

## Original Research Article

## In Investigating the Use of Pigs in Gas Transmission Pipelines

Andi Johnson<sup>1\*</sup>, Andi Brous<sup>1</sup>, Amir Samimi<sup>2</sup>

<sup>1</sup>Department of Research and Development, UOP, Santiago, Chile

<sup>2</sup>Ph.D. of Science in Chemical Engineering, Process Engineer & Risk Specialist in Industries, Iran

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### ABSTRACT

The purpose of this study is to investigate the pigging operation, why it is done, the types of pigments available, and its importance in the gas industry. It is important to identify clogs and reopen them, as well as to identify cracks and corrosion in valves and pipes. The main advantages of piglets include the low-cost cleaning of pipelines, the possibility of rapid sampling inside the pipes to detect and test for impurities, the possibility of inspecting pipelines without the need for power outages, and the ability to use PLCs. In water and sewage pipelines, oil and gas, and petrochemical pipelines have a basic application for cleaning and inspection of pipelines. This study reviews the generalities of pig, pipeline operations, and new aspects of recent technologies in this field, including necessity, capacities, challenges, and innovations of pipeline technology in the maintenance and operation of oil and gas pipelines and the other hydrocarbon products, introducing the types of used pigs, factors for selecting the appropriate pig in terms of application, cleaning, inspection and monitoring of pipelines, comparison and applications of smart pigs, and how they work and record problems in pipelines, decontamination. The results of this study indicated that one of the important strategies in the field of reforming and performing the follow-up process can be increased the statistical research in order to develop practical regulations related to the maintenance of pipelines along with the responsibility of production and transmission.

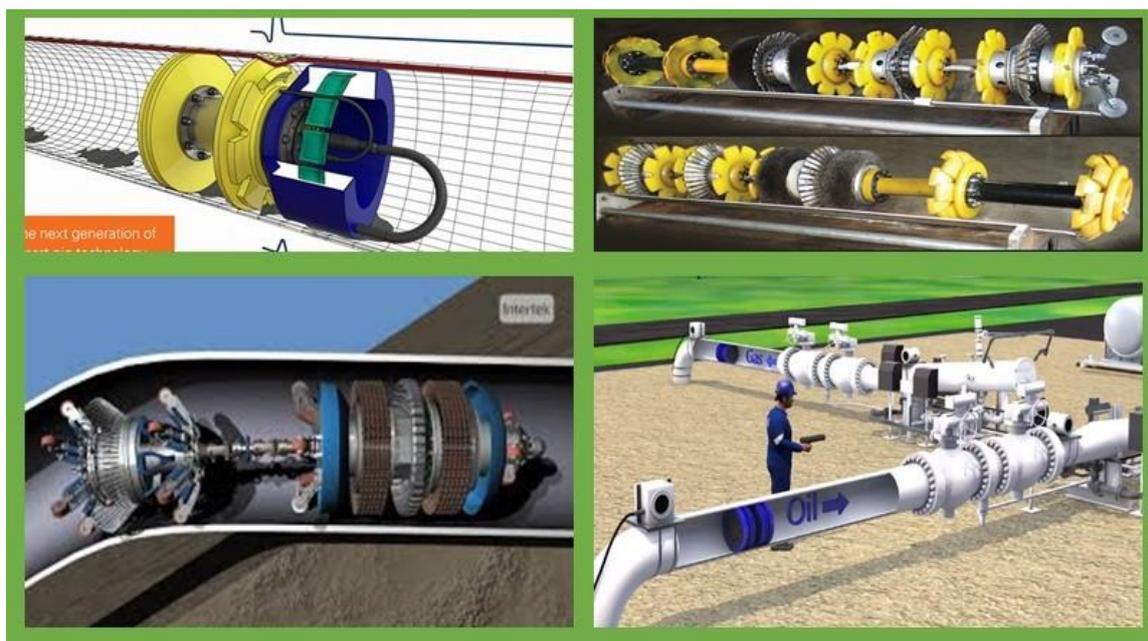
\* Corresponding author: Andi Johnson

✉ E-mail: [andi.johnson.uop@gmail.com](mailto:andi.johnson.uop@gmail.com)

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**GRAPHICAL ABSTRACT**

**Introduction**

The main function of the pipeline is the efficient and reliable transfer of one or more products in the form of fluid or gas [1]. Compared to the other methods such as transportation by tanker, etc., selecting the pipeline and continuing to use it, brings convenience and economic savings, greater safety, and reduced risk. The inspection of oil and gas pipelines and efforts to maintain the flow of crude oil and gas are of great importance. In this regard, it is notable that Iran has 14,000 kilometers of oil pipelines and more than 40,000 kilometers of gas pipelines [2-4]. Leaks in transmission lines, in addition to wasting national resources and wastage of petroleum products in the transmission network, disrupt the activities of refineries and consumers, as well as environmental pollution [5]. Some pipelines in the country are more than 40 years old and due to the end of the design of pipelines in our country, and also the country's future plans to expand the network of oil and gas transmission lines, the need for a monitoring system to detect leaks and prevent makes the pipe burst necessary. It should be noted that

corrosion, geographical, and climatic phenomena (such as floods, earthquakes, and landslides), the third-party interventions such as civil works in the area of pipelines, and also increase the life of pipelines, the end of their design life, and consequently increase the phenomenon. Leaks all affect the proper functioning of the network [6]. Today, the advanced systems in the world have been developed to be applicable to new pipelines, but not to the old pipelines, and to have their own complexities. The leakage of hydrocarbon materials in our country has so far caused extensive environmental damage in the fields, river water, and in some cases, it has caused fires in the villages along the pipeline [7]. Sometimes the leak has caused billions in damage to the villages and residents around the pipeline. According to the statistics, in recent years, 6 leaks due to corrosion and 3 cases due to the third-party interventions in the country have caused the bursting of oil pipelines and 4 cases of gas leaks due to corrosion in gas pipelines have occurred. On the other hand, it should be noted that the cost of replacing oil pipelines per kilometer is \$ 20,000 that means the cost of

replacing a 42-inch pipeline is \$ 800,000. So, it is not the case that they replace the lines with an initial guess about the leak or the possibility of failure. The complete and accurate information should be collected to change lines. But this information is time consuming and costly. Therefore, the necessity of using several types of methods to collect information about the condition of pipelines becomes clear [8].

According to the statistics released by the National Gas Company in recent years, in addition to leaks in pipeline peripherals, which make up the majority of leaks. The following has also happened:

- Leakage due to the internal corrosion;
- Leakage due to the external corrosion;
- Leakage due to the pipe welding wire;
- Leakage due to BCC.

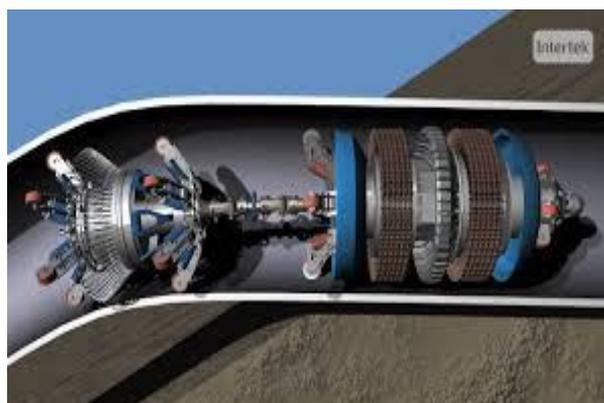
According to the accident statistics, more than 40% of accidents on pipelines have been reported by foreign forces as a result of drilling activities along the pipelines. 50% of all leaks are caused by the external forces on the pipe and the second cause of leaks in pipelines is caused by the internal and external corrosions. The total damage to pipelines, 64% is due to the external forces on the pipe, 14% engineering defects in the design and the selection of materials and construction, 13% due to corrosion and the remaining 9% are the other cases [9].

PIG (Pipeline Inspection Gauge) (Figure 1) is a device used in fluid transfer pipes including water, sewage, oil, and gas pipes. Pigs are commonly used for the following purposes:

- Pipe cleaning
- Creating a physical barrier between two different fluids
- Pipe body monitoring
- Record geometric pipeline information.

Using pigs inside pipes is called “pigmentation”. Tracing is possible without stopping the flow of a fluid. The primary pigments are used only for pipe cleaning, as a low-cost and fast method. Intelligent tracking is performed by smart pigs,

which also perform tasks such as monitoring the pipe body and recording the geometric information of the pipe [10]. The main advantages of pigs are low-cost cleaning of pipelines, the possibility of rapid sampling inside the pipes to detect and test for impurities (Figure 2), the possibility of inspecting pipelines without the need for power outages, and the ability to use PLCs. It is mainly used in water and sewage pipelines, oil and gas, and petrochemical pipelines. Initially, pigtails were made of steel, but over the time, piglets and discs attached to them were made of aluminum to prevent damage to the pipe walls. The general structure of piglets is such that their main body consists of several discs and brushes, the number of which varies according to the needs of each pipeline and according to the diagnosis of experts.



**Figure 1.** PIG machine and performing pigging operations in gas and oil pipelines Royal tube cover [1]



**Figure 2.** Pipeline Inspection Gauge in gas pipeline [2]

### Types of Pigs and Piglets

Smart piglets are the newest and the latest type of piglets made and is the only non-destructive testing tools in this field which have the ability to detect cracks, corrosion, cavities, and record general information of geometry and deformation of pipes by two methods of magnetic flux leakage, as (MFL) and Ultrasonic. The other types of pigs are mentioned as follow:

**General pigs:** Utility PIGs have different sizes, the number of heads (cops), and the number of different brushes, the choice of which is different for various applications. The pig enters the pipeline by means of a transmitter trap (PIG Launcher), and then moves inside the pipe by the pressure of the normal fluid flow; to reach the PIG Catcher at the end of the pipeline [11]. Pigging is used in many applications such as mixing, storage, lubrication, painting, chemicals, sanitation, food, oil, and gas pipelines, etc. (Figure 3).

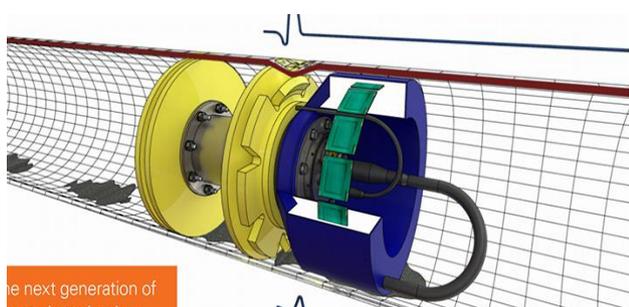


Figure 3. Smart Pigging Solutions [9].

**Pig gels:** Chemical gels are water, hydrocarbon, and acid based, have a good flexibility and are commonly used to purify water and oil. The advantage of chemical pigments over mechanical pigments is that they do not get stuck in the pipe and are biodegradable (Figure 4).

**Metal body pigments:** Metal body pigments, rods, or axles are produced and used in a wide range in terms of the number of heads (cups), brushes, or equipment (Figure 4).

**Balls:** They can be used to separate fluid and pass through the elbow less than 3D (Figure 6).

**Foam pigments:** It is suitable for drying lines from liquids and transferring some fluids based on hydrocarbons and water, and there is no restriction in passing through sections less than 3D.

**Special pigs:** In special operating conditions, in cases where the use of common pigs is not possible; the Special pigs are designed and produced.

**Solid cast pigments:** They can be used for hydrocarbon lines, water, some petrochemical products, and lines which have not been previously formed (Figure 5).



Figure 4. Difference between pig locating and pig tracking [4]



Figure 4. Metal body pigments in pipeline [9]



**Figure 5.** Solid cast pigments in pipe line [3]



**Figure 6.** Pipeline Equipment: The Re-Emergence of Spherical Pigs [12]



**Figure 7.** Foam Pigs Bare Foam Pigs, Medium Density Bare Pipeline [11]

**Smart PIG:** The Intelligent PIG or (Smart PIG), as the only means of carrying non-destructive testing equipment, is a pig which is responsible for collecting various information about its travel path. Different technologies are used in smart pigs that Pig capabilities are defined based on the defined needs and pig design [12].

These capabilities include pitting detection, corrosion, crack, and welding effects. Magnetic Flux Leakage (MFL) or Ultra-sonics are two methods of monitoring the pipe body. Caliper PIGs have further the ability to measure the pipe's sphere to find fractures and deformations and generally record the geometric information of the pipe. By the above methods, the location of defects, their type, and size can be determined and they can be eliminated by digging the location of the defects. Leaks and defects can also be predicted by creating a fault map [13].

It is necessary to completely seal the electronic components of this type of pig to prevent the contents of the pipeline from entering, and in some cases, due to the corrosive materials and very high temperatures. The power of the device is supplied through sealed batteries. There are two types of traps in tracking operations; Pigrani enters the pipeline through a launcher and moves along the pipes with a normal flow of fluid to collect information, and then transfer it to the end of the pipeline to be trapped by the receiver in which it is located. When the pig moves inside the pipe, any obstacle or object which passes by it covers the pig plate in the interval when the pig completely passes by the said object; by examining and tracking the areas in which the pig has crossed the obstacles, it is possible to identify the problematic parts of the pipe and take further steps to correct them [14].

#### **Practical tools for pigs**

In addition to the use of piglets, the other auxiliary tools can be used that increase the use of piglets. These tools can have different capabilities and do their job by connecting to the pig during the search. Some examples of the most important of these tools are:

- Pipeline data logger (Data Logger) is a device which can connect data to the pig, can retrieve data from the environment inside the pipeline. The data vectors have the ability to extract the temperature of the fluid along the pipeline as well as to measure the

pressure inside the line. This information is very important to identify the condition of the pipeline. Some types of data vectors have the ability to determine the pressure difference between the two ends of the pig, and also to determine the acceleration of the pig, which will be very useful in identifying the damaged points of the pipeline and the accuracy of the cleaning operation.

- PIG Locator is a device which can be used to locate the pig inside the pipeline. Likewise, the parts can be installed on the pipeline to ensure that the pig passes through those areas. Due to the fact that it is possible to trap the pig inside the line during the tracking operation, finding the location of the pig is of special importance (Figure 8).



**Figure 8.** Enduro Pipeline Services, Inline Inspection [15]

### **Pipeline Risk Assessment and Pigging Operations in the Kent Molbyer Technique**

Risk assessment is one of the most important steps in risk management that provides a powerful tool for prioritizing risks in the workplace. The popular Bow tie software is one of the newest risk assessment tools which are able to provide powerful bow tie charts of the risk assessment process. The bow tie model is a structured technique for risk assessment in cases where qualitative approaches seem impossible

or undesirable in terms of performance. Furthermore, one of the four indicators calculated in the risk assessment of pipelines with the Kent Molbyer technique is the corrosion index. The corrossions which will occur in the transmission pipeline are three types of the atmospheric corrossion, the internal corrossion, and the external corrossion. The questions that will be asked are as follow:

- What is the reason for pigeoning in pipelines?
- In which parameter is the pig operation seen in the Kent technique?
- To what extent will pigging operations affect the vulnerability of pipelines to the internal corrossion agents?
- How should the risk assessor include the presence or absence of pigeon in his assessment?

One of the parameters that is examined in the calculation of internal corrossion index in risk assessment with Kent technique is the parameter of protection measures against internal corrossion, the maximum score for this parameter is 10 points, and pigging operation as one of these measures. It has 3 points out of 10 points [16]. The risk assessor should look for evidence of principled follow-up at regular intervals. The presence of inspection documents and reports will be helpful. A pig is a cylindrical device which comes in a variety of sizes and shapes. Pigging can be used to clean the inside of the pipe from sediment, separate products, promote products, especially liquids, and collect information. How to do pigging properly will depend a lot on the skill and experience of the relevant operator [17]. Therefore, it is necessary for the operator to be able to identify the appropriate pig in terms of matching the size and type with the characteristics of the pipeline, and on the other hand, the speed of the pig in the pipeline, the distance required to travel in the pipe and the amount of driving force required. The forward pipe in the pipe also depends entirely on the

operator's diagnosis and experience. The effect which pigmentation will have in the face of internal corrosion is that the cleaning pig can reduce or eliminate the internal corrosion by removing corrosive substances. The effectiveness of compaction will be if the internal corrosion-causing material is removed before damaging the pipe wall. In addition, pig-displaced sediments can be monitored to measure internal corrosion by measuring the amount of iron dioxide in it. On the other hand, by using smart pigtails, it is possible to check the wall thickness of pipelines in different places, and thus identify and eliminate critical points before an accident occurs [18].

#### **Intelligent Pursuit; Ensures Increased Safety, Environmental Protection and Oil Transfer Efficiency**

The need for regular inspection of pipelines is very important in terms of the degree of corrosion or change in physical condition, and to deal with the possibility of damage or blockage of pipelines, regular maintenance, and inspection programs can reduce damage caused by pipeline failure and increase service life. Be systematized, one of the most important tools for conducting these inspections is intelligent tracking monitoring.

Therefore, keeping them in any situation is considered as an obligation. When intelligent piercing is performed, the internal and external corruptions are identified and exactly where the corrosion is that causes the repair to take place. Due to the fact that gas pipelines are inspected at least once a year, the use of inspection methods along with other bribes or inspections is one of the needs in this field. As a result of launching a comprehensive monitoring and control system (using other complementary methods) on pipelines, especially the old oil pipelines (16,000 km long on which new systems are not applicable) and gas, the better network management can be achieved. A study of the consumption statistics of items for pipeline

maintenance in Iran in comparison with the other oil countries compared to the flow pipelines which indicate a lack of principled attention to the category of maintenance and prevention that has negative consequences due to non-compliance with the correct principles of pipeline testing [19].

The pipe at the end of the installation and delivery process of the employer as well as the financial damage caused by the inefficient planning for following-up during the operation and for the optimal maintenance of the pipelines. Having a comprehensive plan for following-up operations during the operation of pipelines will ensure the flow continuity in the pipeline. In some cases, the fluid flow should be controlled during the operation of the pipeline operation, and in many cases, it may be necessary to adjust the fluid flow, for instance to reduce pressure or velocity. In addition, there is always the risk of the pig getting stuck in the pipeline, which may cause a complete cessation of product flow, which in some cases incurs high and unacceptable costs for opening the system (Figure 9).

However, the precise studies indicate that a comprehensive following-up program is essential for the effective operation of the system. Surveying during the construction of pipelines and after that the excavations before the commissioning of the pipelines, and also the continuous and with the program of the periodic excavations to achieve different results such as reducing the rate of corrosion, descaling separation of fluids passing through a pipeline from each other, etc., and finally the pipeline' inspection in terms of corrosion or change in its physical condition throughout the operation of the pipeline is necessary to deal with the possibility of damage or pipeline blockage developing the regular maintenance and the inspection schedules of the pipeline can greatly reduce the risk of pipeline failure and increase the service life of the system. Such programs

depend significantly on the use of multiple pigs [20]. At different stages of a pipeline life, the type and frequency of use of pigs' changes.



**Figure 9.** Pipeline Pigging and Pig Manufacturing [6]

### Conclusion

The increasing development of various industries as well as human societies has dramatically increased the need for energy as one of the main pillars of any industrial process and as an important part of human daily life. Meanwhile, fossil fuels such as crude oil and its products have long been considered by humans.

The issue of the oil and gas transmission and the other energy-containing condensates is noteworthy and occupies an important part of the oil and gas industry. The pipeline has long been widely used as the main oil and gas transmission mechanism, and many light and heavy industries related to pipeline issues have been created. One of the topics which has a special importance and status in the case of pipelines is the issue of protection and maintenance of the pipeline from all kinds of possible defects in order to prevent accidents such as leakage and explosion of the pipeline as much as possible. Various techniques and tools have been used so far to protect and inspect various types of pipelines, including pigs.

The following goals can be achieved by pigging in the pipeline:

- Cleaning of sediment inside the pipeline;
- Dimensional measurement of the pipeline (inside diameter, radius and bending angle, etc.);
- Transfer and separate different products from one pipeline;
- Preparing the pipeline for the static testing with water;
- Removing liquids from inside the gas transmission pipeline and extraction of gas from inside the liquid transfer pipeline;
- Preparation of map and profile of the pipeline;
- Preparing the pipeline for commissioning or decommissioning;
- Carrying out the technical inspections of both internal and external surfaces of the pipeline;
- Applying coating on the inner surfaces of the pipeline;
- Applying corrosion inhibitor to the inner surfaces of the pipeline;
- Improve fluid flow efficiency through the pipeline;
- Investigating the problems caused by lack of proper and regular follow-up
- In conclusion, performing piping operations on pipelines helps to ensure the appropriateness and accuracy of pipeline construction operations. Given the history of the oil and gas pipelines in the country, there is a need for close monitoring to ensure the continuation of oil and gas flows in the country. On the other hand, due to the end of the design life of old pipelines and the occurrence of corrosion and leakage, the need to use fast and low-cost methods such as intelligent tracking along with the other methods to monitor the transfer of petroleum products by pipelines is essential.

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