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COMPLETE SPECIFICATION

(SEE SECTION 10 AND RULE 13)

TITLE OF THE INVENTION

"Apparatus and method for EMI based monitoring of sacrificial anode in cathodic protection system"

APPLICANTS:

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The following specification particularly describes and ascertains the nature of this invention and the manner in which it is to be performed:-

FIELD OF INVENTION

[0001] The present disclosure relates to a monitoring system, and more specifically related to an apparatus and a method for electromechanical impedance (EMI) based monitoring of sacrificial anode in a cathodic protection system.

BACKGROUND OF INVENTION

[0002] Corrosion of steel structures deteriorates their overall structural integrity. In order to protect, the steel structures from corrosion, a cathodic protection is applied by means of externally attached anodes. Monitoring the efficacy and adequacy of the performance of the externally attached anodes and the state of the corrosive environment they are in, without interrupting the cathodic protection becomes a necessity for performing preventive maintenance on the steel structure.

[0003] Thus, it is desired to address the above mentioned disadvantages or other shortcomings or at least provide a useful alternative.

OBJECT OF INVENTION

[0004] The principal object of the embodiments herein is to provide an apparatus and method for EMI based monitoring of sacrificial anode in a cathodic protection system without using additional hardware setup and cost effective manner.

SUMMARY

[0005] Accordingly, embodiments herein disclose an apparatus for an EMI based monitoring of a sacrificial anode in a cathodic protection system. The apparatus includes the sacrificial anode, an ultrasonic transducer, and electrical connection parts. The ultrasonic transducer is attached with a portion of the sacrificial anode. The sacrificial anode is connected to the cathodic protection system. One end of the electrical connection part is connected with the sacrificial anode and one end of the electrical connection part is connected with the ultrasonic transducer. The ultrasonic transducer is configured to detect a change in electromechanical impedance on the sacrificial anode and generate an output indicating the change in the electromechanical impedance of the sacrificial anode.

[0006] In an embodiment, the change in mass is caused due to a corrosion on the sacrificial anode.

[0007] In an embodiment, the apparatus further comprises a waterproofing layer, where the waterproofing layer covers the ultrasonic transducer.

[0008] In an embodiment, the ultrasonic transducer is a PZT patch.

[0009] In an embodiment, the sacrificial anode is connected with a current source through the electrical connection part.

[0010] In an embodiment, the ultrasonic transducer is connected with a measurement device through the electrical connection part.

[0011] Accordingly, embodiments herein disclose a method for an EMI based monitoring of sacrificial anode in a cathodic protection system. The method includes attaching an ultrasonic transducer with a portion of the sacrificial anode. Further, the method includes providing an electrical connection with the sacrificial anode and a cathodic protection system to be protected. Further, the method includes detecting, by the ultrasonic transducer, a change in electromechanical impedance on the sacrificial anode. Further, the method includes generating, by the ultrasonic transducer, an output indicating the change in the electromechanical impedance, of the sacrificial anode, on a measurement device.

[0012] Accordingly, embodiments herein disclose a method for an EMI based monitoring of sacrificial anode in a cathodic protection system. The method includes placing a sacrificial anode in an electrolyte solution. Further, the method includes placing a copper electrode in the electrolyte solution. Further, the method includes connecting the copper electrode to a negative terminal of a constant current source. Further, the method includes connecting the sacrificial anode to a positive terminal of the constant current source. Further, the method includes removing a zinc from the sacrificial anode based on an electrolysis process. Further, the method includes changing a material and structural properties of the sacrificial anode detected by the ultrasonic transducer. Further, the method includes generating an output indicating the change in material and structural properties of the sacrificial anode on the measurement device.

[0013] In an embodiment, the electrolyte solution is made of a salt solution, wherein the electrolyte solution emulates a corrosive environment.

[0014] In an embodiment, the change in the material and structural properties of the sacrificial anode is caused due to a corrosion on the sacrificial anode.

[0015] These and other aspects of the embodiments herein will be better appreciated and understood when considered in conjunction with the following description and the accompanying drawings. It should be understood, however, that the following descriptions, while indicating preferred embodiments and numerous specific details thereof, are given by way of illustration and not of limitation. Many changes and modifications may be made within the scope of the embodiments herein without departing from the spirit thereof, and the embodiments herein include all such modifications.

BRIEF DESCRIPTION OF FIGURES

[0016] The present invention is illustrated in the accompanying drawings, throughout which like reference letters indicate corresponding parts in the various figures. The embodiments herein will be better understood from the following description with reference to the drawings, in which:

[0017] FIG. 1 shows a perspective view of an apparatus including an sacrificial anode with a PZT attached with the anode and waterproof coating applied to the PZT, according to an embodiment as disclosed herein;

[0018] FIG. 2 illustrates an example test setup for the sacrificial anode in an electrolyte with a copper cathode, to emulate a real-world corrosive environment, according to an embodiment as disclosed herein;

[0019] FIG. 3 shows an example manufacturing process and an example experimental setup in connection with FIG. 1 and FIG. 2, according to an embodiment as disclosed herein;

[0020] FIG. 4 illustrates a block level diagram for an in-field deployment of the sacrificial anode and the PZT patch, according to an embodiment as disclosed herein;

[0021] FIG. 5a illustrates a model of the sacrificial anode with the PZT patch used in simulations, according to an embodiment as disclosed herein;

[0022] FIG. 5b illustrates a sectional perspective view of the sacrificial anode, according to an embodiment as disclosed herein;

[0023] FIG. 6 illustrates the susceptance data of a simulated model, according to an embodiment as disclosed herein;

[0024] FIG.7 illustrates a radial mode of the simulated model, according to an embodiment as disclosed herein; and

[0025] FIG.8is a flow chart illustrating a method for the EMI based monitoring of the sacrificial anode in the cathodic protection system, according to an embodiment as disclosed herein.

DETAILED DESCRIPTION OF INVENTION

[0026] The embodiments herein and the various features and advantageous details thereof are explained more fully with reference to the non-limiting embodiments that are illustrated in the accompanying drawings and detailed in the following description. Descriptions of well-known components and processing techniques are omitted so as to not unnecessarily obscure the embodiments herein. Also, the various embodiments described herein are not necessarily mutually exclusive, as some embodiments can be combined with one or more other embodiments to form new embodiments. The term “or” as used herein, refers to a non-exclusive or, unless otherwise indicated. The examples used herein are intended merely to facilitate an understanding of ways in which the embodiments herein can be practiced and to further enable those skilled in the art to practice the embodiments herein. Accordingly, the examples should not be construed as limiting the scope of the embodiments herein.

[0027] As is traditional in the field, embodiments may be described and illustrated in terms of blocks which carry out a described function or functions. These blocks, which may be referred to herein as units or modules or the like, are physically implemented by analog or digital circuits such as logic gates, integrated circuits, microprocessors, microcontrollers, memory circuits, passive electronic components, active electronic components, optical components, hardwired circuits, or the like, and may optionally be driven by firmware. The circuits may, for example, be embodied in one or more semiconductor chips, or on substrate supports such as printed circuit boards and the like. The circuits constituting a block may be implemented by dedicated hardware, or by a processor (e.g., one or more programmed microprocessors and associated circuitry), or by a combination of dedicated hardware to perform some functions of the block and a processor to perform other functions of the block. Each block of the embodiments may be physically separated into two or more interacting and discrete blocks without departing from the scope of the invention. Likewise, the blocks of the embodiments may be physically combined into more complex blocks without departing from the scope of the invention

[0028] The accompanying drawings are used to help easily understand various technical features and it should be understood that the embodiments presented herein are not limited by the accompanying drawings. As such, the present disclosure should be construed to extend to any alterations, equivalents and substitutes in addition to those which are particularly set out in the accompanying drawings. Although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are generally only used to distinguish one element from another.

[0029] Accordingly embodiments herein achieve an apparatus for an EMI based monitoring of a sacrificial anode in a cathodic protection system. The apparatus includes the sacrificial anode, an ultrasonic transducer, and electrical connection parts. The ultrasonic transducer is attached with a portion of the sacrificial anode. The sacrificial anode is connected to the cathodic protection system. One end of the electrical connection part is connected with the sacrificial anode and one end of the electrical connection part is connected with the ultrasonic transducer. The ultrasonic transducer is configured to detect a change in electromechanical impedance on the sacrificial anode and generate an output indicating the change in the electromechanical impedance of the sacrificial anode.

[0030] The apparatus can be used for EMI based monitoring of sacrificial anode in the cathodic protection system without using additional hardware setup and cost effective manner.

[0031] Referring now to the drawings, and more particularly to FIGS. 1 through 8, there are shown preferred embodiments.

[0032] FIG. 1 shows a perspective view an apparatus (100) including a sacrificial anode (102) with a PZT patch (104) attached with the sacrificial anode (102) and a waterproof coating or waterproofing layer (106) applied to the PZT patch (104), according to an embodiment as disclosed herein. The PZT patch (104) can be an ultrasonic transducer.

[0033] The sacrificial anode (102) is attached with the PZT patch (104). As shown in the FIG. 1, the sacrificial anode (102) is attached at a centre side of the PZT patch (104). A sectional perspective view of the sacrificial anode (104) is depicted in the FIG. 5b. A model of the sacrificial anode (102) with the PZT patch (104) used in simulations is depicted in the FIG. 5a. In another embodiment, the PZT patch (104) is placed on an edge of the sacrificial anode (102).

[0034] Further, a diameter of the sacrificial anode (102) is 3.6 cm and a thickness of the sacrificial anode (102) is 0.73 cm. A waterproofing epoxy layer (106) is provided, such that the PZT patch (104) is entirely sealed. The sacrificial anode (102) is connected with a current source through an electrical connection part (108). The PZT patch (104) is connected with an impedance analyser/LCR meter through an electrical connection part (110).

[0035] FIG. 2 illustrates an example test setup for the sacrificial anode (102) in an electrolyte with a copper cathode, to emulate a real-world corrosive environment, according to an embodiment as disclosed herein. As shown in the FIG. 2, the sacrificial anode (102), as described in the FIG. 1 is placed in an electrolyte solution (206) made of a 3.5% salt solution that emulates the corrosive environment. A copper electrode (204) is also placed in the electrolyte. The copper electrode (204) is connected to the negative terminal of the constant current source (208) whereas the zinc anode is connected to a positive terminal of the constant current source (208). This configuration forms an electrolytic cell. As electrolysis takes place, in accordance with Faraday’s law of electrolysis, zinc from the sacrificial anode

(102) will get removed. It is further hypothesized that this zinc will form Zinc Oxide on the anode's surface. Removal of matter (zinc) and further addition of another (Zinc oxide), changes the material and structural properties of the sacrificial anode (102). These changes are detected by the change in the electromechanical impedance of the PZT patch (104) attached to the sacrificial anode (102). The PZT patch (104) is connected to the impedance analyzer/LCR meter (210) which records the impedance signature of the PZT patch (104) over a spectrum of frequencies. The acquired signature is then analysed by a computer (202) for percentage frequency shift occurring at different instances of time. The susceptance of the PZT patch (104) attached to the sacrificial anode (102) is acquired before the commencement of the experiment.

[0036] In the real-life application of the apparatus (100) (as shown in the FIG. 4), the entire assembly – the sacrificial anode (102) with the attached PZT patch (104) and the waterproofing layer (106) must be electrically connected (108) with a metal structure (402) that is to be cathodically protected. This assembly is also to be embedded in the same environment/material as the metal structure (402). The signal output connections (306) from the PZT patch (104) can be connected to any EMI measuring device (210) (e.g. impedance analyzer, LCR meter, etc.) or have an electric ICs/oscillator circuit designed to measure the EMI and/or the resonant frequencies.

[0037] FIG. 3 shows an example manufacturing process and an example experimental setup, according to an embodiment as disclosed herein. As shown in the FIG. 3, a notation "A" of the FIG. 3 illustrates the PZT patch (104) bonded to the sacrificial anode (102). The notation "B" of the FIG. 3 illustrates the waterproofing coating layer (106) applied to the sacrificial anode (1022). The notation "C" of the FIG. 3 illustrates the apparatus (100) used to test the setup. The apparatus (100) includes the sacrificial anode (102) and the PZT patch (104). The apparatus (100) is immersed in a salt solution (302). The sacrificial anode (102) is electrically connected to a constant current source (not shown), and a copper electrode (304) is also similarly connected and immersed in the same salt solution for accelerated corrosion to take place. The EMI signal from the PZT patch (104) is monitored by connecting to the impedance analyser.

[0038] The block level diagram for an in-field deployment of the sacrificial anode (102) and the PZT patch (104) is depicted in the FIG. 4.

[0039] The susceptance signature acquired from the simulation is depicted in the FIG. 6. As shown, there are two separate signatures at 30.492 kHz and 69.420 kHz corresponding to different (bulk modes) of vibrations of the combined anode and PZT system. One such mode (i.e., radial mode) is depicted in the FIG. 7.

[0040] FIG. 8 is a flow chart (S800) illustrating a method for the EMI based monitoring of the sacrificial anode (102) in the cathodic protection system, according to an embodiment as disclosed herein. At S802, the method includes attach the PZT patch (104) with the sacrificial anode (102). At S804, the method includes covering the waterproofing layer (106) on the PZT batch (104). At S806, the method includes provide an electrical connection with sacrificial anode (102) and a metal to be protected. The metal is a part of the cathodic protection system. At S808, the method includes measure the EMI. At S810, the method includes measuring the resonance frequency based on the EMI. At S812, the method includes generating an output indicating the measured resonance frequency.

[0041] Industrial Applicability: The dependence of admittance/impedance of the PZT patch (104) that is attached to sacrificial anode (102), on the mass and stiffness of the sacrificial anode (102) has been applied to the monitoring of deterioration of the sacrificial anode (102) due to corrosion. Since the sacrificial anode (102) form an integral part of any steel structures with a cathodic protection system, this method is widely applicable wherever a cathodic protection system is used. Especially for embedded steel structures such as that of RCC (Reinforced Cement Concrete) structures, underground steel pipelines and storage tanks EMI based anode monitoring can be applied.

[0042] The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the embodiments as described herein.

CLAIMS

We claim:

1. An apparatus (100) for an electromechanical impedance (EMI) based monitoring of a sacrificial anode (102) in a cathodic protection system, comprising:

    the sacrificial anode (102);

    an ultrasonic transducer (104); and

    electrical connection parts (108 and 110),

    wherein the ultrasonic transducer (104) is attached with a portion of the sacrificial anode (102),

    wherein the sacrificial anode (102) is connected to the cathodic protection system,

    wherein one end of the electrical connection part (108) is connected with the sacrificial anode (102);

    wherein one end of the electrical connection part (110) is connected with the ultrasonic transducer (104), and

    wherein the ultrasonic transducer (104) is configured to detect a change in electromechanical impedance on the sacrificial anode (102) and generate an output indicating the change in the electromechanical impedance of the sacrificial anode (102).

2. The apparatus (100) as claimed in claim 1, wherein the change in mass is caused due to a corrosion on the sacrificial anode (102).
3. The apparatus (100) as claimed in claim 1, wherein the apparatus (100) further comprises a waterproofing layer (106), wherein the waterproofing layer (106) covers the ultrasonic transducer (104).
4. The apparatus (100) as claimed in claim 1, wherein the ultrasonic transducer (104) is a PZT patch.

5. The apparatus (100) as claimed in claim 1, wherein the sacrificial anode (102) is connected with a current source (208) through the electrical connection part (108).
6. The apparatus (100) as claimed in claim 1, wherein the ultrasonic transducer (104) is connected with a measurement device (210) through the electrical connection part (110).
7. An method for an electromechanical impedance (EMI) based monitoring of sacrificial anode (102) in a cathodic protection system, comprising:

   attaching an ultrasonic transducer (104) with a portion of the sacrificial anode (102);

   providing an electrical connection with the sacrificial anode (102) and a cathodic protection system to be protected;

   detecting, by the ultrasonic transducer (104), a change in electromechanical impedance on the sacrificial anode (102); and

   generating, by the ultrasonic transducer (104), an output indicating the change in the electromechanical impedance, of the sacrificial anode (102), on a measurement device (210).
8. The method as claimed in claim 7, wherein the ultrasonic transducer (104) is a PZT patch.
9. The method as claimed in claim 7, wherein the change in the electromechanical impedance on the sacrificial anode (102) is caused due to a corrosion on the sacrificial anode (102).

Dated this 25th Day of September 2020

Signature:

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ABSTRACT

"Apparatus and method for EMI based monitoring of sacrificial anode in cathodic protection system"

Accordingly, embodiments herein disclose an apparatus (100) for an EMI based monitoring of a sacrificial anode (102) in a cathodic protection system. The apparatus (100) includes the sacrificial anode (102), an ultrasonic transducer (104), and electrical connection parts (108 and 110). The ultrasonic transducer (104) is attached with a portion of the sacrificial anode (102) and the sacrificial anode (102) is connected to the cathodic protection system. One end of the electrical connection part (108) is connected with the sacrificial anode (102) and one end of the electrical connection part (110) is connected with the ultrasonic transducer (104). The ultrasonic transducer (104) is configured to detect a change in electromechanical impedance on the sacrificial anode (102) and generate an output indicating the change in the electromechanical impedance of the sacrificial anode (102).

FIG. 1