Presentation on : Fundamentals of pipeline design

Fundamentals of pipeline design

Key word : Introduction

pipeline design

Liquid pipelines

Gas pipelines

Two phase pipeline design

Arctic pipeline design

Energy efficiency

Introduction

- The amount of fluid flow through the pipeline is one of the first items of information required for design
- Different industries use pipeline for different purposes. requirements & types of pipe are different
- Petroleum industry & natural gas industry use steel pipe with welded joints.
- This allows the pipeline to withstand very high pressure, sometimes above 3000 psig
- High pressure allow the use of long pipelines, often more then 1000 miles with only a booster pump or station for each pipeline
- Some pipelines are designed with some excess capacity or design so capacity can be increased by the addition of compression or pumping horsepower

Key design terms

When we discuss the basic of pipeline design , it is necessary to be familiar with how key physical properties of fluids affect pipeline design. The key terms are :

- Pipe diameter
- Pipe length
- Specific gravity & density
- Compressibility
- Temperature
- Viscosity
- Pour point
- Vapor pressure
- Reynolds number
- Friction factor

Pipeline design

- The most appropriate method depends on the system, the designer, the number of fixed variables, the availability of pipe & equipment and the cost
- Pipeline design typically follow the general steps

1.required delivery pressure

2.pressure losses due to friction

3.allowable operating pressure

4.line size

5.pumping or compression horsepower

6. load determination

7.economic calculation

This simplified outline represents the basic steps involved in a preliminary design of a single pipeline with no branches connections, no alternative routes & no significant changes in Throughput during its life.

Pipeline design (contd.)

Steps in pipeline design :

- The determination of the problem which includes
  - the characteristics of the fluid , The flow rate, Head loss
  - The location of the pipelines, separator station, power plant.
  - The design code to be followed
  - The material to be used
- Determination of preliminary pipe route
- Pipe diameter based on allowable head loss
- Structural analysis includes
  - Pipe wall thickness
  - Stress analysis
- Support & anchor design
- Preparation of drawings, specification & the design report .

Pipeline design (contd.)

- pipeline design based on three board categories. They are
  1. high pressure pipes
  2. low pressure pipes
  3. intermediate pressure pipes
- High pressure pipes :
  - Internal pressure is so high
  - It dominates the design
  - Most long distance natural gas & petroleum pipelines belong to this
- Low pressure pipes :
  - Internal pressure is low
  - Design is governed by external loads
  - Most sewer pipes belong to this.

Pipeline design (contd.)

- Intermediate pressure pipes :
- Internal pressure load & the external loads are of similar magnitudes
- Both must be considered
- This group includes pressure sewer pipes, water pipes & certain petroleum & natural gas pipe

Liquids pipelines

- The design of a liquids pipeline is similar in concept to the design of a natural gas pipeline. In both cases, a delivery pressure & the volume the pipeline must handle are known,
- The allowable working pressure of the pipe can be determined by using pipe size & type & specified safety factor.
- petroleum products transported in liquid pipelines are :

- Crude oil
- Gasoline
- Aviation gasoline
- Distillate fuel oils
- Jet fuel
- Anhydrous ammonia
- Liquefied petroleum gases (LPG)
- Diesel fuel

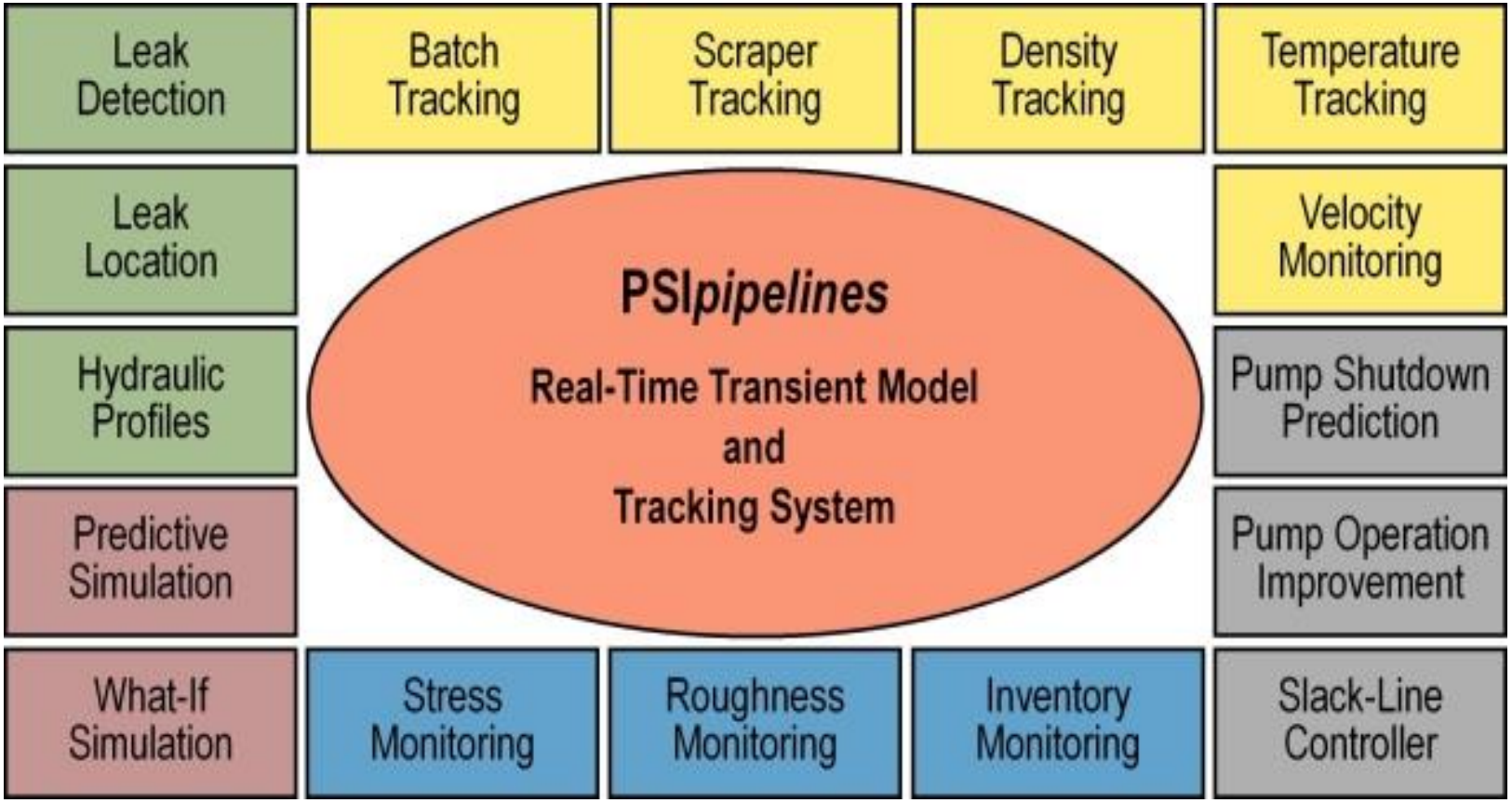
Liquid pipeline (contd.)

- pressure drop calculation : Bernoulli's theorem describes the flow of fluids –gases & -liquids in a pipe the general equation for the flow of liquids in a pipe is Darcy's formula. To determine pressure drop, for instance, the equation is used in this form
- $dp = \frac{\grave{\rho} f l \text{-} v^2}{144 D 2 g}$

where,

- P = pressure drop, psig
- P= density of fluid, lb/ft^3
- f= friction factor, dimensionless
- L=length of pipe, ft
- v=velocity of flow, ft/sec
- D= inside diameter of pipe, ft
- g= acceleration of gravity, ft/sec^2

Fundamental components for liquid pipeline



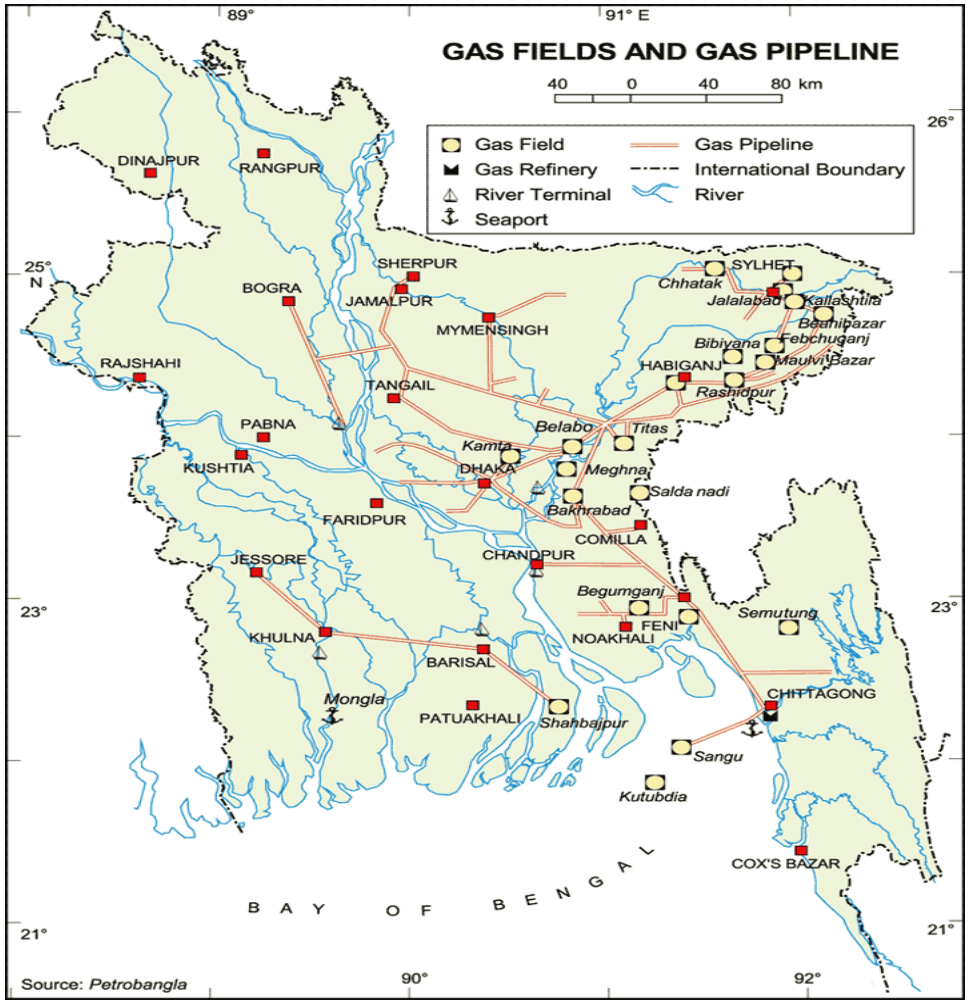
Gas pipelines

The flow of gas in a pipeline is effected by :

- pressure
- Temperature
- Pipe diameter
- Pipe length
- Specific gravity
- Pipe roughness
- Gas deviation

Darcy's equation can also be used in flow calculation but it must be done with care & restriction on its use are recommended.

Gas fields & gas pipelines in Bangladesh



Pipeline of Titas gas field

Two Phase Pipeline Design

- There are situations in which are economically advantageous to transport both liquid and gas in a single pipeline simultaneously .This is called Two phase flow pipeline.

- An example of two phase flow pipeline involves certain offshore oil operation, where it is extremely expensive to separate the liquid and gas phases in deep water.

Two phase flow pipeline design Consideration

- Some things have to consider before designing two phase flow pipelines. These are

1. Pipe size
2. Flow capacity
3. Pressure drop
4. Liquid holdup
5. Flow regimes

Two phase pipeline design Consideration

- Pressure drop:

Two phase flow technology is much more complex than single phase flow technology. Experimental studies reveal that two phase flow shows larger pressure drops compare to single phase flow.

Two components of pressure drop are

1.The pressure due to friction

2.The pressure drop due to head of liquid in inclined lines

Two phase flow pipeline design consideration

- Flow Regime:

Flow regime is a term used to characterize how liquid and gas flow within the pipeline.

Some Flow Regimes can be classified into two categories:

1. Horizontal fluid Flow
2. Vertical fluid flow

Flow Regimes

- Horizontal Fluid flow:

  Horizontal flows are

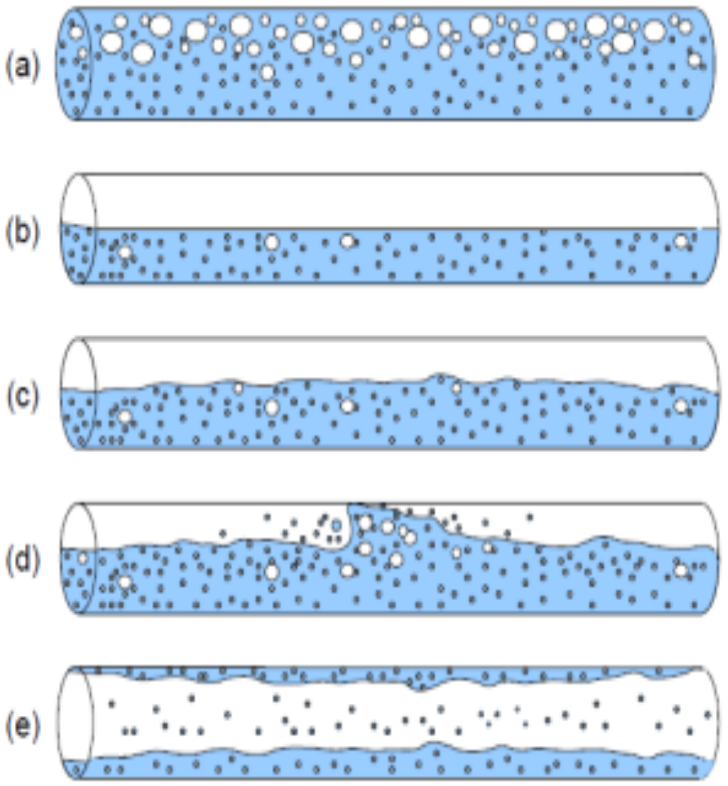
  a. Bubble Flow

  b. Stratified Flow

  c. Wavy Flow

  d. Slug Flow

  e. Annular flow



Flow Regimes

- Vertical Fluid Flow

Vertical flows are

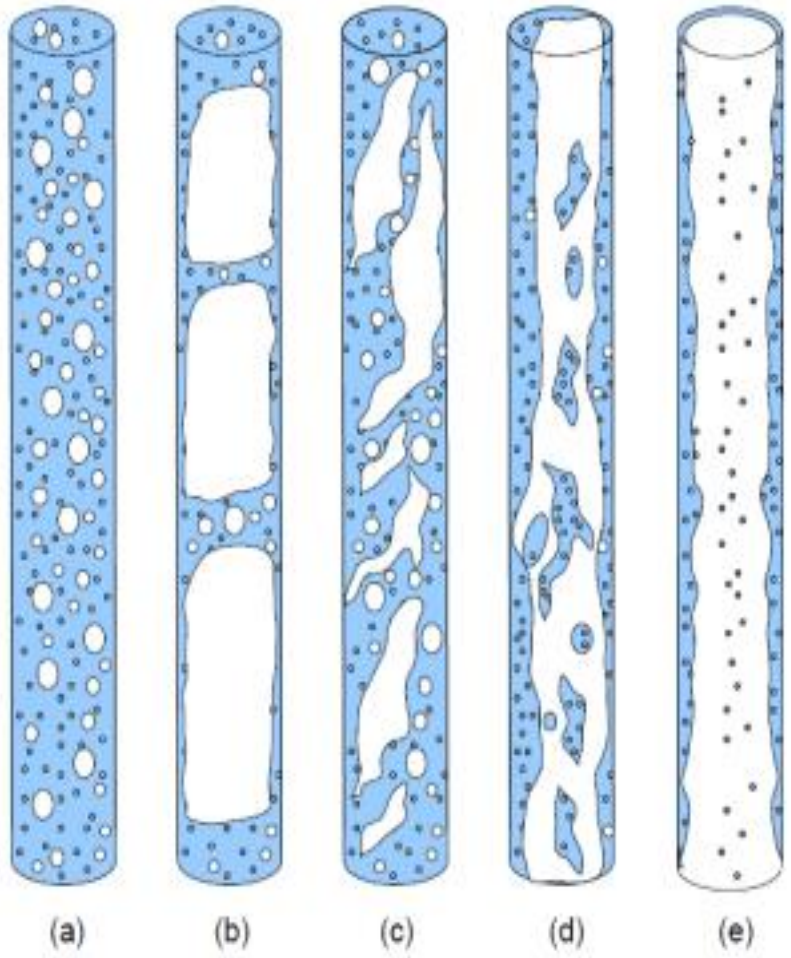
a. Bubble flow

b. Plug slug flow

c. Foam flow

d. Annular streak flow

e. Annular Flow



Arctic Pipeline design

- Several Special Considerations must be included in designing an oil or gas pipeline for Arctic zone. Such as

1. Temperature
2. Internal pressure
3. Ice gouging
4. Permafrost thaw settlement
5. Frost heave
6. Strudel scour

Arctic pipeline

Trans Alaska oil pipeline in the north side of Antigun

Arctic Pipeline

Trans ALASKA OIL pipeline

Arctic Pipeline Design Process

- Because of the significant uncertainties associated with the inputs and models used in the design process, it is suggested that reliability-based design methods provide the most rational approach.
- Reliability-based design and assessment is an iterative process to search for a cost-effective set of design and operational parameters that meet a set of target reliability levels for all applicable limit states.
- The first three steps compile the models and data required to calculate reliability, by identifying the relevant limit states, formulating a limit state functions for each, and selecting appropriate probabilistic models for the corresponding basic random variables.

Design process

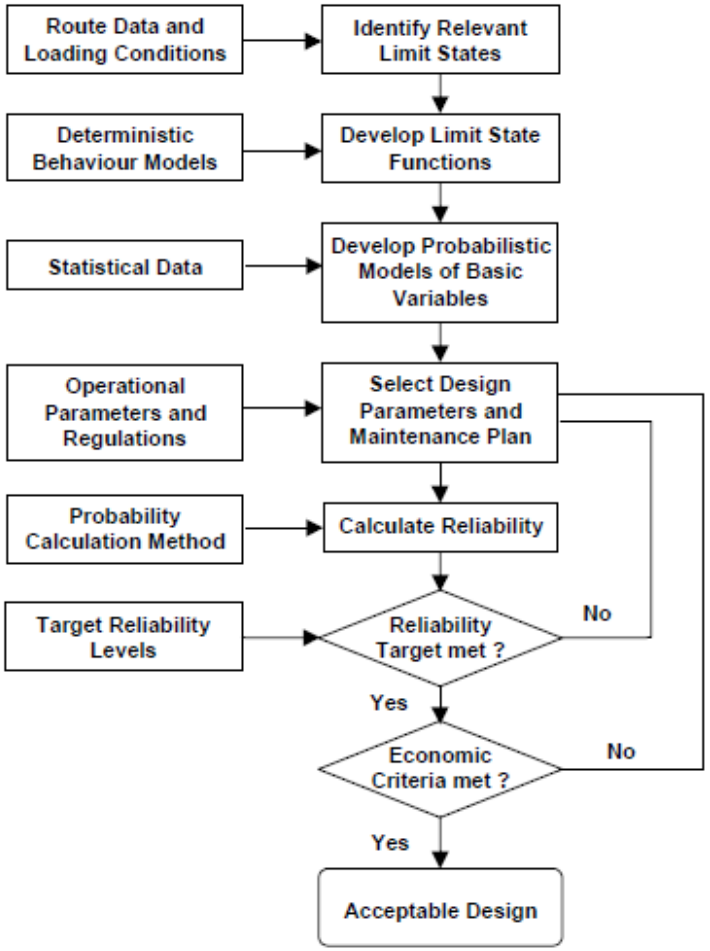


Figure 8 Reliability-based Design Process

Energy Efficiency

- Many Decision on designing for energy efficiency or for increasing the efficiency of existing system hinge on the trade off between larger lines and greater pumping or compression horsepower. Engine fuel is typically the largest use of energy in a pipeline system.
- Some approaches to compressor station design also can save energy

1.Use proper pipe diameter and full ported valves to keep piping pressure losses to a minimum.

2. Design Scrubbers and other vessels in the station for a minimum pressure loss.

3.Use measurement devices other than orifice meter to reduce compressor station pressure losses further.

Pipeline design Problem

- Steel selection is critical in special environments such as the arctic and offshore.
- Calculation of laying stresses is an important part of offshore pipeline design. Pipe stresses are often greater during installation.
- Calculating buckling and collapse resistance
- Change in temperature
- Calculating pump and compressors horsepower and pressure drop calculation
- Corrosion control
- Station design
- Economic calculation