

I

Fundamental Principles of Pigging Technology

1

Introduction to Pigging Technology

1.1

Historical Development and Definition

Pigging technology can be regarded as a subdivision of materials-transport and cleaning technology. It is a strongly interdisciplinary field with close contact to fluid mechanics, pipeline technology, and chemical engineering. Theoretical investigations are based on findings from tribology, the theory of friction, lubrication, and wear.

A general definition of pigging is the propulsion through a pipe of a mobile plug pig which can execute certain activities inside the pipe.

Pigging can be used, for example, to clean a pipe mechanically (pig with brushes), to check a channel (pig with video camera), or to inspect the welding seams of pipelines (pig with eddy current sensors).

On the basis of applications in the oil industry (pipelines), which began as early as the late 1800s, from ca. 1970 onwards more precisely cleaning and sealing pigs were introduced in the chemical industry; the first industrial pigging units resulted. The pig was developed into a snug-fitting plug. These pigging units are used primarily to remove a product from a pipeline. Apart from the pig, other components such as pipes, valves, and the control system had to be selected carefully and adapted to each other.

The following, more precise definition is valid mainly for applications in the chemical industry [1]; it defines a pigging procedure in an industrial pigging unit:

In pigging the contents of a pipeline are pushed by a snug-fitting plug (pig) with the goal of removing the product almost completely from the pipeline. The pig is propelled through the pipe by a gas or a liquid (propellant).

The pig can be spherical, elongated, or composed of several parts. The pig is oversized relative to the pipe; thus, the pipe is sealed in front of and behind the pig, and the pig can be driven by a gaseous or a liquid propellant.

The gas most frequently is used compressed air, and the liquid can be e.g. water, cleaning agent or product.

This book primarily deals with industrial pigging units in the chemical industry. However, special chapters treat other branches of pigging such as sterile and pipeline technology.

Table 1–1. Types of pigs

Type of pig	Driving mechanism	Driving energy	Signal transmission	Main application
Snug-fitting, sealing	propellant medium	external pump	magnet sensor	industrial pigging systems
Brush pigs and /or intelligent pigs with sealing effect, body with sealing elements	propellant medium	external pump	magnet/sensor, telemetry, signal storage	industrial pigging systems, pipelines
Driven friction wheels for motion and/or centering, inspection pigs with wheels	electric motor	battery	magnet/sensor, telemetry, signal storage	pipelines, open channels, sewage pipes
Pulled and/or pushed pigs	cable winch	external motor	magnet/sensor, telemetry, signal storage	pipelines, open channels, sewage pipes
Jets with hose attachment	repulsion, pulsed ejections of a liquid	external pump		pipelines, open channels, sewage pipes.

Pigging Unit and Types of Pigs

Often pigging is a one-off procedure, for example, when a pipeline is assembled or inspected. For such purposes mobile pigging units are available.

On the other hand, in industrial pigging units pig runs take place regularly and at short time intervals and the equipment required for pigging is a fixed part of the plant.

Such an industrial pigging unit usually consists of the following components:

- Pig
- Piggable pipe with piggable valves
- Pig loading and unloading station
- Propellant supply
- Control system

In the simplest case the pigging unit (see Fig. 1–1) consists of a single pipe, which is travelled by a pig. The entire pigging line, including the valves, must be piggable.

Pigs, the mobile part of pigging units, are available in innumerable designs, sizes, and materials: From simple spherical pigs, mandrel pigs, separating pigs, and isolating pigs to in-line testing and inspection pigs; and from the fluid-driven pigs to self-driven camera vehicles. The total range of applications of pigs is thus very large.

At the beginning and end of the pigging line, pig stations are located. The control system for the pigging unit can be a component of the overriding distributed control system (DCS) of the plant.

Table 1.1 summarizes of the different types of pigs.

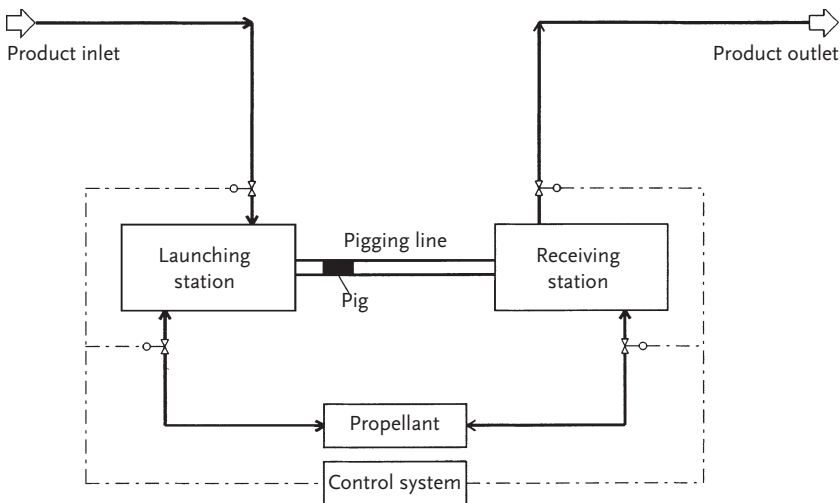


Fig. 1–1. Overview of the components of a pigging unit

1.2

Fields of Application of Pigging Technology

Concerning the piggability of products, in principle you can say: “if you can pump it, you can pig it.”

Gas pipelines must be freed of the condensate that accumulates in low-lying sections, and in crude oil and mineral oil pipelines paraffin deposits must be removed. Apart from cleaning, inspection of these pipelines is also of importance. With pipelines the interior condition, the welding seams, the wall thickness, and the surface quality are checked.

Channels and sewers must be examined and maintained.

In sterile technology frequent cleaning is necessary to maintain quality. In many cases cleaning of the pipes can be performed reliably by pigging [2].

The most important applications of pigging are:

- Sweeping liquids from pipelines.
- Removing incrustations and deposits.
- Removing condensate (gas pipelines).
- Filling/emptying of a pipeline by a plug flow.
- Separation of products pumped one after the other in the same pipeline (e.g., product A – pig 1 – product B – pig 2 – propellant). This process is called “batch pigging”.
- Inspection, detecting and observation.
- Cleaning.
- Measurement and control.
- Repairing.

The applications of industrial pigging units encompass four major tasks:

- Several products are pumped through a single pipe. Instead of many individual lines only one pigging line is required. A pig run is required for each change of product.
- Product is removed from a pipe, i.e., the pipe is cleaned by pushing the product almost completely out. Moreover product can be removed from a pipeline without any slope or from a pipeline with siphons.
- Rinsing a pipeline with a cleaning agent and/or a solvent (e.g., water) contained between two pigs running in the same direction (tandem pigging).
- Foaming is prevented or reduced by a pig in front of the product. For an initially empty pipe, especially one with a downward slope, a pig driven by the product results in gentle transport, and mixing with air is avoided.

In chemical plants pigging can be applied in various locations:

- Between vessels in a production plant (e.g., vessel–filter, reactor–vessel, stirred tank–vessel).
- In the connections of plant sections outside the process building, (e.g., crude plant–pure plant, process plant–tank farm, tank farm–filling facilities).

Since these parts of a plant are usually connected to many individual pipelines, a pigging unit can be valuable here.

In particular with long pipelines, multiproduct plants, and batch operation the economic benefits of pigging become apparent:

- One pipeline for several products (saves on investment costs and space requirement).
- Easy emptying of the pipeline in the case of products which can freeze, condense, decompose, or polymerise.
- No need for insulation and/or tracing.
- Saving of time relative to a manual emptying.
- No rinsing procedures or substantially smaller amounts of cleaning agents (lower chemical oxygen demand (COD), lower incineration costs, reduced losses of valuable product).
- No slope necessary, to empty the pipeline completely, siphons are allowed.

Especially these benefits helped the breakthrough of pigging technology in the chemical industry. However numerous problems have to be solved in this area, such as material resistance and selection of the pig type and the pigging system, so that plant design requires careful coordination with the operator. This is a topic of the following chapters of the book.

