational Fluid Dynamics (CFD);Multiphase flow; Fluid Structure Interaction (FSI); Phase separation

1. Introduction

Multiphase flow occurs when more than one material is present in a flow field and the materials are present in different physical states of matter or are present in the same physical state of matter but with distinct chemical properties. The materials present in multiphase flow are often identified as belonging to the primary or secondary phases. The primary phase is defined as the phase that is continuous or enveloping the secondary phase. The secondary phase is the material that is distributed throughout the primary phase [3]. The study of multiphase flow is very important in energy-related industries and in many industrial processes. Multiphase flows are also an important feature of our environment such as rain, snow, fog, mud slides, sediment transport, and debris flows etc. The

* Corresponding author. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000 .
*E-mail address:*author@institute.xxx

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simplest case of multiphase flow is two-phase flow. Two-phase flow can be solid-liquid flow, liquid-liquid flow, gas-solid flow, and gas-liquid flow.
Pipelines are widely used in industrial applications for the transport of multiphase mixtures of liquid phases or gas and liquid phases. Here a small and common component of pipe network is considered for the study: T-junction. T-junction is a small, but very important part of the pipe-line system. It can vary in shape and it is primarily used for dividing or combining of flow in pipeline. The T-junction can be also used for mixing of two different liquids, liquid and gas or two different gases. Junctions between pipes can involve the mixing or splitting of fluids. When the split at junctions involves more than one phase, the process becomes complicated since the ratio of phases at inlet and outlet are different.

Numerical studies related to two phase flow through T junction have been started long back. Experiments have been conducted for the investigation of the two-phase flow structure in the vicinity of the junction using the void probe technique developed by Herringe and Davis to investigate velocity, void fraction and bubble size distributions within the flow [4]. When a two phase flow enters a T junction, phase separation will often occurs. The lighter phase preferably gets diverted into the side arm and the heavier phase will flow towards the main arm. Hence the side arm of the dividing T-junction will carry a higher proportion of the gas than the straight arm [6].

Fluid Structure Interaction (FSI) occurs when fluid flow causes deformation of the structure. This deformation, in turn, changes the boundary conditions of the fluid flow. In FSI an important region is the interface surface which separates the fluid and the solid domain. At this interface surface, both the governing equations and the boundary conditions from the fluid and solid domain must be satisfied simultaneously. From previous literatures it is clear that three liquid-pipe interaction mechanisms can be distinguished: friction coupling, Poisson coupling and junction coupling. Friction coupling represents the mutual friction between liquid and pipe. Poisson coupling relates the pressures in the liquid to the axial (longitudinal) stresses in the pipe through the radial contraction or expansion of the pipe wall. Friction and Poisson coupling act along the entire pipe, junction coupling acts as specific points in a pipe system such as unrestrained valves, bends and tees [7][8].

Previous studies showed that that detailed studies were conducted on two phase flow through T junction. CFD studies were conducted on two phase flow. Fluid Structure Interaction studies were also conducted in piping systems. But studies incorporating CFD modelling of two phase flow through T junction with Fluid Structure Interaction is not reported. Hence this paper focuses on the study of redistribution of phases when multiphase flow enters a T junction and also to study the deformation occurs in pipe using Fluid Structure Interaction.

2. Multiphase models

Models are used to describe and predict the physics of multiphase flow. Modelling of multiphase flow is very complex. In addition, there are also limitations in time, computer capacity etc. when performing numerical studies. This has led to the development of models that can account for different levels of information, meaning different levels of accuracy, and are suitable for different multiphase flow applications. There are two approaches for the numerical calculation of multiphase flows: the Euler-Lagrange approach and the Euler-Euler approach [3].

In ANSYS FLUENT, three different Euler-Euler multiphase models are available: the Volume of Fluid (VOF) model, the Mixture model, and the Eulerian model. The Eulerian model is the most complex of the multiphase models in ANSYS FLUENT. It solves a set of momentum and continuity equations for each phase [3] [8].

3. Methodology

3.1. Problem Description

T-junctions are commonly encountered in pipeline systems. In this study a vertical T junction with a horizontal branch is used with 500 mm length for each arm having inner diameter 50 mm. When a multiphase flow enters a T-junction a redistribution of phases often occurs. This redistribution can be desirable for certain situations where