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PIG TECHNOLOGY FOR OIL PIPELINE SERVICE

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Introducnion

A "pig" in the pipeline industry is a tool that is sent down a pipeline and propelled by the pressure of the product flow in the pipeline itself, see Fig. 1. There are four main uses for pigs:

1. Physical separation between different fluids flowing through the pipeline
2. Internal cleaning of pipelines
3. Inspection of the condition of pipeline walls (also known as an Inline Inspection (ILI) tool)
4. Capturing and recording geometric information relating to pipelines (e.g., size, position).

One of the most common and versatile is the foam pig which is cut or poured out of open cell polyurethane foam into the shape of a bullet and is driven through pipelines for many reasons such as to prove the inner diameter of, clean, de-water, or dry out the line. There are several types of pigs for cleaning in various densities from 2 lb to 10 lb foam and in special applications up to 20 lb. Some have tungsten studs or abrasive wire mesh on the outside to cut rust, scale, or paraffin wax deposits off the inside of the pipe. Other types are fully or criss-cross coated in urethane, or there are bare polyurethane foam pigs with a urethane coating just on the rear to seal and assist in driving the pig. There are also fully molded urethane pigs used for liquid removal or batching several different products in one line.

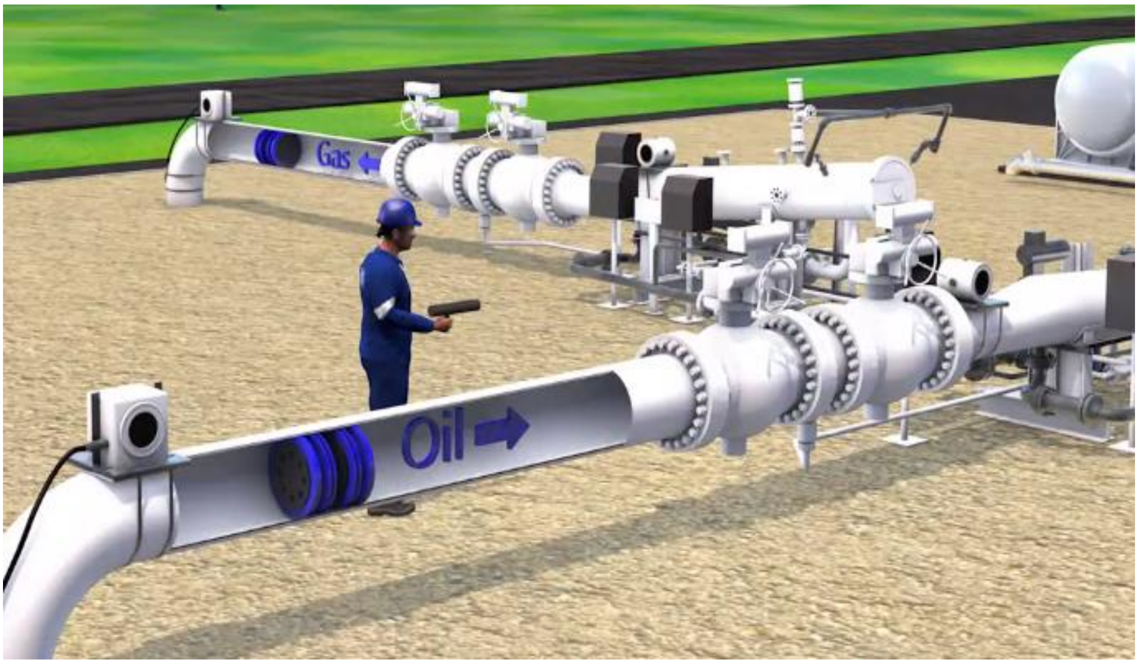

Fig. 1. A pig in a pipeline

Inline inspection pig

Inline inspection pigs use various methods for inspecting a pipeline. A sizing pig uses one (or more) notched round metal plates as gauges. The notches allow different parts of the plate to bend when a bore restriction is encountered. More complex systems exist for inspecting various aspects of the pipeline. Intelligent pigs are used to inspect the pipeline with sensors and record the data for later analysis. These pigs use technologies such as magnetic flux leakage (MFL) and ultrasound to inspect the pipeline. Intelligent pigs may also use calipers to measure the inside geometry of the pipeline.

In 1961, the first intelligent pig was run by Shell Development. It demonstrated that a self-contained electronic instrument could traverse a pipeline while measuring and recording wall thickness. The instrument used electromagnetic fields to sense wall integrity. In 1964 Tuboscope ran the first commercial instrument. It used MFL technology to inspect the bottom portion of the pipeline. The system used a black box similar to those used on aircraft to record the information; it was basically a highly customized analog tape recorder. Until recently, tape recording (although digital) was still the preferred recording medium. As the capacity and reliability of solid-state memory improved, most recording media moved away from tape to solid-state.

Capacitive sensor probes are used to detect defects in polyethylene pipe gas pipeline. These probes are attached to the pig before it is sent through the polyethylene pipe to detect any defects in the outside of the pipe wall. This is done by using a triple plate capacitive sensor in which electrostatic waves are propagated outward through the pipe's wall. Any change in dielectric material results in a change in capacitance. Testing was conducted by NETL DOE research lab at the Battelle West Jefferson's Pipeline Simulation Facility (PSF) near Columbus, Ohio.

Intelligent pig

Modern intelligent or "smart" pigs are highly sophisticated instruments that include electronics and sensors that collect various forms of data during their trip through the pipeline. They vary in technology and complexity depending on the intended use and the manufacturer.

The electronics are sealed to prevent leakage of the pipeline product into the electronics since products can range from being highly basic to highly acidic and can be of extremely high pressure and temperature. Many pigs use specific materials according to the product in the pipeline. Power for the electronics is typically provided by onboard batteries which are also sealed. Data recording may be by various means ranging from analog tape, digital tape, or solid-state memory in more modern units.

The technology used varies by the service required and the design of the pig; each pigging service provider may have unique and proprietary technologies to accomplish the service. Surface pitting and corrosion, as well as cracks and weld defects in steel/ferrous pipelines are often detected using magnetic flux leakage (MFL) pigs. Other "smart" pigs use electromagnetic acoustic transducers to detect pipe defects. Caliper pigs can measure the roundness of the pipeline to determine areas of crushing or other deformations. Some smart pigs use a combination of technologies, such as providing MFL and caliper functions in a single tool. Trials of pigs using acoustic resonance technology have been reported.

During the pigging run the pig is unable to directly communicate with the outside world due to the distance underground or underwater and/or the materials that the pipe is made of. For example, steel pipelines effectively prevent any significant radio communications outside the pipe. It is therefore necessary that the pig use internal means to record its own movement during the trip. This may be done by odometers, gyroscope-assisted tilt sensors and other technologies. The pig records this positional data so that the distance it moves along with any bends can be interpreted later to determine the exact path taken.

Location verification

Location verification is often accomplished by surface instruments that record the pig's passage by either audible, magnetic, radio-transmission or other means. The sensors record when they detect the passage of the pig (time-of-arrival); this is then compared to the internal record for verification or adjustment. The external sensors may have Global Positioning System capability to assist in their location. A few pig passage indicators transmit the pig's passage, time and location, via satellite uplink. The pig itself cannot use GPS as the metal pipe blocks satellite signals.

After the pigging run has been completed, the positional data from the external sensors is combined with the pipeline evaluation data (corrosion, cracks, etc.) from the pig to provide a location-specific defect map and characterization. In other words, the combined data reveals to the operator the location, type and size of each pipe defect. This information is used to judge the severity of the defect and help repair crews locate and repair the defect quickly without having to dig up excessive amounts of pipeline. By evaluating the rate of change of a particular defect over several years, proactive plans can be made to repair the pipeline before any leakage or environmental damage occurs.

The inspection results are typically archived for comparison with the results of later pigging runs on the same pipeline.

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