MULTIPHASE FLOW MEASUREMENT

1

MULTIPHASE FLOW

2

Multiphase Flow

- Multiphase flow is simultaneous flow of:
  - Materials with different states or phases (i.e. gas, liquid or solid).
  - Materials with different chemical properties but in the same state or phase (i.e. liquid-liquid systems such as oil droplets in water).

Classification of Multiphase flows

Gas-liquid flows	Bubbly flows, Separated flows, Gas-droplet flows
Gas-solid flows	Gas-particle flows, Pneumatic transport, Fluidized beds
Liquid-solid flows	Slurry flows, Hydrotransport, Sediment transport
Three-phase flows	Bubbles in a slurry flow, Droplets/particles in gaseous flows

3

Flow patterns/ Flow Regimes

- The behavior and the shape of the interface between phases in a multiphase mixture is referred as the flow regime or the Flow pattern
- There are competing forces or mechanisms occurring within the multiphase fluid at the same time. the balance between these forces determines the flow pattern

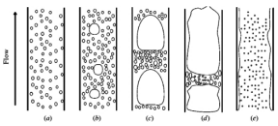
The several factors that dictate the flow pattern are

1)Phase properties, velocities, fractions

2)Operating pressure and temperature

3)Conduit diameter,shape,inclination and roughness

4)Presence off any upstream or downstream pipe work (bends, valves)



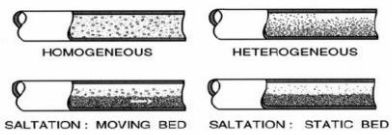
4

Importance of Flow Regime Predictions

- Better predictions of ΔP and Holdup (volume fraction), if flow regime is known.
- Flow regime prediction is not only important for reliable design, but for pipeline operability.
- Phenomena like pipe corrosion and erosion depend on flow regimes.
- Distribution of corrosion, hydrate etc. inhibitors depend on flow regimes.
- Flow regime at pipe outlet affects gas-liquid separation efficiency.

5

Different Flow Regimes in a Horizontal Pipe for Liquid-Solid System

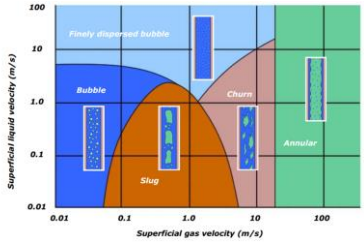


Flow regimes for liquid-solid slurry flow in a horizontal pipe

6

Flow pattern: Gas-liquid flows vertical view

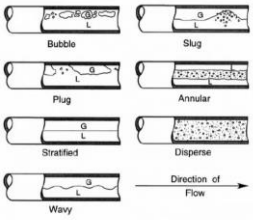
7



Superficial velocity (or superficial flow velocity), in engineering of multiphase flows and flows in porous media, is a hypothetical (artificial) flow velocity calculated as if the given phase or fluid were the only one flowing or present in a given cross sectional area.

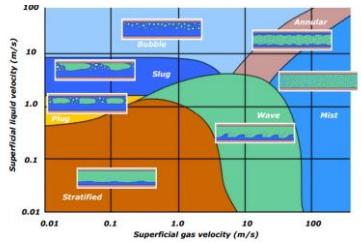
8

Different Flow Regimes in a Horizontal Pipe for Gas-Liquid System



Sketches of flow regimes for flow of air/water mixtures in a horizontal, ***5.1 cm*** *diameter pipe. Adapted from Weisman (1983).*

9



Superficial velocity (or superficial flow velocity), in engineering of multiphase flows and flows in porous media, is a hypothetical (artificial) flow velocity calculated as if the given phase or fluid were the only one flowing or present in a given cross sectional area

10

Multiphase Flow Metering principles

- The objective of multiphase flow metering(MFM) is to determine the flow rates of the individual components .
- The number of instruments depends upon whether or not the three components can be mixed together upstream

of the instrumentation.

Homogenous flow

1. The fluids are uniformly mixed and moving as a pseudo fluid at the mixture velocity.
2. The slip velocity between the phases negligible which implies that both the fluids are moving at an average velocity.
3. Attainment of thermodynamics equilibrium between the phases.

If the homogeneity of flow can be achieved, number of measurements can be reduced.

11

IN PRINCIPLE:
responses R_1, R_2, R_3 are measured

$$R_1 = f_1\left(\dot{M}_G, \dot{M}_O, \dot{M}_W\right)$$
$$R_2 = f_2\left(\dot{M}_G, \dot{M}_O, \dot{M}_W\right)$$
$$R_3 = f_3\left(\dot{M}_G, \dot{M}_O, \dot{M}_W\right)$$

f_1, f_2, f_3 — established by calibration

$\dot{M}_G$, $\dot{M}_O$, $\dot{M}_W$

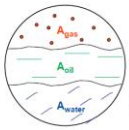
IN PRACTICE:
f_1, f_2, f_3 depend on (unknown) upstream conditions
impossible to calibrate for real fluids over full range.

Figure 3.1 The first MFM approach.

12

Mass flow rate$_{(i)}$ = Area$_{(i)}$ * Density$_{(i)}$ * Velocity$_{(i)}$

for the (i)th phase



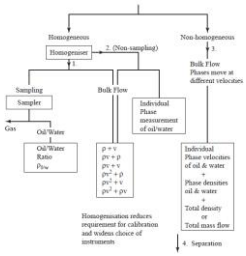
Need to measure only 2 areas.

Need to measure only 1 velocity if flow is homogenised.

Figure 3.2 The second MFM approach.

13

The Four Possible Routes to MFM



14