CHAPTER - 4

RESEARCH OUTLINE

4.1 OVERVIEW

Field testing, experimentation and empirical correlation development are major steps in any research project. Suitable and adequate experimental facility shall be planned and built up. In this section the field testing facility is properly described and the various hardware requirements such as mechanical, instrumentation & control system, software and other requirements are mentioned and set up.

4.2 EXPERIMENTS AND SIMULATIONS

4.2.1 EMPIRICAL CORRELATIONS BASED ON FIELD TEST RESULTS

Correlations to determine the pig travel time based on the production flow during pigging, the speed reduction due to by-pass, expected slug reduction with help of bypass, back pressure conditions in the pipeline, etc. can be evolved based on a correlation developed from experimental results.

The liquid hold up in a long distance pipeline is a function of the Gas Liquid Ratio(GLR) prevailing in the pipeline which is an indication of production level. GLR has got an inverse relation with the liquid hold up. Based on liquid hold up in the pipeline, the back pressure starts increasing earlier or later while pigging. A simple correlation for the inventory collected during pigging is proposed in this paper. Empirical equations were developed to
describe the flow characteristics of by-pass pig. Slope of best fit was done. Regression fit is developed based on the data using straight line model

\[ Y = mX + C. \]

- Eqn (4.1)

### 4.2.2 FIELD TESTING SYSTEM HARDWARE DEVELOPMENT

There are few major facility requirement for carrying out pigging operations and field testing. Following are the main hardware requirement:

- Pipeline with Riser System
- Pig Launcher & Pig Receiver Facility
- The PIG
- Pig Tracking System
- Data Gathering System

Following figures shows a typical long distance offshore subsea pipeline profile and pigging operation set up in the field. The subsea in filed pipeline transports multiphase fluid (oil, gas, water, with little sand and wax particles) from wellhead platforms to the nearest Block collection platform. From the Block collection platform the multiphase fluid is transported to Onshore processing plant through a subsea trunk pipeline. The offshore riser portion is in the order of 30-40 meter long. The flow pipeline profile has high potential for slugging at sub optimal flow rate.

Fig 4.1 provides the elevation profile of a typical 30” subsea pipeline. The pipeline starts from the top deck of platform which is approximately 20 meter above the sea level. The approximate water depth in the area is 25 meter. The pipeline terrain is non uniform. Various
colours are used for indicating Riser, Offshore and Onshore portion of the pipeline. The receiving end also has very bad profile which leads to severe slugging phenomenon.

![Fig 4.1: Typical 30” pipeline elevation profile](image)

Below figures (Fig 4.2a, Fig 4.2b, Fig 4.2c) shows an overall field arrangement for pigging operations. There are 3 main facilities for carrying out successful pigging operation. First is the pig launching and receiving system with pipeline manifold. Next is the instrumentation and data acquisition system for collecting and recording valuable field data during actual operation and the third is the advanced pig tracking system for monitoring the pig movement inside the pipeline.
Fig 4.2a: Pigging System Set Up with Pig Launcher/Receiver & Pipeline manifold

Fig 4.2b: Data Monitoring and Acquisition arrangement with Pinger
Fig 4.2c: Pig tracking unit

Figure Fig 4.3 below shows the field flow schematic of general pigging operation.

Fig 4.3: Offshore pipeline pigging flow scheme
Key drivers of pigging in a system are wax and sand control specially at winter conditions where the fluid temperature drops down below the Wax Appearance Temperature (WAT).

Mechanical Pigging operation is a regular and vital flow assurance tool in the field. Normal bi-directional by-pass pigs are commonly used in the field to reduce production and process upset and to control the pig velocity. Several pigging operations were carried out in many of the selected pipelines with bypass pigs at different operating and flow conditions.

Mechanical Pigging operation is a regular and vital flow assurance tool in the field. Normal bi-directional bypass pigs are commonly used in the field to reduce production and process upset and to control the pig velocity. Several pigging operations were carried out in many of the selected pipelines with bypass pigs at different operating and flow conditions.

The PIG

Depending on the purpose of the pipeline pigging operation all cleaning tools can be equipped with different accessories such as:

- Gauge Plate
- Spider nose
- Brushes
- Magnets
- Tool Location Transmitter
- Pressure Bypass Nose

A combination of above-mentioned accessories is also possible

Tool Specifications

Pipeline tools for cleaning, gauging and batching are built using materials according to the following standard specifications (as far as applicable to the model/configuration concerned):

**Guiding Discs**: Proprietary polyurethane composition with High Wear Resistance.

**Sealing Discs**: Proprietary polyurethane composition with High Wear Resistance.

**Cups**: Proprietary polyurethane composition with High Wear Resistance.
**Spacer Discs**: Polyethylene

**Gauging Plates**: Aluminum, AlMg3.

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**Gauge Plate**

A gauge plate gives a first impression whether larger obstructions are to be expected in the pipeline and whether the following tools can freely pass the pipeline. The gauge plate is generally used for the first or second run only.

**Spider Nose**

The spider nose creates turbulence, thus avoiding accumulation of debris and wax in front of the tool.
Brushes

This tool type is very effective in scraping solid debris from the pipe wall.

Fig 4.6 Pig Spider nose

4.3 STATISTICAL TESTS TO TEST THE RESEARCH PROBLEM

Pig Launching and Receiving Process for field testing

The following pig launching and receiving procedure is followed for the field testing operations as a general standard.

Fig 4.7 Typical Pig Launcher

PIG Launching Procedure

1. Make sure that the isolation valve and the kicker valve are closed.
2. In liquid systems, open the drain valve and allow air to displace the liquid by opening the vent valve. In natural gas systems, open the vent and vent the launcher to atmospheric pressure.

3. When the pig launcher is completely drained (0 psi), with the vent and drain valves still open, open the trap (closure) door.

4. Install the pig with the nose firmly in contact with the reducer between the barrel and the nominal bore section of the launcher.

5. Clean the closure seal and other sealing surfaces, lubricate if necessary, and close and secure the closure door.

6. Close the drain valve. Slowly fill the trap by gradually opening the kicker valve and venting through the vent valve.

7. When filling is complete, close the vent valve to allow pressure to equalize across the isolation valve.

8. Open the isolation valve. The pig is ready for launching.

9. Partially close the main line valve. This will increase the flow through the kicker valve and behind the pig. Continue to close the main line valve until the pig leaves the trap into the main line as indicated by the pig signaller.

10. After the pig leaves the trap and enters the main line, fully open the main line valve. Close the isolation valve and the kicker valve.

11. The pig launching is complete.

**PIG Receiving Procedure**

1. Make sure the receiver is pressurized.

2. Fully open the bypass valve.

3. Fully open the isolation valve and partially close the main line valve.
4. Monitor the pig signaller for pig arrival.
5. Close the isolation valve and bypass valve.
6. Open the drain valve and the vent valve.

![Fig 4.8 Typical Pig Receiver](image)

7. Check the pressure gauge on the receiver to assure the trap is depressurized (0 psi).
8. Open the trap closure and remove the pig from the receiver.
9. Clean the closure seal and other sealing surfaces, lubricate if necessary, and close and secure the trap (closure) door.
10. Return the receiver to the original condition.

**Field Data Collection**

The Following are main sources of data for this research study project

a) Pipeline and multiphase flow parameters data collection from records
b) Pigging data collection from field experiments & records
c) Primary data collection while field application of the new design BY-PASS pig.

The data were collected during pig run operations with various pigs without by-pass hole and with different by-pass profiles.

4.4 EXPLORATORY ANALYSIS OF CONTINGENT EFFECTS

The following are main reasons for using the Exploratory Data Analysis for this project:

- Detection of mistakes
- Checking of assumptions
- Preliminary selection of appropriate models
- Determining relationships among the explanatory variables, and
- Assessing the direction and rough size of relationship between explanatory and outcome variables.

Pigging input and output data from all the field experiments are generally collected into a rectangular array (e.g. spreadsheet or database), most commonly with one row per experimental subject and one column for each subject identified, outcome variable, and explanatory variable. Each column contains the numeric values for a particular quantitative variable or the levels for a categorical variable. (Some more complicated experiments require a more complex data layout.). The details of the field test data collection is as per APPENDIX-A2. Graphical and non-graphical representations along with single and multivariate analysis are followed with different combinations.

4.5 SUMMARY

The section presented the details of the test facilities and various components that have been used to test different pig profile and develop the empirical correlation and test the new profile and model. Development of proper and adequate field testing set up/facility is very important for model testing and validation. System adequacy and reliability is also very vital
to get accurate data. All system components shall be properly calibrated and in good operating condition.