Corrosion control in pipeline due to stray current of high voltage systems

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Abstract: Stray currents can impact the ability to protect a pipeline or other buried metallic structure from corrosion. They can be generated from a variety of manmade and natural sources. Common sources of stray currents are cathodic protection on other lines, DC transit systems and telluric activity. The electrochemical mechanism of aqueous corrosion is outlined and it is demonstrated that the process depends upon a complex interaction between the material and its environment given the particular circumstances of exposure. Failure to recognize the full implications of the environment or the circumstances will often lead to unexpected corrosion failure. The techniques for controlling corrosion are sub-divided into the detect the stray current of electrical discharge using optical method which implement inside the lab. Electrical Discharge (ED) is a term used to describe electrical discharge activity which is normally accompanied by sparks. ED can occur when electric field difference across the void exceeds the minimum breakdown field strength. Therefore, ED measurement and diagnosis is an important nondestructive technique for assessing the quality and integrity of high voltage transformer. In practice, ED measurements suffer from noise interference due to low sensitivity of available sensors. Sensors usually pick up noise from the environment. Noisy signal at the output of the sensors cause inaccuracy in the detection of ED. In this study, Fibre Optic Sensor (FOS) was used because of two main factorsanalyzing results of ED signal generated patterns appear to be associated with discharge show more accuracy. The technique could be used as a predictive technique to check the progression of ED, and hence keep the pipeline under constant supervision into prevent the corrosion.
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1. Introduction

Corrosion is an electrochemical process involving electrical currents. It consists of the destruction of a metal through its interaction with the environment. The corrosion phenomenon occurs in metallic structures, where a basic “corrosion cell” consisting of anode, cathode, electrolyte, and connecting conductor can be observed [1], [2].

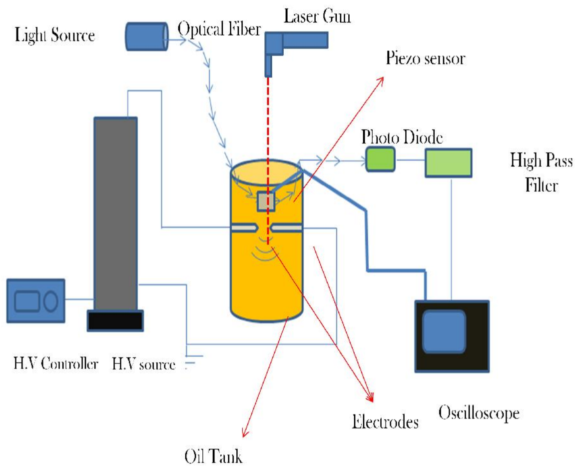
When corrosion occurs, an electric current moves through the electrolytes so that positive ions enter the electrolyte from the anode, while electrons move from the anode to the cathode via the metallic connection. At the interface between metal electrodes (i.e., anode A and cathode C) and electrolyte, there is an electromotive force, called the electrode “standard potential.” There are several methods in which cathodic protection for metallic structures can be accomplished [3]. These methods are based alternatively on the growth of the cell equivalent resistance (for instance, using a bitumen layer) either on the construction of a new electrochemical cell, where the protected part can be assumed as a cathode with respect to a sacrificial material assumed as anode Electrolytic corrosion is the result of current coming from outside sources, entering and then leaving a particular metal structure by way of the electrolyte. Where a current enters the structure, that structure is usually unaffected or is provided with some degree of protection. Where the current leaves the structures, corrosion occurs. In underground work, this type of corrosion is often referred to as stray current corrosion. Although damage by alternating (ac) is less than by direct current (dc), the resultant corrosion is usually greater for lower frequency and less for higher frequency currents. According to [4], it is estimated that for metals like steel, lead, and copper, 60-Hz ac current causes less than 1% of the damage caused by equivalen dc current. Many industrial installations will have some sort of stray current problem if no attention has been given to its control. The source of these dc stray currents may be welding equipment, electroplating processes, battery charging apparatus, motor generators, dc control circuits, uninterruptable and interruptable power systems, inverter systems, nearby impressed current cathodic protection systems, dc transit systems, etc. A common practice with welding equipment that often causes trouble is to ground one welding electrode to a metal building frame. This superimposes dc on the grounding system of the building and, if the current which leaves the grounding electrode is large enough, considerable corrosion will result. Stray currents are caused by sources of current flowing through unintended paths. These can have significant effects on buried pipelines and other metallic structures [5]. Also can say the leakage current (stray current) it is Any current flowing from hot conductor to ground over the outside surface of a device is called leakage current. In case of insulators on a transmission line, it is the current that flows over the surface of insulator, and, if no ground exists, the current flowing from a conductive portion of a device to a portion that is intended to be non conductive under normal conditions.

Power transformers are the most critical and costly component in transmission systems, especially those of large capacity such as generator step-up transformers and system tie auto-transformers. Catastrophic failures of power transformers can occur without any warning, resulting in serious oil spills, fires, and extensive damage to adjacent equipment, and major disruption of service. If the transformer cannot be repaired due to the extensive damage, it will then be necessary to get a new transformer to replace that which has been damaged entailing some hefty expenditure. The cost of failures will also include the cost of reinstallation, transportation, cost of other equipment which have been damaged, cost of outages after the failure and loss of revenue, etc., which can easily drive the total cost of a single transformer failure into tens of millions of dollars. extra high voltage (EHV) power transformers have unacceptable failure rates of more than 3% per year per device [1]. An informal survey indicated that over 75% of large, EHV transformer failures are caused by dielectric problems. During the process of transformer insulation failure, ED degrades the electrical insulation gradually until the transformer experiences total loss. It is important to monitor the ED activity of important transformers so that the incipient insulation failure can be recognized before it can create any internal fault. In this way, the transformer can be repaired or replaced in a controlled fashion. ED in transformers includes arcing, flashover, and sparking. In most cases, ED in power transformers start well before the structure fails. An exception is the static electrification of normal AC and accumulated DC voltages, particularly during transformer startup. ED typically happens at regular time intervals ranging from seconds to hours apart. The more frequently they occur the more severe their activities are. Once there is ED activity, failure can occur at any moment. Therefore, online monitoring and quick reaction to the monitoring information of ED activities is necessary and mandatory. The commonly used methods for EDs detection are there are: the electrical method, the chemical method, the acoustic method and the optical method. For electrical method the main advantage of this technique is its high sensitivity and its ease of use in quantitative measurement. The disadvantage of this technique is the false alarm generated due to high sensitivity and hence it is not suitable for use in the monitoring of a transformer for a longer period of time [2-4]. For chemical method needs some time which is required to collect detectable volume of gas produced. For this reason dissolved gas analysis is not suitable for real time online monitoring. All chemical techniques are not able to locate the exact position of ED sources [5-7]. For acoustic method can be used to estimate the location of the source of ED signals by measuring the time of arrival of the acoustic wave with the help of sensors at multiple locations. The acoustic method provides information regarding the strength and position of ED in real time. Due to the sensitivity of the acoustic method, interfering environmental noise can be pick up easily. Environmental noise can cause problem in the detection of the acoustic signal [8-15]. For optical method makes use of fiber optic intrinsic interferometers such as Michelson interferometers or multimode fiber and fiber optic extrinsic interferometers such as Fabry–Perot interferometric sensors. It also uses Mach–Zehnder interferometer sensors which have been known to suffer from fringe fading problems caused by random polarization rotation. Fabry–Perot interferometric sensors are more compact than Michelson and Mach–Zehnder fiber sensors, and therefore achieve virtually single-point measurement. Until now, use of optical method for ED detection has limitations due to low measurement sensitivity of sensors.

2. Experimental work

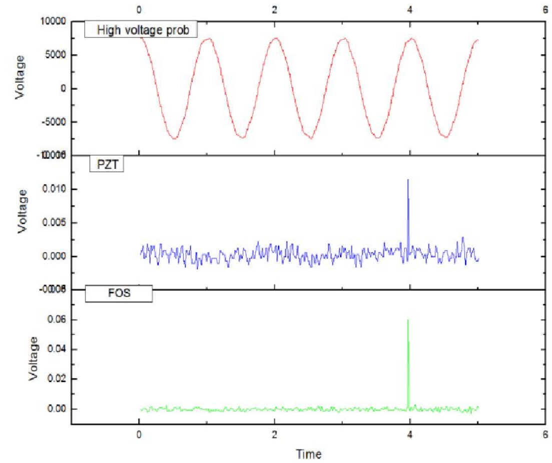
Corrosion control in pipeline X60 carbon steel simulated due to stray current of high voltage discharge simulates arc discharge between two steel electrodes [21-24]. The simulated ED is generated using 7.5 kV power source in two round shape steel electrodes having 5 mm gap. This distance (between the sensor and arc discharge source) is set at 5 cm. The infrared thermometer (laser gun) was used to capture the insulation oil temperature by sending a laser light toward the insulation oil and that light will be reflected beck and received by the device and then the temperature of the oil will be captured and measured. The experimental setup is shown in Fig. 1

The complete experimental setup for the detection of acoustic wave emission induced by ED is shown in Figure 1 Sensitivities of the two sensors, PZT and FOS, were compared and using the characteristics of responses (captured by the multichannel oscilloscope) due to AE generated by ED.



ability to act as acoustic sensor with sensitivity higher than PZT sensor.

From the thermal analysis, it is been observed that the temperature of the insulation oil is rising proportionally with time with and without ED.



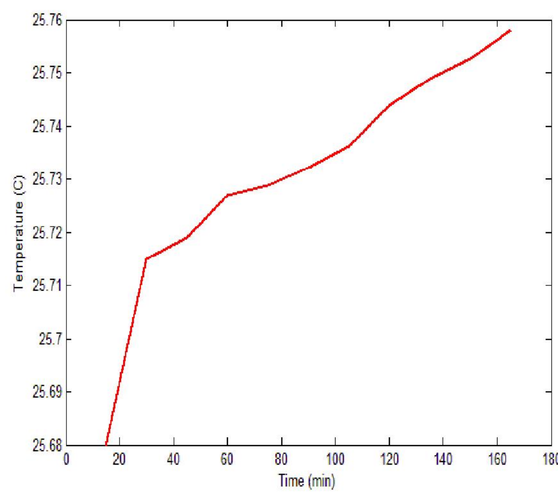


Fig 3. The temperature time curve with ED

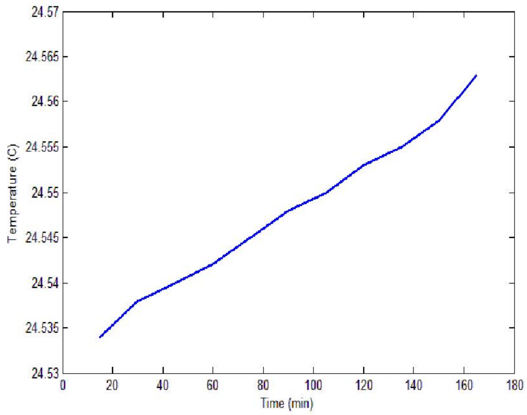


Fig 4. The temperature time curve without ED

4. Conclusion

The corrosion control on X60 carbon steel due to simulated ED led to following conclusion:

1-The detection and diagnostic of corrosion control is clarify by detect the effects of temperature on breakdown voltage and electrical discharge patterns in mineral oil.

2- The experimental results showed that the breakdown voltage increased with temperature in the temperature range from room temperature up to 60oC.

3-The experimental results on ED showed the negative ED appear early than those of positive ED.

4- The inception of negative ED slightly is lower than those of positive ED.

5-The inception voltage decreased with temperature. ED took place at around the peak of the applied voltage.

6-Phase-resolved analysis indicated that ED magnitude as well as ED occurrence was strongly dependent on the instantaneous applied voltage. The results of phase-resolved measurement of partial discharges and analysis on ED in the oil showed that the ED magnitude as well as the ED occurrence was dependent on the instantaneous applied voltage.

7- This work indicated that the temperature of the insulation oil was rising proportionally with time in the two cases but when ED occurs, the slope of the temperature rising becomes much bigger than the case without ED.

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