A Review of flow regime transition and pressure drop in two phase flow for vertical pipe

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ABSTRACT

In this study, the flow patterns of air–water, two-phase flows have been investigated in a vertical mini pipe. Different flow patterns of air–water flow were observed simultaneously in the mini pipe at different values of air and water flow rates. Pressure drop prediction is investigated for vertical pipe in two phase flow. Pressure drop is causing more damage to vertical pipes as it has been many applications.

Keyword: *regimes, Surfactant: a substance which tends to reduce the surface tension of a liquid in which it is dissolved.*

1. FLOW PATTERN TRANSITIONS IN VERTICAL FLOW

The regimes encountered in vertical flows are illustrated in Figure 1. They include Bubble Flow, where the liquid is continuous, and there is a dispersion of bubbles within the liquid; Slug or Plug Flow where the bubbles have coalesced to make larger bubbles which approach the diameter of the tube; Churn Flow where the slug flow bubbles have broken down to give oscillating churn regime; Flow where the liquid flows on the wall of the tube as a film (with some liquid entrained in the core) and the gas flows in the center; and Wispy Annular Flow where, as the liquid flow rate is increased, the concentration of drops in the gas core increases, leading to the formation of large lumps or streaks (wisps) of liquid.

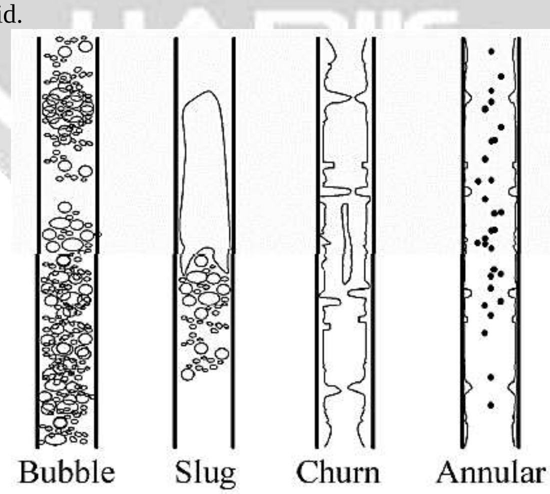

Fig: Types of Vertical Flow Regimes

1.1 Pressure Drop

Pressure losses occur in two-phase flow systems due to friction, acceleration and gravitational effects. If a fixed flow is required, then the pressure drop determines the power input of the pumping system. Here, examples are the design

of pumps for the pipeline transport of slurries, or for pumping of oil-water mixtures. If the available pressure drop is fixed, the relationship between velocity and pressure drop needs to be invoked in order to predict the flow rate.
There are two types of pressure drop prediction i.e. homogeneous model and separated flow model.
In the *homogeneous model*, the two phases are assumed to be travelling at the same velocity in the channel and the flow is treated as being analogous to a single phase flow.
In Separated flow models, the two fluids are considered to be travelling at different velocities and overall conservation equations are written taking this into account

1.2 Application of vertical flow regime transition
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. The design of boilers requires a detailed understanding of two-phase flow heat-transfer and pressure drop behavior, which is significantly different from the single-phase case. Even more critically, nuclear reactors use water to remove heat from the reactor core using two-phase flow. A great deal of study has been performed on the nature of two-phase flow in such cases, so that engineers can design against possible failures in pipework, loss of pressure, and so on (a loss-of-coolant accident (LOCA)
Another case where two-phase flow can occur is in pump cavitation. Here a pump is operating close to the vapor 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 vapor 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.
Other interesting areas where two-phase flow is studied includes in climate systems such as clouds, and in groundwater flow, in which the movement of water and air through the soil is studied.
Other examples of two-phase flow include bubbles, rain, waves on the sea, foam, fountains, mousse, cryogenics, and oil slicks.

2. LITERATURE REVIEW

Safa Sharaf,G. Petervander Meulen, Ezekiel O. Agunlejika Barry J. Azzopardi paper presents detailed experimental data obtain educing a Wire Mesh Sensor. It shows that the most obvious features of the flow are huge waves travelling on the liquid film. Wisps, large tendrils of liquid and the product of in complete atomization, which had previously detected in smaller diameter pipes, have also been found in the larger diameter pipe employed here. The output of the Wire Mesh Sensor has been used to determine the overall void fraction.

P. Hanafizadeh, M.H. Saidi ∗, A. Nouri Gheimasi, S. Ghanbarzadeh has discussed about air–water, two-phase flow patterns were investigated experimentally for mini pipes with diameters of 2, 3 and 4 mm. An image processing technique was used for detection of flow patterns from pictures derived from films recorded with a high speed camcorder. The obtained flow patterns reveal that there is no noticeable difference between two-phase, upward flow patterns in this range of diameters. A new flow pattern map was achieved for vertical mini pipes, due to a comparison of the flow patterns of these three diameters of pipe. The proposed map was compared with existing research. A comparison of the present work and previous research shows that the flow patterns of slug, messy slug and semi-annular in the present work are compatible with the intermittent flow pattern of Ide et al. However, in the present study, the annular flow is seen at a lower

Zhou, Jing had discussed the influence of a surfactant on two-phase upward vertical flow regime was investigated in this study. With the addition of surfactant, the churn regime was extended towards lower gas velocity, and no bubble flow was observed at lower gas/liquid velocity for the range of conditions studied. The bubble sizes in all flow regimes were changed due to the lower surface tension caused by addition of the surfactant solution. The comparison between this experimental studies with several predictive models was provided.

Garaev Damir had presented the experiments in vertical air/water two phase up flow were performed using a riser of 127 mm in diameter at different pressure to change the density of the gas. Data on void fraction were gained using a Wire Mesh Sensor (WMS). The data were analyzed to obtain flow patterns, frequency etc. Using these data comparison with different prediction methods was carried out.

Shanthi C, Pappa N, Aswini Suganya J has an approach for identifying the flow pattern using Neural Network and Support vector machine is developed. Flow images are captured using high speed SLR camera and are preprocessed. After preprocessing the images, the textural features such as entropy, homogeneity, contrast, correlation and energy are extracted. The textural features extracted are given as the input to the neural network and support vector machine. Four typical flow regimes such as bubbly flow, slug flow, stratified flow and annular flow are captured from the experimental set-up. The results obtained shows that support vector machine method of classification is very effective with accuracy of 98.03 percent and hence higher recognition is done.

Maqbool Muhammad Hamayun, Björn Palm, Khodabandeh R., Ali Rashid deals with experiments performed to study the behavior of the two phase flow pressure drop of ammonia , in a vertical mini channel made of stainless steel having an internal diameter of 1.224 mm and a heating length of 245 mm. The test conditions are: mass fluxes from 200 to 500 kg/m^2s, heat fluxes from 20 to 340 kW/m^2 and saturation temperatures of 23^oC, 33^oC and 43^oC. The experimental results are compared to well-known correlations for frictional pressure drop in macro and micro scale channels.

Biria, Saeid aim to develop a better approach for predicting pressure gradient in vertical multiphase flow with and without use of Sodium dodecyl sulfate (SDS) as a surfactant and to develop a program for the prediction of pressure drop by using Microsoft Visual Basic in Excel. Data was collected from four fixed liquid superficial velocity at different ranges of gas superficial velocity in a 0.052m i.d. and 10m long, clear PVC pipe. Results indicate that the addition of SDS resulted in reducing surface tension between phases from 72 to 64 mN/m, decreasing pressure drop by approximately 26% and also Hasan and Kabir model for Air/DI water and Hagedorn and Brown model in the presence of SDS in the mixture is the best model and leads to a reasonably accurate pressure gradient according to measured pressure drop.

3. CONCLUSION

For flow regime transition in vertical pipes P. Hanafizadeh, M.H. Saidi ∗, A. Nouri Gheimasi, S. Ghanbarzadeh has proposed Experimental investigation of air–water, two-phase flow regimes in vertical mini pipe.

For pressure drop prediction in vertical pipes Maqbool Muhammad Hamayun, Björn Palm, Khodabandeh R., Ali Rashid has proposed experimental investigation of two phase pressure drop in a vertical mini-channel at three saturation pressures.

4. REFERENCES

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