CHAPTER

4

HRT AND ESAVR OF BIOLOGICAL CATHODIC PROTECTION

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4.1 INTRODUCTION

The transmission and distribution of oil and gas are done by conducting pipeline network. Carbon steel is the most favourable type of pipelines used in the industry for this purpose. Factors such as the wide availability and high strength of carbon steel pipe have made this type of pipeline is widely used in the oil and gas industry (Mutahhar et al., 2017). Although the use of this pipeline is very helpful towards its purpose to ensure the efficient supply of the oil and gas demands to the end users, the use of carbon steel pipe has caused harmful effect due to the phenomenon of corrosion. According to Norsworthy (2014), corrosion is a term used to explain the process of chemical or electrochemical reaction that results in deterioration of metal due to its reaction with the surrounding. This phenomenon has inhibited the productivity of the pipelines and impacted the process. Severe consequences include the cost of its maintenance due to the damages occurring on the structures of the pipelines and safety problems, whereby the corrosion may lead to fire and explosions.

To prevent such corrosion from happening, cathodic protection (CP) system is commonly implemented thoroughly in the oil and gas industry.

The principle of CP is to reduce the corrosion rate of a metal surface for acceptable degradation by treating the metal surface as the cathode of an electrochemical cell (Abootalebi et al., 2010). The use of external power source is introduced in the process in order to provide electricity to shift the potential of the metal in the negative direction. Two commons technologies used as CP system are sacrificial anode cathodic protection (SACP) and impressed current cathodic protection (ICCP). SACP is a galvanic relationship between more electronegative metal used as anode and connected to the metal structure to be protected to supply the required CP current. Meanwhile, the power supply, or referred to as a rectifier in an ICCP is used to apply current on the structure while its anode is buried in the medium (Christodoulou et al., 2010). Adequate current need to be applied on the protected structure of carbon steel pipe to guarantee the effectiveness of the CP.

Therefore, there are certain criteria that need to be in compliance to complete the procedures. The criteria mentioned could be in accordance to National Association of Corrosion Engineers (NACE) standards or the criteria that have been successfully applied on existing piping systems. For example, as carbon steel pipe is protected using CP, at least -850mV potential as compared to copper sulfate electrode is applied to ensure the corrosion control could be achieved and this CP criterion differs according to the type of metals as well as the environmental conditions of the metals (Paul Guyer, 2018).

Apart from using direct electric supplies to provide current for the implementation of CP, another approach is used in this study using the concept of bioelectrochemical systems (BESs). This technology harnesses the use of electrons obtained from the oxidation of substrates to produce electricity (Bajracharya et al., 2016). The principal of the electricity generation is due to the potential difference that occurs during redox reactions of anode and cathode in the BESs system. This causes electrons to move from low to high potential through an external circuit, which is measured as electric current. There are several types of BESs available, one of them is the microbial fuel cell (MFC).

The bioelectricity generation from the MFC device further represents a new method of CP called biological CP. The functionality of biological CP using MFC system is explained by the generation of current originated from the oxidation of organic matter by microbe is transferred to the electrode (carbon steel) through external wire connection and allowing the protection of the structure from corrosion (Bajracharya et al., 2016). MFC consists of two chambers; anode and cathode, physically separated by a proton exchange membrane (PEM). Theoretically, microorganism will oxidize substrate fed in the anode chamber and generate proton and electron to cathode through proton exchange membrane (PEM), and external circuit respectively. Microorganism from wastewater is utilises in the biological CP to produce continuous current for the structure protection purpose, accordingly this system also achieves the removal of pollutants to the environment.

The performance of biological CP is greatly influenced by several parameters on the system with a tendency to fluctuate. Among the parameters that controlled the output efficiency of this system are substrate, microorganisms and their metabolism, electron transfer mechanism in an anodic chamber, electrodes material and the shape of electrodes, type of membrane, operating conditions such as temperature, pH and salinity, electron acceptor in a cathodic chamber and geometric design of the MFC (Aghababaie et al., 2015).

Current generation becomes the real challenge for the implementation of biological CP system hence continuous research and development was performed to overcome such issues. There are several parameters studied that influenced the performance of biological CP, according to Azman (2021), the hydraulic retention time (HRT) and electrode surface area to anode-compartment volume ratio (ESAVR) were identified as the two parameters that affected the performance of biological CP. However, uncertainty may arise due to the magnitude or variability of the experimental parameter model (Gobas, 2008) led to the unreliability of the results. Thus, this study was conducted to study the probability and sensitivity of the system to ensure the effectiveness