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Cathodic Protection Performance Improvement of Metallic Pipelines based on Different DC Compensation Methods

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ABSTRACT

Nowadays, natural gas in the Middle East has been discovered in extremely many quantities, and it is considered the most vital natural resource. Sometimes, the natural gas pipeline is constructed in the desert and paralleled with the high voltage overhead transmission lines (HVOHTLs). An induced AC voltage has appeared on the pipeline due to interfering with the HVOHTLs. Mainly, hydroxide potassium polarization cell (KOH-PC) has been applied to discharge this voltage to the soil within a safety limit. But, the mitigation units have negatively impacted cathodic protection (CP). The DC voltage of the pipeline is initially compensated using externally supplied impressed current cathodic protection (IMCP) units. In many cases, the external power sources have continuity and stability issues. Therefore, this paper presents different strategies as a promising solution to be utilized in reducing the disturbance of the external power sources. The first strategy is exploiting the induced voltage via converting it as DC form by using the controlled rectifier circuit and reapplying on the pipeline as a cathodic protection voltage. The second strategy involves a photovoltaic (PV) system, which integrates into the pipeline. This paper also explores the superiorly of the fuzzy system with different compensation strategies in managing the DC voltage along the pipeline to guarantee better CP performance under any disturbance in the impressed current stations. From the comparative analysis, it is observed that the behavior of the various strategies in compensating the DC voltage deterioration is reasonable. The obtained results reveal that the robustness of the fuzzy logic controller in mitigating the induced voltage and has capable of compensating the cathodic protection disturbance.

1. Introduction

Corrosion is the degradation of a metal as a result of electrochemical reactions. Furthermore, AC corrosion is caused by interference between the pipeline and nearby power transmission lines. Coatings and cathodic protection are the primary methods for preventing AC corrosion in underground pipelines (CP). Coatings are typically designed to form an electrically insulating material on the pipeline's surface. Electrochemical reactions are inhibited by these coatings, which have high electrical resistance. Cathodic protection is a corrosion-prevention technique that involves applying an external current to a corroding metal surface. Current leaves the auxiliary anode (also known as a 'sacrificial' anode), travels through the corrosion cells' cathodic and anodic areas, and then returns to the DC source. Cathodic protection can be accomplished in two ways: impressed current (IC) and sacrificial anode (SA). The first technique does not require a power supply to impress current from the sacrificial anode to the cathodically protected area. Therefore, the anode metal's potential must be higher than the cathode metal's according to the galvanic series. The second method is confirmed as a vigorous technique usually utilized in the pipeline's corrosion prevention. DC power supply is utilized to impress the demanded current. A rectifier (if AC power is available) or a diesel generator is used to provide DC power.

1.1. Literature review

NACE recommends a cathodic potential of -850 mV vs $Cu/CuSO_4$ electrode (CSE) as the standard CP criteria for protecting the buried steel structures [1]. In [2], the CP criteria are insufficient to offer adequate corrosion protection for buried pipelines in the presence of AC

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