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Corrosion control in oil and gas pipelines

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Abstract- Corrosion is the main problem affecting the pipeline system in the United States. Briefly, corrosion refers to the destructive reaction of a metal with its environment. It takes place in the presence of a supportive medium, which is referred to as an electrolyte. Corrosion leads to problems such as leakages that lead to disasters such as fires and explosions. Therefore, it affects the safety concerns and standards held in oil and gas pipelines. There are different ways of preventing or controlling corrosion that mostly focus on the prevention of contact between the pipes and the medium or environment that leads to corrosion. Oil and gas pipes are made of low-carbon steel, which makes them susceptible to corrosion. The fatal consequences of corrosion reinforces the need to engage in constant monitoring, which aims at identifying the presence and extent of corrosion. This paper focuses on the specifics of corrosion in oil and gas pipelines, which will include a discussion of the reasons for corrosion, disadvantages and the methods of inspecting corrosion. The discussion will seek the views of different sources and individuals regarding different aspects of corrosion in oil and gas pipelines under analysis.

Keywords— Corrosion, Oil, Gas, Pipeline, Inspection.

INTRODUCTION

In different countries, different sources of energy, such as fuels, natural gas, fossils and oils are used. Oil and gas are the dominant sources of energy for production and supporting life in the United States and the world over. Just like any other product, there is need to enhance the efficient distribution of oil and gas from the production centers to different users through intermediaries (if present). In this case, efficient distribution of both oil as well as gas to the users ensures that they are safe. In addition, it ensures that energy factories are safe, since any leakages that may occur are detected and prevented with immediate effect. As a result, environmental pollution is minimized. Different sources of energy require transportation from one area to another, which implies that efficiency and effectiveness have to be observed during the process. For instance, crude oil has to be transported from the production areas or the source to the oil refineries and from the oil refineries to the final users. Therefore, there is need to devise an appropriate mechanism of transporting oil and gas from the production centers to the refineries and from the refineries to the users. The oil and gas pipeline technology is the major medium of transport used in the movement of oil and gas in the United States of America. Different sectors of the global economy have evolved, and thus the energy sector is not exceptional. The technology used in the sector has been experiencing massive growth, which revolves around the need to enhance safety and the overall efficiency of the oil and gas pipelines. These developments have made the system the most effective in the transport of oil and gas across different locations.

TYPES OF OIL AND GAS PIPELINE

As mentioned earlier, the types of oil and gas pipelines depends on the area of transportation and the substance under transit. Gathering lines transport products over short distances. They are mostly used in transporting crude oil and natural gas from the areas of production to the refineries. The gathering lines are relatively short because they involve the transportation of unrefined oil and natural gas from the production centers to the refineries (Kennedy, 1993). Feeder lines are involved in the transport of oil and gas from the refineries to the storage facilities or connect the refined oil and gas to the long distance pipelines (Kennedy, 1993). Therefore, these lines cover relatively short distances compared to those that distribute oil and natural gas to the users/market. Transmission lines are among the most complex systems of pipelines. They consist of a network of lines that distribute natural gas and oil across boundaries. The transmission lines are responsible for the distribution of oil and gas to the final users, which is the reason they cover relatively long distances. Notably, the government mostly manages the transmission lines because they distribute oil and gas across internal and external boundaries. Distribution pipelines, just as the name suggests, are responsible for the distribution of oil and gas to the users. In most cases, these pipelines are owned and managed by distribution companies that retail oil and gas to the final consumers. The final consumers include businesses, homes and industries that depend on the forms of energy (Miesner & Leffler, 2006). The distribution pipelines are the most complex because they focus on serving customers in different geographical locations.

Uses and importance of oil and gas pipelines

The importance of pipelines cannot be underestimated considering the important role of gas and oil in the running of the economy. Oil and gas are important sources of energy for industries, which implies that they support the running of the economy. The basic use of pipelines regards the distribution of oil and gas to the final users. It is the most convenient, efficient and safe method of transporting large volumes of oil and gas from the production centers, to the refineries and the final consumers (Miesner & Leffler, 2006). The importance of pipelines is a factor of its use in distributing oil and gas pipelines. To begin with, oil and gas pipelines have proved to be safe methods of

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transporting oil and gas. They are located under the streets, across buildings, and fields but do not affect the quality of life of the residents. In addition, their wide coverage helps in extending the access to energy for all communities irrespective of their location. Therefore, they are important in the generation of energy, which is an important aspect of the survival of the human race. Without energy, it would be hard for countries to sustain their citizens due to lack of the essential goods and services. The other importance of oil and gas pipelines is that they enhance the complete utilization of natural resources in the country. Pipelines enable the transportation of crude oil and natural gas from their sources to the refineries. Therefore, the country can take advantage of the availability of natural gas and oil even in rural areas because of the ease in transportation. Oil exploration activities in rural areas would have been impossible without the existence of the pipelines. It then follows that the pipelines influence the production of all petroleum products from crude oil extracted from the sources. The oil and gas pipelines have also helped countries that do not have adequate sources of oil and gas. It is possible to transport oil and gas from country to country using the pipelines. Therefore, countries without oil wells or refineries can still use petroleum products, oil and gas as their primary source of energy (Miesner & Leffler, 2006). They consist of complex network of distribution lines that help in serving communities that do not have adequate natural sources of energy. Arguably, our everyday life is widely dependent on the existence of the pipeline technology. The availability of gasoline across the street, cooking gas, jet fuel and industrial engines is the results of investment in the pipeline technology. The wide network of pipelines in the United States and in other countries is an indication of their importance in supporting life and economic activities. Oil and gas, as mentioned by Miesner & Leffler (2006), are the most essential elements of the industrial productivity of nations, which implies that it is the new form of competitive order. Companies with adequate access to the forms of energy are likely to be more competitive, which justifies the existence and importance of the pipeline network even further. The importance of oil and gas pipelines is also reinforced by the failures and inefficiencies of other forms of transporting oil and natural gas. For instance, it is infeasible to transport large volumes of oil and gas using the trucks and rail due to the associated costs. In addition, the pipelines do not hurt other forms of infrastructure such as roads, which implies that they are cost-effective and independent forms of transport.

Materials used in oil and gas pipelines

Pipelines can be thought as part of our life because they are underneath our buildings and streets. Therefore, the safety of pipelines is paramount in their design and engineering. Steel is the main material used in the construction of oil and gas pipelines. The main reason for the use of steel is its characteristics of toughness, ductility and weldability (Kiefner & Trench, 2001). Toughness helps in resisting cracks, which would lead to leakages. Therefore, steel helps the pipelines in withstanding the pressure of the load, heat and changing weather patterns because it is resistant to cracks. However, stainless steel is not an effective material in the construction of pipelines, although it is the most effective regarding the characteristics mentioned above. Low-carbon steel, according to Kiefner & Trench (2001), is a cost effective form of steel that bears the characteristic of strength and ductility required for the pipelines. Other metals such as iron are not as strong and can lead to cracks and fractures. Therefore, low-carbon steel is the most effective material for use in the construction of pipelines because it prevents fractures, which can lead to oil and gas spillages. The other reason for the use of steel in the construction of pipelines is their ability to withstand changing temperatures over time. Steel does not change over time, which implies that it is the most effective for use in the construction of materials exposed to varying weather conditions. The tensile strength of low-carbon steel remains constant over time, which implies that it is the best for use in long-term infrastructural development (Kiefner & Trench, 2001). The construction of pipelines is a costly investment, which implies the need to approach it from a long-term perspective. Low-carbon steel is, therefore, the best for use in the construction of pipelines because it helps in minimizing the need for constant repairs. Low-carbon steel, which is used in the construction of oil and gas pipelines, has its disadvantages. It supports oxidation in the presence of air, soil and water (Kiefner & Trench, 2001). Oxidation leads to corrosion, which might compromise the quality of oil and gas under transportation. Therefore, the low-carbon steel must be covered by coatings that prevent the oxidation since the pipelines are, in most cases, buried under soil, which also supports oxidation. Therefore, the materials used in the construction of oil and gas pipeline must meet the requirements of strength (ability to withstand pressure in loading and offloading), ductility (ability to withstand strain over time or tensile strength), and ability to be resistant to change, cracks and fractures.

Ways to avoid corrosion

Corrosion has been identified as the main challenge affecting the efficiency of the oil and gas pipelines. The disadvantages of corrosion point to the need to devise ways of overcoming the threat, especially in preventing the occurrence of accidents resulting from leakages and fractures. Low-carbon steel has been associated with susceptibility to oxidation in the presence of electrolytes, water and carbon dioxide.

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External corrosion is also a factor of contact with soil, which also supports oxidation. Therefore, one of the basic method of controlling external corrosion is through coating and cathodic protection (Baker, 2008). Cathodic protection is the application of current to the pipeline to disrupt the movement of electrons from the anode to the cathode. It creates a cathodic field over the pipeline, which implies that the anodes in the exposed surface are non-reactive. The pipe acts like a cathode, which implies the lack of movement of electrons. In addition, cathodic protection leads to the development of deposits that protect the steel since they are alkaline in nature. Baker (2008) suggests two main methods of cathodic protection. The sacrificial anode protection method involves connecting the pipe with an external metal that has a relatively higher activity than steel. The metal is then placed away from the pipeline but within the electrolyte (soil). The result is that current will flow to the metal since it reacts more than steel. Therefore, the sacrificial metal undergoes corrosion thereby protecting the oil and gas pipeline from corrosion. The impressed-current anode method involves the introduction of direct current between the pipeline and anode. The purpose is to attract current away from the pipeline, which prevents corrosion. Therefore, cathodic protection involves the disruption of the movement of current from the anode to the pipelines through the electrolyte. Its use and application depends on the nature of the pipeline system, and the geological characteristics of the area under consideration (Baker, 2008). However, the method cannot be effective on its own because it would be costly to match the current required to the entire stretch of the pipeline.

The best way to inspect corrosion

Corrosion has been identified as the main challenge affecting the safety concerns of the pipeline technology in the United States. Therefore, management of corrosion should be the utmost priority of stakeholders in the oil and gas industry. The focus or objective of stakeholders revolves around the development of accident free pipelines, which is especially possible through the management of corrosion. Therefore, stakeholders need to invest in continuous monitoring of the pipeline system to identify areas affected by corrosion, as well as those that need protective action. Inspection is the most widely used method of monitoring because it helps in the identification of defects within the system. There are different methods used in the inspection of oil and gas pipelines, and their choice depends on the nature and location of the pipeline, as well as the motives of the assessment. The cathodic protection method of avoiding corrosion can also be used in the inspection. It helps experts in collecting the data required to assess the extent of corrosion on a pipe, which implies that the method is mostly applicable in the inspection of external monitoring. Data collected over a long period helps in determining the extent of damage to a pipe, which influences the development of corrective action. Arguably, the external inspection of corrosion is relatively easy because it depends on the observation of the outer surface, as well as collection of data using the cathodic protection method. Pipeline Inspection Gauges (PIGS herein) are devices introduced inside the oil and gas pipelines with the aid of the flowing fluid. The PIGs technology has since revolutionized to include aspects of intelligence that help in the easy determination of faulty areas within the pipes. The intelligence regards the ability of the devises to record data on the nature of the pipes, as well as record data for later analysis (Pistoia, 2009). The technology adopts various forms, and has been praised for its non-destructive nature. The electromagnetic form of PIGs is one of the popular forms of assessment. It helps in the identification of defects within the pipes, and the nature of the severity of these defects. The PIGs assessment method is very complex and is an epitome of increased technological applications, especially in the mechanisms of sensitivity to defects within the pipes. The method is particularly applicable for the assessment of gas pipelines because the devices do not interfere with the composition and characteristics of the gas. PIGs help in detecting common pipe defects such as corrosion fatigue and dents among other faults. Corrosion fatigue refers to the increased degradation of the mechanical abilities of steel after corrosion. In fact, some stakeholders use corrosion fatigue to inspect the extent of corrosion. The rationale is that corrosion is a form of mechanical attack, which is possible in the presence of catalysts such as hydrogen sulphide. Therefore, determining the extent of the mechanical attack on steel, which constitutes the corrosion fatigue, is an effective way of inspecting corrosion. In fact, developers have come up with devices that help in quantifying the extent of corrosion fatigue. Therefore, measuring corrosion fatigue is an effective way of inspecting the extent of corrosion in oil and gas pipelines. This method applies for both external and internal inspection of corrosion because of its complex electronic and structural composition. The method detects defects inside and outside the pipeline using the thickness of the residual wall resulting from corrosion. The advantage of this method is that it enable s the inspection of corrosion on the outer and inner surfaces of the oil and gas pipelines. This method of inspection has gained popularity in the recent past due to its cost effectiveness, reliability and speed. However, it has associated with the limitation of unreliability if exposed to noise. In addition, according to Dai *et al.* (2007), the method is affected by the texture of the pipe, especially the roughness of the wall.

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Conclusion

In conclusion, corrosion is an emerging issue that requires urgent attention through the development of new designs and mechanisms of prevention and control. The effects of corrosion have proven to be a threat to the sustainability and efficiency of pipelines in the distribution of oil and gas from the production centers to the users. Oil and gas are important sources of energy in the United States and the world, which justifies the need to invest in effective strategies and methods of distribution. The lack of effective means of distributing oil and gas would not only challenge engagement in productive activities but also threaten survival due to the increased likelihood of accidents. Corrosion leads to mechanical reduction of the strength of oil and gas pipes, which leads to leakages and other problems. Leakages are dangerous because they expose populations to the risk of explosions and fires, as well as damaging the surrounding environment. In addition, the prevalence of accidents that relate to corrosion in oil and gas pipes decreases public confidence in the system because it challenges the hyped safety aspects of the pipelines. Various protective mechanisms put in place to control corrosion in oil and gas pipelines focus on the properties of low-carbon steel, which is the main material used in the manufacture and construction of pipes. As has been discussed in the paper, there is need to invest in the mechanisms of detecting and inspecting corrosion in the pipes because it is the foundation of prevention and control. Technology has provided limitless possibilities for the achievement of the same, but there is need to invest more in determining the best approaches of detecting, preventing and controlling corrosion, which will improve the associated outcomes.

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