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AN EMI SENSOR FOR NON-DESTRUCTIVE CORROSION ESTIMATION IN CONCRETE

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A portable Electromagnetic Induction (EMI) sensor for non-destructive concrete corrosion estimation is disclosed. The sensor, which uses a Multiple Loop Coil (MLC), is able to detect and differentiate the chemical contents present in a concrete structure. The sensor is integrated with various component such as batteries, measuring sensor head, micro controller, memory storage for saving measured data, LED for indication and graphical display of measurement on the device. The MLC technique enables detection of corrosion of concrete structures for different chemical contents at any stage of corrosion occurring in real-time.

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Drawings

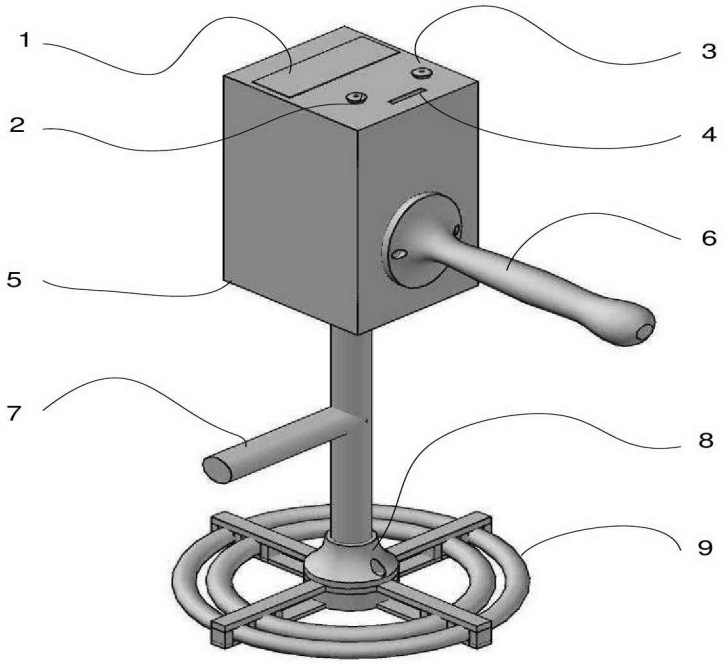

Fig. 1

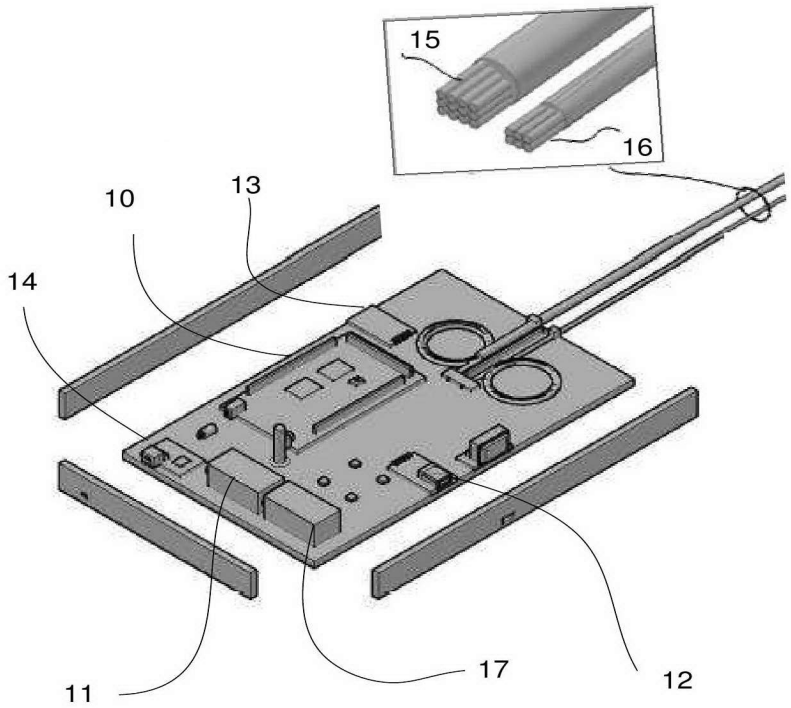

Fig. 2

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COMPLETE SPECIFICATION
INOVATION PATENT

AN EMI SENSOR FOR NON-DESTRUCTIVE CORROSION ESTIMATION IN CONCRETE

The following statement is a full description of this invention, including the best method of performing it Known to me.

AN EMI SENSOR FOR NON-DESTRUCTIVE CORROSION ESTIMATION IN CONCRETE

Corrosion is the destructive attack of a material's surface by chemical or electrochemical reaction with environment. It is primarily induced by acids, sulphate, ammonium ions, magnesium ions, pure water or alkali aggregate reactions. Though the surface deposits caused by corrosion can be beneficial they are more often damaging to the host material and/or surrounding material(s) or structure(s). Corrosion of steel reinforcement is the main cause of damage and early failure of reinforced concrete structures in civil engineering. This mode of failure often leads to enormous unbudgeted direct costs for inspection, maintenance, restoration and/or replacement of the associated infrastructure; plus potential indirect costs. Concrete can deteriorate in a number of ways, but concrete degradation due to the corrosion induced deterioration of the reinforcing steel dominates.

Initiation and propagation are the two main stages involved in the corrosion process which are supported by means of various mechanisms (i.e. diffusion, sorption, permeation and migration). Aggressive (corrosive) agents are transported through the concrete layer (protective cover) during the corrosion initiation stage, which is followed by corrosion propagation causing de-passivation of the steel. This in turn leads to an electrochemical oxidation reaction, resulting in weakening (thinning) of the reinforcing steel and spalling of the concrete. Various reported research focuses on one particular type of corrosion resulting from chemical or electrochemical reaction to the environment, more specifically pitting corrosion. The new sensor proposed in this report is able to detect and differentiate the chemical contents present in the concrete structure which causes pitting and can consequently be used as a NDE technique for concrete corrosion detection and further evaluation.

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To detect corrosion within a concrete structure, many solutions have been developed, amongst them are Non-destructive Evaluation (NDE) techniques which are normally preferred because of their nature and cost effectiveness. But also comes with some limitations. Among several other reported NDE techniques, this invention focuses on exploitation of the Electromagnetic Induction (EMI) principle, which is considered suitable, by the inventors, for concrete corrosion detection and evaluation. Essentially, an appropriately configured EMI based technique is able to detect moisture, determine crack presence and estimate size, determine susceptibility of concrete towards corrosion, identify regions susceptible to chloride penetration and it can also be used to map corrosion activity. However, in this invention, a novel NDE technique is being proposed to monitor concrete corrosion, based on an Electro-Magnetic Induction (EMI) principle. The focus for this research is the detection of the corrosive chemical properties, which adversely affects the concrete. Sea water is one of the main causes of corrosion in concrete. Sodium Chloride (NaCl) is a chemical present in sea water responsible for pitting corrosion. Sea water generally contains 3.5% of NaCl. Hence, it is imperative to have NaCl solution as a testing corrosive chemical for this research. To elaborate, the detection is more focused on the corrosive chemical contents and/or levels that are present in a concrete structure. By detecting these chemical contents and/or levels, the corrosion of concrete can be predicted based on the type and the amount of corrosive chemical compounds present in the concrete. Different concepts are being developed with the use of the EMI principle to detect minerals beneath the earth's surface; but till to date no literature has been found where an EMI based NDE sensor is being used to monitor concrete corrosion.

An adequate number of researches have been carried out and designed various Sensors for Non-destructive Corrosion Estimation in Concrete worldwide but all comes with their own merits and demerits. This invention has been specially devised in order to provide a Nobel way of NDE of concrete corrosion based on Electromagnetic Induction (EMI) principles following Faraday's Law of

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electromagnetic induction. This EMI Sensor for Non-destructive Corrosion Estimation in Concrete is mainly comprises with mechanical and electrical components. A portable EMI sensor for Non-destructive concrete corrosion estimation device which utilizes A/C current for the transmitter coil and generates D/C voltage to the receiver coil following the Faraday's law thereof. The basic principle of Time Domain Electromagnetic (TDEM) is followed and exploration of this concept is applied for the design of concrete corrosion sensor in this teaching. It is an electromagnetic method used to provide the vertical distribution of resistivity within the concrete surface. The measured voltage changes linearly with resistivity and detect the corrosion stage of the concrete as a NDT.

A portable EMI Sensor for Non-destructive Corrosion Estimation in Concrete in accordance with this invention comprises a container having free space within it and a close fitting cover on top surface. The said container is attached with two sets of coils (Transmitter and Receiver) and work as a hand held portable device. Inside the said container a microcontroller, set of rechargeable battery, SD/Micro-SD card port are placed. The said micro controller can be connected to a PC via USB or WiFi communication protocol to access the measured data and also can be used for re-programming the controller. The said enclosure/casing top cover has a LCD user viewing display and Power switch and voltage controller.

The container of the EMI Sensor for Non-destructive Corrosion Estimation in Concrete is preferably made from plastic material; however other materials can also be used. For example sheet metal fabricated containers or perspex made is found also suitable.

The invention and all the related features will be better understood with reference to the illustrations of embodiments of the invention which are provided to assist in an understanding of the present teaching.

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Brief Description Of The Drawings

The present teaching will now be described with reference to the accompanying drawings in which:

Figure 1 is a perspective view of a portable EMI sensor for Non-destructive concrete corrosion estimation device with external parts and the co-acting position of the MLC, enclosure, handles, LCD, voltage regulators and top cover.

Figure 2 is a perspective view of a portable EMI sensor for Non-destructive concrete corrosion estimation device of Figure 1 includes internal parts and the co-acting position of the controller, battery units, SD/micro card slot, A/C power input port, USB and Bluetooth connectivity unit.

Figure 3 is an exploded view of the portable EMI sensor for Non-destructive concrete corrosion estimation device showing all components.

Detailed Description Of The Drawings

The application will now be described with reference to some exemplary portable EMI sensor for Non-destructive concrete corrosion estimation device which are provided to assist in an understanding of the present teaching.

Referring to Figures 1 to 3 there is provided a portable EMI sensor for Non-destructive concrete corrosion estimation device which utilizes A/C current for the transmitter coil and generates D/C voltage to the receiver coil following the Faraday's law thereof. The basic principle of Time Domain Electromagnetic (TDEM) is followed and exploration of this concept is applied for the design of concrete corrosion sensor in this teaching. It is an electromagnetic method used to provide the vertical distribution of resistivity within the concrete surface. The measured voltage changes linearly with resistivity and detect the corrosion stage of the concrete as a NDT.

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Referring now to Figure 1 there is provided a diagrammatic illustration of the enclosure/casing 5 which is a rectangular box to contain the other sensitive electronics components preventing from the harsh environment with two handles 6-7 and a cover 3 in its wall said top, which is made to access the internal components for installation and maintenance purpose. The said top comprises of a LCD user view display 1, Power switch and voltage regulator switch 2. A micro/Micro SD card slot 4 is also place on the said top.

The said enclosure/casing 5 is connected with the sensor head of multi loop coils 9 (MLC) which are attached with a holder 8. The said coils 9 act as transmitter and receiver unit connected with the microcontroller system via cables 15-16. AC power is supplied to the transmitter coils and the receiver coils receive the induced electromagnetic voltage signal. Both the coils are placed on air media then there is no change of the voltage output, but If they placed on the concrete media then depending on the internal corrosive situation different output voltage is obtained which indicate the degree of corrosion.

Internal electronics components (inside the said enclosure/casing 5) are comprises of a micro controller system 10, a set of battery unit 11, A/C power input unit 12, SD/Micro card slot 14 , USB 13 and Bluetooth 17 connectivity unit.

While the exemplary teaching will be described with reference to the portable EMI sensor for Non-destructive concrete corrosion estimation device, it will be appreciated that a portable EMI sensor for Non-destructive concrete corrosion estimation device 1 to 17 in accordance with the present teaching may be used with a variety of different dimensions and indeed whole or part of individual components. It is not intended to limit the portable EMI sensor for Non-destructive concrete corrosion estimation device to any particular shape or size.

The EMI sensor device as described in the present application provides a portable, low cost, EMI sensor for Non-destructive concrete corrosion estimation system with compact characteristic and can be used for concrete infrastructures corrosion monitoring application.

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It will be understood that what has been described herein are exemplary portable EMI sensor for Non-destructive concrete corrosion estimation device. While the present application has been described with reference to exemplary arrangements it will be understood that it is not intended to limit the teaching of the present application to such arrangements as modifications can be made without departing from the spirit and scope of the application.

Similarly the words comprises/comprising when used in the specification are used to specify the presence of stated features, integers, steps or components but do not preclude the presence or addition of one or more additional features, integers, steps, components or groups thereof.

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The claims defining the invention are as follows:

1. A portable EMI sensor for Non-destructive concrete corrosion estimation device in accordance with this invention comprises an enclosure (i.e. a container) assembly includes a sensor head with two handles.

2. Enclosure of the portable EMI sensor for Non-destructive concrete corrosion estimation device as claimed in claim 1 formed using plastic metal or sheet metal.

3. The portable EMI sensor for Non-destructive concrete corrosion estimation device further comprising a set of multiple loop coils (MLC) sensor head attached from one side of the container as claimed in claim 1 and 2.

4. The MLC as claimed in claim 3, where the sensor head supported with holder, laid in coplanar manner a which is made from *X* coil turns for transmitter and *Y* coil turns for receiver. The ratio of *X:Y* is 2:1.

5. A device as claimed in any preceding claim, further comprising two handles for the purpose of using this system as hand-held device.

6. A device as claimed in claim 1 and claim 2, wherein a Microcontroller unit is attached for processing the sensor signals and analyze for the corrosion detection and estimation.

7. A device as claimed in any preceding claim, wherein the Microcontroller unit connected with a set of rechargeable batteries to supply power to the devices.

8. A device as claimed in claim 1 and claim 2, wherein a LCD graphical direct user view display is attached on the device that is connected to the microcontroller as claimed in claim 6.

9. A device as claimed in claim 1 and claim 2, wherein a SD cards/micro SD card storage slot is connected to the microcontroller as claimed in claim in 6 for recording and transferring measured data.

10. A device as claimed in claim 1 and claim 2, wherein an USB connectivity unit is attached with microcontroller as claimed in claim 6 for access to the microcontroller via pc to program updated and data transfer purpose.

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11. A device as claimed in any preceding claim, further comprising an AC power input unit to supply current to the transmitter coil as claimed in claim 3.

12. A device as claimed in claim 1 and claim 2, comprising two regulators to control the voltage of the transmitter coils as claimed in claim 3.

13. A device as claimed in claim 1 and claim 2, wherein a Bluetooth connectivity unit is connected with the microcontroller as claimed in claim 6 to interface with smartphone and communicate with an Android app for easy report generation and cloud database backup.

14. The portable EMI sensor for Non-destructive concrete corrosion estimation device as claimed in claim 1 and claim 2; thereof the cover can be removed to allow the casing/enclosure to be access equipment as claimed in any preceding claim.

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Drawings

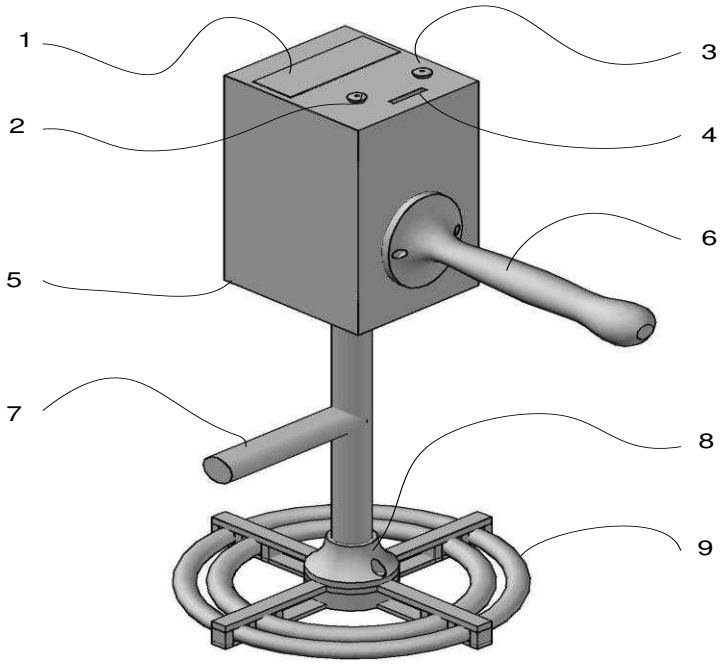

Fig. 1

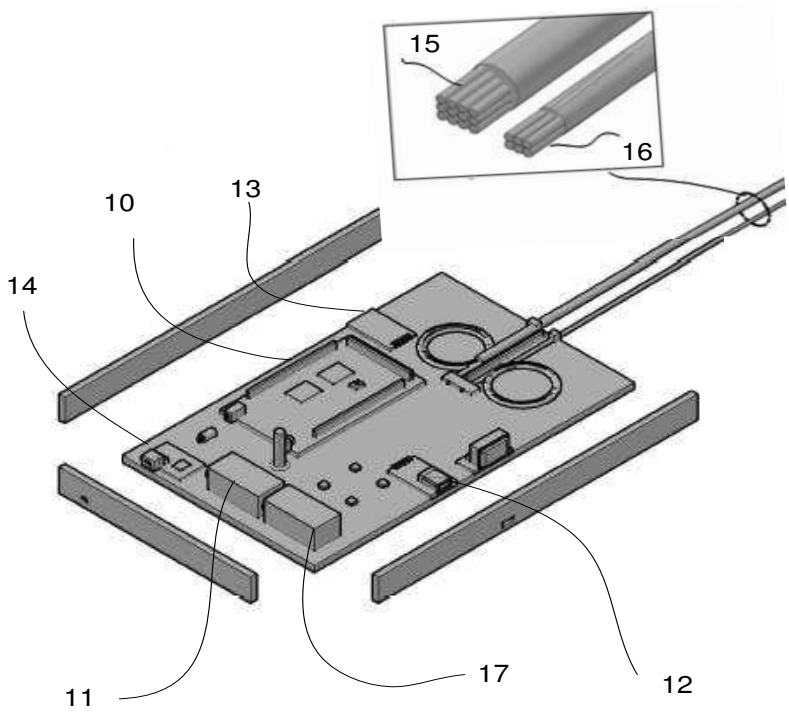

Fig. 2

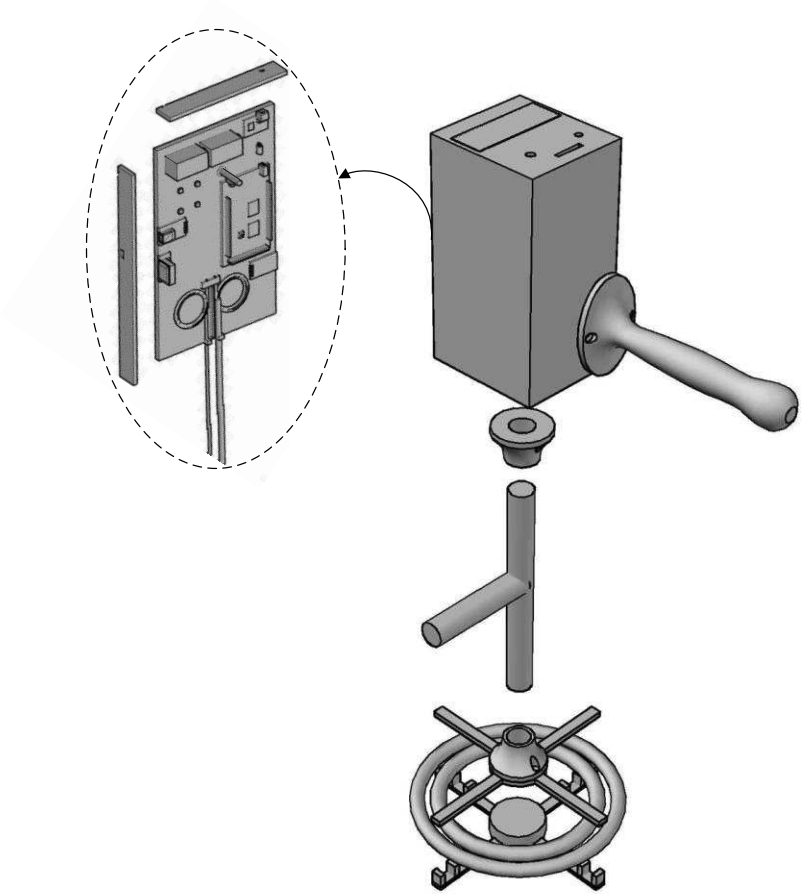

Fig. 3