

# Research Proposal

(Submitted to Department of Mechanical Engineering, University Putra Malaysia)

## An Investigation on the Effect of Gas-Liquid Flow Characteristics on Pipe Vibration

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## Abstract

The pipeline vibration can occur in petroleum, natural gas and chemical industry because of unsteady flow, the change of flow direction, pipe diameter, etc. this problem will affect safe running of pipeline severely if it is not handled well. Therefore the pipe vibration arouses more and more people attention. But nowadays, the study on it is mainly focused on the pipe vibration due to mechanical vibration source. However there is a kind of pipelines in engineering with gas-liquid flow inside and whose both inlet and outlet are without pump and compressor, and they occur severe vibration. The reasons of this situation are too difficult to analyze.

Generally, the vibration of the pipe system happens because of mechanical vibration, fluid vibration, vibration of themselves, earthquake and so on. Fluid vibration includes fluid pulsation, gas-liquid flow vibration, high-speed flow vibration, and flow vibration outside the pipeline. The vibration of gas-liquid flow pipeline will be studied by this research.

## Introduction

In fluid mechanics, **two-phase flow** typically occurs in a system containing gas and liquid. Historically, probably the most commonly-studied cases of two-phase flow are in large-scale power systems. Coal and gas-fired power stations used very large boilers to produce steam for use in turbines. In such cases, pressurized water is passed through heated pipes and it changes to steam as it moves through the pipe. Another case where two-phase flow can occur is in pump cavitations. Here a pump is operating close the vapour pressure of the fluid being pumped. If pressure drops further, which can happen locally near the vanes for the pump, for example, then a phase change can occur and gas will be present in the pump. Similar effects can also occur on marine propellers; wherever it occurs, it is a serious problem for designers. When the vapour bubble collapses, it can produce very large pressure spikes, which over time will cause damage on the propeller or turbine.

The above two-phase flow cases are for a single fluid occurring by itself as two different phases, such as steam and water. The term 'two-phase flow' is

also applied to mixtures of different fluids having different phases, such as air and water, or oil and natural gas. Sometimes even *three*-phase flow is considered, such as in oil and gas pipelines where there might be a significant fraction of solids.

On the other hands, Fluid flow is a source of energy that can induce structural and mechanical oscillations. Flow-induced vibrations best describe the interaction that occurs between the fluid's dynamic forces and a structure's inertial, damping, and elastic forces. Piping vibration analysis involves describing how much the pipe is moving and at what frequency the motion exists. The piping motion can be further described by showing the motion as a modal plot. Pipes can vibration in three orthogonal directions just like a machine. Vibration data should be collected in the X, Y, and Z axis.

## **Problem Statement**

Though gas-liquid flows typically cause feebleness pipe vibration and it could not damage the equipment, but more intense vibration may cause pipes' construction and the equipments at upper stream and downstream harmful, even to make them stop running. Through experimental researches on gas-liquid two-phase flow in pipes, some experimental results were obtained, but the mechanism is not further analyzed at the fluid flowing parameters effect pipe's vibration.

## **Objective**

The main objectives by this research are:

- Theoretical study of gas-liquid flow characteristics
- Investigation of parameters effects on gas-liquid flow characteristics
- Analyze the effect of gas-liquid (*bubble and slug*) flow characteristics on pipe vibration

## Scope of Study

The scope of this research is to know the vibration of gas-liquid pipelines mechanism and to adopt reasonable steps to decrease the vibration.

## Layout of the Research

The research will report the whole process and results of performed research in six chapters as listed below:

**Chapter 1 (Introduction):** presents an introduction and background of the research, the problems and the main objectives of this study.

**Chapter 2 (Literature review):** presents the previous research on *Multiphase Flow, Slug Flow, Pipe Vibration and Relationships*.

**Chapter 3 (Methodology):** explains the methods and strategies, which were used in the research to achieve the specified objectives. These methods consist of the strategies had been used by previous research explained in chapter 2 and those will be applied by the author in this work.

**Chapter 4 (Results):** expresses the obtained results in details. These results are illustrated as tables, plotted curves, figures.

**Chapter 5 (Discussion):** explains the represented results in chapter 4 and presents a complete discussion in order to clarify the obtained results.

**Chapter 6 (Conclusions and Recommendations):** lists the final achievements and verifies them with the drawn objectives in the first chapter to ensure all of the objectives have been fulfilled.

## Literature Review

To put multiphase flows in perspective, it should be noted that even *single phase flows*, in which only one fluid flows in the system, are highly complex, mainly due to the existence of turbulence which cannot be predicted fundamentally at high Reynolds numbers (i.e., at high velocities). For multiphase flows, the system is not only usually turbulent but also has

deformable interfaces between the phases. It is common practice to classify the forms of interfacial distribution as *flow patterns* or *flow regimes*.

Fig.1 shows the flow patterns that can occur in vertical and horizontal pipes. For vertical up flow we see (from left to right), as the amount of gas is gradually increased, the following flow patterns evolve: bubbly flow, slug flow, churn flow, and annular flow.

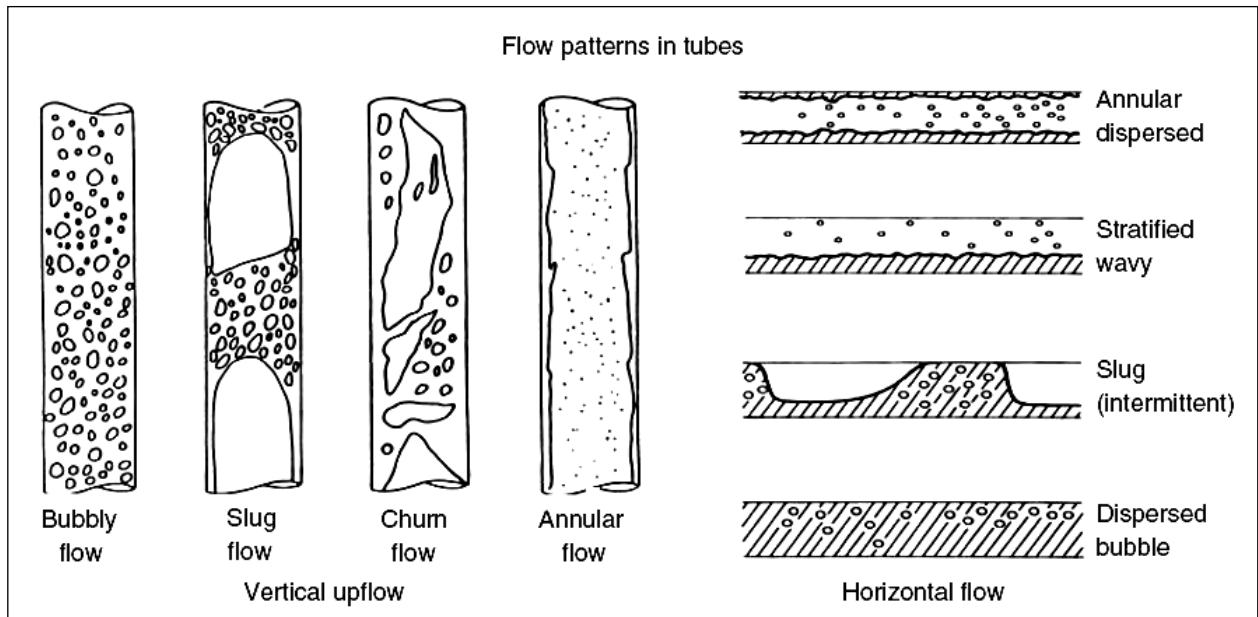


Fig. 1) Flow patterns for two-phase gas-liquid flow in vertical and horizontal pipes

Flow Pattern	Characteristics
Bubbly flow	discrete gaseous bubbles in a continuous liquid
Droplet flow	discrete fluid droplets in a continuous gas
Particle-laden flow	discrete solid particles in a continuous fluid
Slug flow	large bubbles in a continuous liquid
Annular flow	continuous liquid along walls, gas in core
Stratified and free-surface flow	immiscible fluids separated by a clearly-defined interface

## Definition of bubble and slug flows

### 1. *Bubble flow*

Here, the liquid phases are continuous and a dispersion of bubbles flows within the liquid continuum.

### 2. *Slug or plug flow*

At high gas flows, the bubbles coalesce and large, characteristically bullet-shaped bubbles are formed that may be separated by regions containing dispersions of smaller bubbles. Typically, the liquid phase flows down the outside of the large bubble in the form of a falling film, although the net flow of both the liquid and gas can be upwards.

## Methodology

In order to obtain the objectives two main phases will be fulfilled by this research. The first phase is analysing the effect of gas-liquid flow on pipe vibration theoretically and the second phase is the illustration of the phase 1 results by experimental study. For experimental studies a Test Loop will be designed and fabricated. Fig.2 is the primary design of test loop.

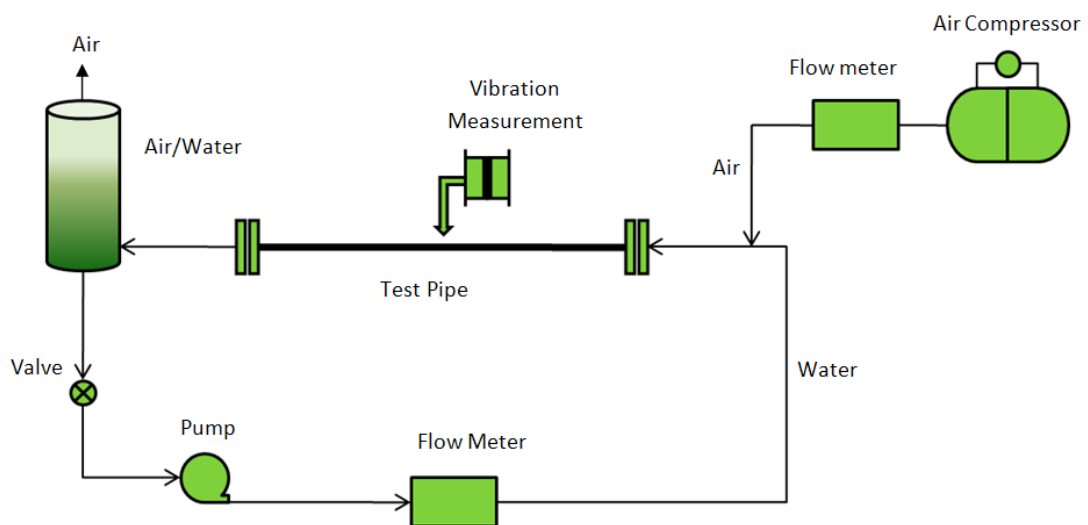


Fig. 2) Primary design of test loop

Details of the research phases are as following:

**Theoretical Study**

Step 1) study of multiphase flow fundamentals

Step 2) study of bubble and slug flow characteristics

Step 3) analyzing the effects of bubble and slug flows on pipe vibration

Obtaining the Theoretical Results

**Experimental Study**

Step 4) design a simple but proper test loop

Step 5) fabricate the test loop

Step 6) obtain the bubble and slug flows in test loop

Step 7) measuring the vibration induced by the flows

Step 8) Study of the flows characteristics on the pipe vibration

Obtaining the final results

(time table for performing the research is attached as a Gantt chart)

WORK PLAN	Second Semester 2008 - 2009				First Semester 2009 - 2010				Second Semester 2009 - 2010			
Study Multiphase Flow Foundations												
Bubble and Slug Flow Analysis												
Analysing the Effect of Multiphase Flow on Pipe Vibration												
Design and Fabricate the Test Loop												
Experimental Works												
Writing the Thesis (Introduction and Literature Reviews)												
Writing the Thesis (Methodology)												
Writing the Thesis (Results and Discussion)												
Thesis Corrections and Edits												

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