FORM 2

The Patent Act 1970

(39 of 1970)

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The Patent Rules, 2005

COMPLETE SPECIFICATION

(SEE SECTION 10 AND RULE 13)

TITLE OF THE INVENTION

"Apparatus and method for detecting corrosion of conducting material based on pulsed eddy current"

APPLICANT:

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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 embodiments herein relate to corrosion detection. More particularly relates to an apparatus and method for detecting corrosion of conducting material based on pulsed eddy current.

BACKGROUND OF THE INVENTION

[0002] In general, material properties such as corrosion, strength, etc. of conducting materials used in structures such as for example, iron rods used in building construction are tested using non-destructive methods. An example for the non-destructive method for testing the material properties of the conducting materials includes but may not be limited to eddy current testing. In the eddy current testing, an eddy current is induced into a conducting material and a state of the conducting material is determined by detecting a change in electrical and magnetic properties of the conducting material.

[0003] Conventionally, the conducting material is buried within a non-conducting structure or material like wood, concrete or is underground. Therefore, an apparatus used to detect a change in the material property such as occurrence of corrosion on the conducting material must be capable of doing so through the non-conducting structure or material. However, the conventional apparatuses provide detection of the material properties such as the corrosion through very low lift-off distances making the detection of corrosion through thick non-conducting structure inaccurate or in many cases impossible.

[0004] Thus, it is desired to address the above mentioned disadvantages or other shortcomings or at least provide a useful alternative.

OBJECT OF INVENTION

[0005] The principal object of the embodiments herein is to provide an apparatus and a method for detecting corrosion of conducting material based on pulsed eddy current which is induced into a conducting material which includes a corroded region.

[0006] Another object of the embodiments herein is to use an area under the curve of a response signal which is detected in the conducting material to detect the corroded region in the conducting material. Either the complete area under the curve or at least one portion thereof is used to detect the corroded region to increase the possibility of detecting even minute occurrences of corrosion in the conducting material.

SUMMARY

[0007] Accordingly, the embodiments herein provide an apparatus for detecting corrosion of a conducting material based on a pulsed eddy current. The apparatus includes a signal controller for providing a signal to an excitation coil for generating a changing magnetic field that induces the pulsed eddy current into the conducting material based on the signal provided by the signal controller. The conducting material comprises a corroded portion and a non-corroded portion. The apparatus also includes a magnetic field sensor for detecting a response signal of the conducting material based on a change in the magnetic field. The apparatus also includes a corrosion detection controller for determining the corrosion of the conducting material based on the response signal.

[0008] In an embodiment, the magnetic field sensor detects the response signal without coming in contact with the conducting material i.e. with lift-off between the sensor and the conducting material.

[0009] In an embodiment, the corrosion detection controller detects the corrosion of the conducting material by analyzing at least one portion of area under a curve of the response signal of the conducting material.

[0010] In an embodiment, the signal provided to the excitation coil is an amplified pulse signal.

[0011] In an embodiment, the corrosion detection controller is further configured to determine the corrosion in the conducting material with higher resolution by analyzing a plurality of portions of the area under the curve of the response signal using a principal component analysis (PCA) technique.

[0012] Accordingly, the embodiments herein provide a method for detecting corrosion of a conducting material based on a pulsed eddy current using an apparatus. The method includes providing, by the apparatus, a signal to an excitation coil of the apparatus and generating, by the apparatus, a changing magnetic field in an excitation coil of the apparatus. Further, the method includes inducing, by the apparatus, a pulsed eddy current into the conducting material by the changing magnetic field based on the signal provided by the signal controller and detecting, by the apparatus, a response signal of the conducting material based on a change in the magnetic field. Further, the method also includes determining, by the apparatus, the corrosion of the conducting material based on the response signal of the conducting material.

[0013] 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

[0014] This 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:

[0015] FIG. 1 is a block diagram of an apparatus for detecting corrosion of a conducting material based on a pulsed eddy current, according to the embodiments as disclosed herein;

[0016] FIG. 2 is an experiment setup of the apparatus for detecting the corrosion of the conducting material based on the pulsed eddy current, according to the embodiments as disclosed herein;

[0017] FIG. 3 is a graph illustrating an output of the apparatus for detecting the corrosion of the conducting material based on the pulsed eddy current, according to the embodiments as disclosed herein;

[0018] FIG. 4 illustrates box plot of the corrosion detection of various conducting materials, according to the embodiments as disclosed herein;

[0019] FIG. 5 is an example illustrating an application of the apparatus for detecting the corrosion of the conducting material based on the pulsed eddy current, according to the embodiments as disclosed herein; and

[0020] FIG. 6 is a flow chart illustrating a method for detecting the corrosion of the conducting material based on the pulsed eddy current, according to the embodiments as disclosed herein.

DETAILED DESCRIPTION OF INVENTION

[0021] 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.

[0022] 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 and 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 disclosure. Likewise, the blocks of the embodiments may be physically combined into more complex blocks without departing from the scope of the disclosure.

[0023] 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.

[0024] Generally, in eddy current testing mechanism, a coil carrying an alternating current is placed in proximity to the conducting material of a structure. The alternating current in the excitation coil generates a changing magnetic field that interacts with the conducting material and induces eddy currents in the conducting material. An amplitude and phase change of the eddy current is monitored using a detection coil, or by a magnetic field sensor.

[0025] Changes in conductance and permeability of the conducting material due to defects such as for example but not limited to corrosion, structural deformities, cracks, will perturb the eddy currents induced in the conducting material correspondingly changing the phase and the amplitude of a detected signal. The change in the phase and the amplitude of the detected signal due to the worsening of the eddy currents induced in the conducting material is a basis of eddy current inspection techniques. Since the eddy currents are affected by thickness, electrical and magnetic variations of the conducting material, the eddy currents are commercially important to measure thinning of structural components, such as, walls of storage tanks and pipelines due to corrosion.

[0026] Accordingly, the embodiments herein provide an apparatus (100) for detecting corrosion of a conducting material based on a pulsed eddy current. The apparatus includes a signal controller for providing a signal to an excitation coil and the excitation coil for generating a changing magnetic field that induces the pulsed eddy current into the conducting material based on the signal provided by the signal controller. The conducting material comprises a corroded portion and a non-corroded portion. The apparatus also includes a magnetic field sensor for detecting a response signal of the conducting material based on a change in the magnetic field. The apparatus also includes a corrosion detection controller for determining the corrosion of the conducting material based on the response signal.

[0027] Accordingly, the embodiments herein provide a method for detecting corrosion of a conducting material based on a pulsed eddy current using an apparatus. The method includes providing, by the apparatus, a signal to an excitation coil of the apparatus and generating, by the apparatus, a changing magnetic field in an excitation coil of the apparatus. Further, the method includes inducing, by the apparatus, a pulsed eddy current into the conducting material by the changing magnetic field based on the signal provided by the signal controller and detecting, by the apparatus, a response signal of the conducting material based on a change in the magnetic field. Further, the method also includes determining, by the apparatus, the corrosion of the conducting material based on the response signal of the conducting material.

[0028] In the conventional apparatus used for the detecting corrosion of the conducting material based on the pulsed eddy current, detector coil or Hall sensors are used for detecting the response signal of the conducting material based on the change in the magnetic field which increases the size of the apparatus and makes the apparatus bulky and expensive. Unlike the conventional methods and apparatus, the proposed method and apparatus uses anisotropic magnetoresistive (AMR) sensor which provides better sensitivity and detection with higher lift-off.

[0029] Unlike the conventional methods and apparatus, the proposed method and apparatus is capable of detecting presence of corrosion in the conducting material at higher lift-off distance with a minimal magnetic field thus providing superior Figure of Merit (FoM).

[0030] Unlike the conventional methods and apparatus, the proposed method and apparatus uses an area-under-curve signal feature for signal analysis which increases the efficiency of detection of the defects/presence of corrosion in the conducting material.

[0031] Referring now to the drawings, and more particularly to FIGS. 1 through 6, where similar reference characters denote corresponding features consistently throughout the figures, there are shown preferred embodiments.

[0032] FIG. 1 is a block diagram of an apparatus (100) for detecting corrosion of a conducting material based on a pulsed eddy current, according to the embodiments as disclosed herein.

[0033] Referring to the FIG. 1, the apparatus (100) includes a signal controller (110), an excitation coil (120), an optional cancellation coil (130), a magnetic field sensor (140), a corrosion detection controller (150), a memory (160) and a processor (170).

[0034] In an embodiment, the signal controller (110) includes a function generator (112) and a coil driver (114). The function generator (112) is configured to generate a pulse which is amplified by the coil driver (114). The amplified pulses are provided to the excitation coil (120). The pulsed excitation is used instead of sinusoidal alternating current since the pulsed signal includes a multitude of frequencies penetrating into range of depth in the conducting material, thus eliminating the need to manually adjust excitation frequency for defects at various depths. The response to the input excitation also depends on distance between the conducting material and the magnetic field sensor (140) referred to as lift-off.

[0035] In another embodiment, the signal controller (110) may be outside the apparatus (100) which is located remotely and connected to the excitation coil (120) through a wirered or wireless medium to send the amplified pulses. The signal controller (110) is implemented by processing circuitry 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.

[0036] The amplified pulses generated by the signal controller (110) passed through the excitation coil (120) and generates a changing magnetic field. The changing magnetic field induces the pulsed eddy current into an electrical conducting material which includes a corroded region and a non-corroded region. Further, the cancellation coil (130) is provided for reducing stray magnetic field which may be generated in the conducting material.

[0037] In an embodiment, the magnetic field sensor (140) is configured to detect a response signal of the conducting material when there is a change in the magnetic field which induces the pulsed eddy current into the conducting material. The magnetic field sensor (140) for example is not limited to an anisotropic magneto-resistive (AMR) sensor. The response signal of the magnetic field sensor (140) is integrated over a time interval to evaluate a degree of corrosion of the conducting material.

[0038] In an embodiment, the corrosion detection controller (150) includes an amplifier (152) and a data management controller (154). The amplifier (152) is configured to amplify the response signal from the conducting material and stored in the memory (160). The data management controller (154) is configured to determine whether there are corroded regions in the conducting material by analyzing the response signal of the conducting material. The analysis of the response signal includes plotting a hysteresis curve using the response signal and determining an area under a hysteresis curve. Using the area under the curve to determine the corroded region and the non-corroded region in the conducting material. The area under the curve changes (reduces) due to the presence of the corrosion. The change in the area under the curve is due to volume loss, and reduction in conductivity of the conducting material, which lowers the time constant of the exponential decay in the signal. Therefore, the corroded region in the conducting material is differentiated from the non-corroded regions in the conducting material based on the area under the curve changes.

[0039] The data management controller (154) is also configured to determine the corrosion in the conducting material with higher resolution by analyzing multiple portions of the area under the curve of the response signal using a principal component analysis (PCA) technique.

[0040] The magnetic field (B_z) generated by the excitation coil (120) is given by

$$\mu_o \mu_r I N R^2 \Big/ 2\left(R^2 + z^2\right)^{3/2}$$

where μ_o is a magnetic permeability of vacuum, μ_r is relative permeability of the core material in the excitation coil (120), I is current in the excitation coil (120), R is a radius of the excitation coil (120), N are number of turns of the excitation coil (120) and z is the distance between the apparatus (100) and the conducting material. The capability of the sensor is measured by defining a figure of merit (FoM) as the performance metric of the apparatus (100). It is desirable to have an apparatus (100) that can distinguish corroded samples from uncorroded samples at higher lift-off L with minimal field B. Therefore, the figure of merit is defined as $FoM = L/B_z$. A list of FoM values of the apparatus (100) along with similar conventional systems used for detection of the corrosion are provided in a table. 1.

Reference prior art	Type of Sensor used	Signal Feature used	Excitation Coil Parameters	Maximum demonstrated lift-off (L)	B_z at z = 1m (x 10^{-9} T)	FoM (x 10^6 m/T)
Y. Li et al., Sensors, 2017	Tunnel Magnetoresistance (TMR 4002)	Absolute value	Turns: 28 OD: 14.20 mm Current: 0.28 A	3 mm	23.55	0.02
G. Piao et al., Sensors and Actuators A, 2019	Coil	Absolute value	Turns: 28 OD: 14.20 mm Current: 0.28 A	3 mm	0.25	12.08
N. Ulapane et al., Sensors, 2017	Coil	Slope	Turns: 600 OD: 57 mm Current: 0.2 A	14 mm	61.17	0.23
C. Angani et al., Journal of Applied Physics, 2010	Hall sensors	Differential value	Turns: 120, Ferrite Core, OD: 26 mm Current: 0.5 A	8 mm	9554.3	<0.01

B. Lebrun et.al., NDT&E International, 1997	Hall sensors	Differential value	Turns: 100, OD: 26 mm Current: 1.6 A	15 mm	16.99	0.88
I. Z. Abidin et al., NDT&E International, 2009	Coil	Absolute value	Turns: 400 Ferrite Core, OD: 13.9 mm Current: 0.02 A	3.25 mm	364.17	<0.01
Apparatus (100)	magnetic field sensors	Area under the curve	Turns: 45 OD: 25 mm Current: 0.2 A	50 mm	0.88	56.59

Table. 1

[0041] The corrosion detection controller (150) is implemented by processing circuitry 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.

[0042] The memory (160) can include non-volatile storage elements. Examples of such non-volatile storage elements may include magnetic hard discs, optical discs, floppy discs, flash memories, or forms of electrically programmable memories (EPROM) or electrically erasable and programmable (EEPROM) memories. In addition, the memory (160) may, in some examples, be considered a non-transitory storage medium. The term “non-transitory” may indicate that the storage medium is not embodied in a carrier wave or a propagated signal. However, the term “non-transitory” should not be interpreted that the memory (160) is non-movable. In certain examples, a non-transitory storage medium may store data that can, over time, change (e.g., in Random Access Memory (RAM) or cache).

[0043] The processor (170) is configured to execute various instructions stored in the memory (160) for detecting the corrosion of the conducting material based on the pulsed eddy current. The processor (170) may include one or a plurality of processors. The one or the plurality of processors may be a general-purpose processor, such as a central processing unit (CPU), an application processor (AP), or the like, a graphics-only processing unit such as a graphics processing unit (GPU), a visual processing unit (VPU), and/or an AI-dedicated processor such as a neural processing unit (NPU). The processor (170) may include multiple cores and is configured to execute the instructions stored in the memory (160).

[0044] Although the FIG. 1 shows the hardware elements of the apparatus (100) but it is to be understood that other embodiments are not limited thereon. In other embodiments, the apparatus (100) may include less or more number of elements. Further, the labels or names of the elements are used only for illustrative purpose and does not limit the scope of the invention. One or more components can be combined together to perform same or substantially similar function.

[0045] FIG. 2 is an experiment setup of the apparatus (100) for detecting the corrosion of the conducting material based on the pulsed eddy current, according to the embodiments as disclosed herein.

[0046] Referring to the FIG. 2, the experimental setup comprises the conducting material (1) such as for example a steel rebar which is buried within a wood insulation (2). The conducting material (1) is of 20 mm diameter and has been corroded by impressed current corrosion. The conducting material (1) includes a non- corroded portion (3) and a corroded portion (4). The apparatus (100) in the form of a single probe is used for detecting the corrosion. In an example, the apparatus (100) for example can be an array of probes. In another example, the apparatus (100) for example can be a flexible device. In another example, the apparatus (100) for example can be a single probe or an array of probes mounted on a robot.

[0047] FIG. 3 is a graph illustrating an output of the apparatus (100) for detecting the corrosion of the conducting material based on the pulsed eddy current, according to the embodiments as disclosed herein.

[0048] Referring to the FIG. 3, consider that the apparatus (100) measures the magnetic field due to pulsed eddy current generated in the conducting material. The detected output signal (1) is obtained at the magnetic field sensor (140) by measuring the pulsed eddy current. The detected output signal (1) is in form of a magnetic field versus time. For analysis the detected output signal (1) of the time varying eddy current is integrated over a time interval and the value is used for interpretation.

[0049] The detected output signal (1) is amplified and processed by the corrosion detection controller (150). The detected output signal (1) is for example a hysteresis curve of the eddy current in the conducting material plotted on a semi-log plot. The corrosion detection controller (150) determines a region of interest (2) using the detected output signal (1). The region of interest (2) comprises a complete area derived after defining a time window which includes the detected output signal (1) completely within the ambit. Further, within the region of interest (2), an area under a curve (3) is determined. The area under the curve (3) includes only a portion of the region of interest (2) which lies below the detected output signal (1). The area under the curve (3) is used to determine the presence of the corrosion in the conducting material. The area under the curve (3) is determined using for example but not limited to a trapezoidal rule for integration.

[0050] Unlike the conventional methods and apparatuses, no curve fitting of the decayed response signal is required in the apparatus (100). The evaluation is done by choosing a convenient time interval of the decayed response signal and finding the area under the curve.

[0051] The data management controller (154) is also configured to determine the corrosion in the conducting material with higher resolution by analyzing multiple portions (A_1, A_2, A_3,.... A_n) of the area under the curve of the response signal using a principal component analysis (PCA) technique. In the PCA technique, data from multiple portions of the area under the curve of the response signal are obtained, as shown by dotted lines in the FIG. 3. However, the data is dimensionally reduced by considering only a principal set of the data which represents all the data from the multiple portions of the area under the curve. For example, the data from 100 portions of the area under the curve of the response signal are obtained, then data from only 20 principal components which are representative of the 100 portions of the area under the curve of the response signal are considered to determine the corrosion of the conducting material. The use of PCA technique provides higher efficiency and higher resolution in the detection of the corrosion of the conducting material.

[0052] FIG. 4 illustrates box plot of corrosion detection of various conducting materials, according to the embodiments as disclosed herein.

[0053] Referring to the FIG. 4, consider an experiment conducted on the conducting material such as for example a pre-corroded steel rebar of 20 mm diameter. The apparatus (100) in this case is in the form of a probe. The apparatus (100) is placed on the rebar sample such that the axis of the probe coincides with the radius of the conducting material and the output such as for example provided in the FIG. 3 is obtained. Consider that the apparatus (100) allows the lift-off distance in the range of 0 mm to 10 mm and 20 mm and 50 mm distances. For every measurement on the corroded region and the non-corroded region of the conducting material, the lift off distance is varied in the range of 0 mm to 10 mm and 20 mm and 50 mm. Further, three measurements are acquired for every such configuration of the lift-off distance. The results of the measurements after analysis are depicted in the box plot as shown in the FIG. 4. The box plot shows that the apparatus (100) and the area under the curve analysis method is able to distinguish between the corroded region and the non-corroded region of the conducting material for a lift off distance of as high as 50 mm.

[0054] FIG. 5 is an example illustrating an application of the apparatus (100) for detecting the corrosion of the conducting material based on the pulsed eddy current, according to the embodiments as disclosed herein.

[0055] Referring to the FIG. 5, consider the conducting material (1) is a metal structure which needs to be inspected for corrosion and is insulated with for example concrete (2). The conducting material (1) has a region of defect which is the corroded region (4). The apparatus (100) used can be for example in the form of a probe (3) which is used to detected the corroded region (4) in the conducting material (1). Here, the lift-off distance is a thickness of the concrete (2). Hence, the apparatus (100) can be used to detect corrosion in any conducting material which may be encapsulated within the insulation. For example, the conducting material may be an iron/aluminium pipe which is buried underground, encapsulated by a concrete pillar in a building, etc.

[0056] In another example, the conducting material may be the iron/aluminium pipe which is laid on seabed, buried in the seabed, etc. Further, the apparatus (100) may be designed such that the apparatus (100) can be operated at any pressure and temperature such as for example, in underground mines, trenches, seabed, etc. The apparatus (100) can be used as a nondestructive inspection device for detecting defects in electrically conductive structures such as aircraft bodies, pipelines, storage tanks, ships, and for both off-shore and inland infrastructures.

[0057] FIG. 6 is a flow chart illustrating a method 600 for detecting the corrosion of the conducting material based on the pulsed eddy current, according to the embodiments as disclosed herein.

[0058] Referring to the FIG. 6, at step 602, the method (600) includes the apparatus (100) providing the signal to the excitation coil (120).

[0059] At step 604, the method (600) includes the apparatus (100) generating the changing magnetic field in the excitation coil (120).

[0060] At step 606, the method (600) includes the apparatus (100) inducing the pulsed eddy current into the conducting material by the changing magnetic field based on the signal provided by the signal controller (110).

[0061] At step 608, the method (600) includes the apparatus (100) detecting the response signal of the conducting material based on the change in the magnetic field.

[0062] At step 610, the method (600) includes the apparatus (100) determining the corrosion of the conducting material based on the response signal of the conducting material.

[0063] 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 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 detecting corrosion of a conducting material based on a pulsed eddy current, the apparatus (100) comprising:

   a memory (160);

   a processor (170) coupled to the memory (160);

   a signal controller (110) coupled to the memory (160) and the processor (170), and for providing a signal to an excitation coil (120);

   the excitation coil (120) for generating a changing magnetic field that induces the pulsed eddy current into the conducting material based on the signal provided by the signal controller (110), wherein the conducting material comprises at least one of a corroded portion and a non-corroded portion;

   a magnetic field sensor (140) for detecting a response signal of the conducting material based on a change in the magnetic field; and

   a corrosion detection controller (150) for determining the corrosion of the conducting material based on the response signal of the conducting material.

2. The apparatus (100) as claimed in claim 1, wherein the magnetic field sensor (140) detects the response signal without coming in contact with the conducting material with a lift-off.

3. The apparatus (100) as claimed in claim 1, wherein the corrosion detection controller (150) detects the corrosion of the conducting material by analyzing at least one portion of an area under a curve of the response signal of the conducting material.

4. The apparatus (100) as claimed in claim 1, wherein the signal provided to the excitation coil (120) is an amplified pulse signal.

5. The apparatus (100) as claimed in claim 3, wherein the corrosion detection controller (150) is configured to determine the corrosion in

the conducting material with higher resolution by analyzing a plurality of portions of the area under the curve of the response signal using a principal component analysis (PCA) technique.

6. A method for detecting corrosion of a conducting material based on a pulsed eddy current using an apparatus (100), the method comprising:

providing, by the apparatus (100), a signal to an excitation coil (120) of the apparatus (100);

generating, by the apparatus (100), a changing magnetic field in an excitation coil (120) of the apparatus (100);

inducing, by the apparatus (100), a pulsed eddy current into the conducting material by the changing magnetic field based on the signal provided by the signal controller (110);

detecting, by the apparatus (100), a response signal of the conducting material based on a change in the magnetic field; and

determining, by the apparatus (100), the corrosion of the conducting material based on the response signal of the conducting material.

7. The method as claimed in claim 6, wherein the apparatus (100) comprises:

the signal controller (110) for providing the signal to the excitation coil (120);

the excitation coil (120) for generating the changing magnetic field that induces the pulsed eddy current into the conducting material based on the signal provided by the signal controller (110), wherein the conducting material comprises at least one of a corroded portion and a non-corroded portion;

a magnetic field sensor (140) for detecting the response signal of the conducting material based on the change in the angle of the magnetic field; and a corrosion detection controller (150) for determining the corrosion of the conducting material based on the response signal of the conducting material.

8. The method as claimed in claim 7, wherein the magnetic field sensor (140) detects the response signal without coming in contact with the conducting material with a lift-off range.

9. The method as claimed in claim 7, wherein the corrosion detection controller (150) detects the corrosion of the conducting material by analyzing at least one portion of an area under a curve of the response signal of the conducting material.

10. The method as claimed in claim 7, wherein the signal provided to the excitation coil (120) is an amplified pulse signal.

11. The method as claimed in claim 9, wherein the corrosion detection controller is configured to determine the corrosion in the conducting material with higher resolution by analyzing a plurality of portions of the area under the curve of the response signal using a principal component analysis (PCA) technique.

Dated this 27th Day of April, 2021 Signature

Arun Kishore Narasani

Patent Agent IN/PA 1049

ABSTRACT

"Apparatus and method for detecting corrosion of conducting material based on pulsed eddy current"

Embodiments herein provide an apparatus (100) for detecting corrosion of a conducting material based on a pulsed eddy current. The apparatus (100) includes a signal controller (110) for providing a signal to an excitation coil (120) and the excitation coil (120) for generating a changing magnetic field that induces the pulsed eddy current into the conducting material based on the signal provided by the signal controller (110). The conducting material comprises a corroded portion and a non-corroded portion. The apparatus (100) also includes a magnetic field sensor (140) for detecting a response signal of the conducting material based on a change in the magnetic field. The apparatus (100) also includes a corrosion detection controller (150) for determining the corrosion of the conducting material based on the response signal.

FIG.1

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Total No Of Sheets: 6

Application Number: **Sheet No.: 1/6**

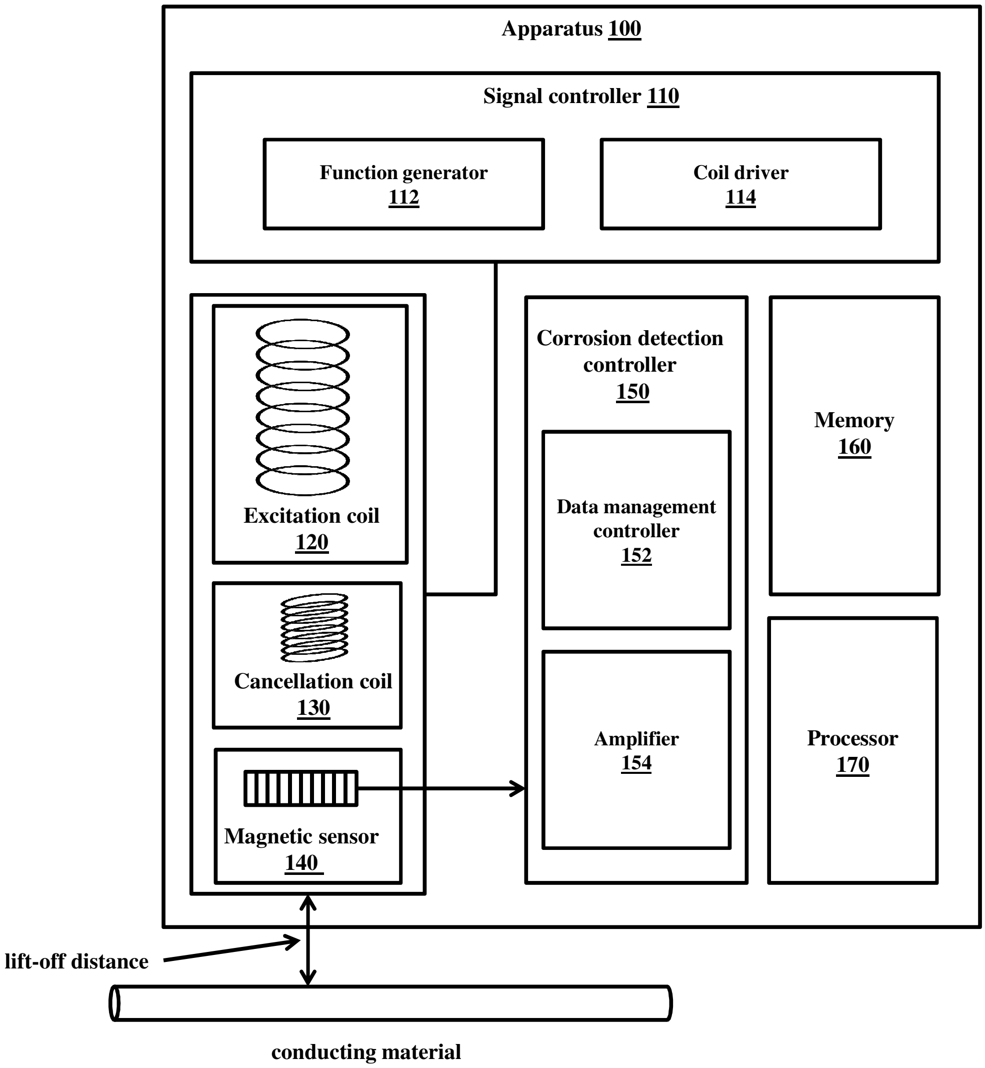

FIG. 1

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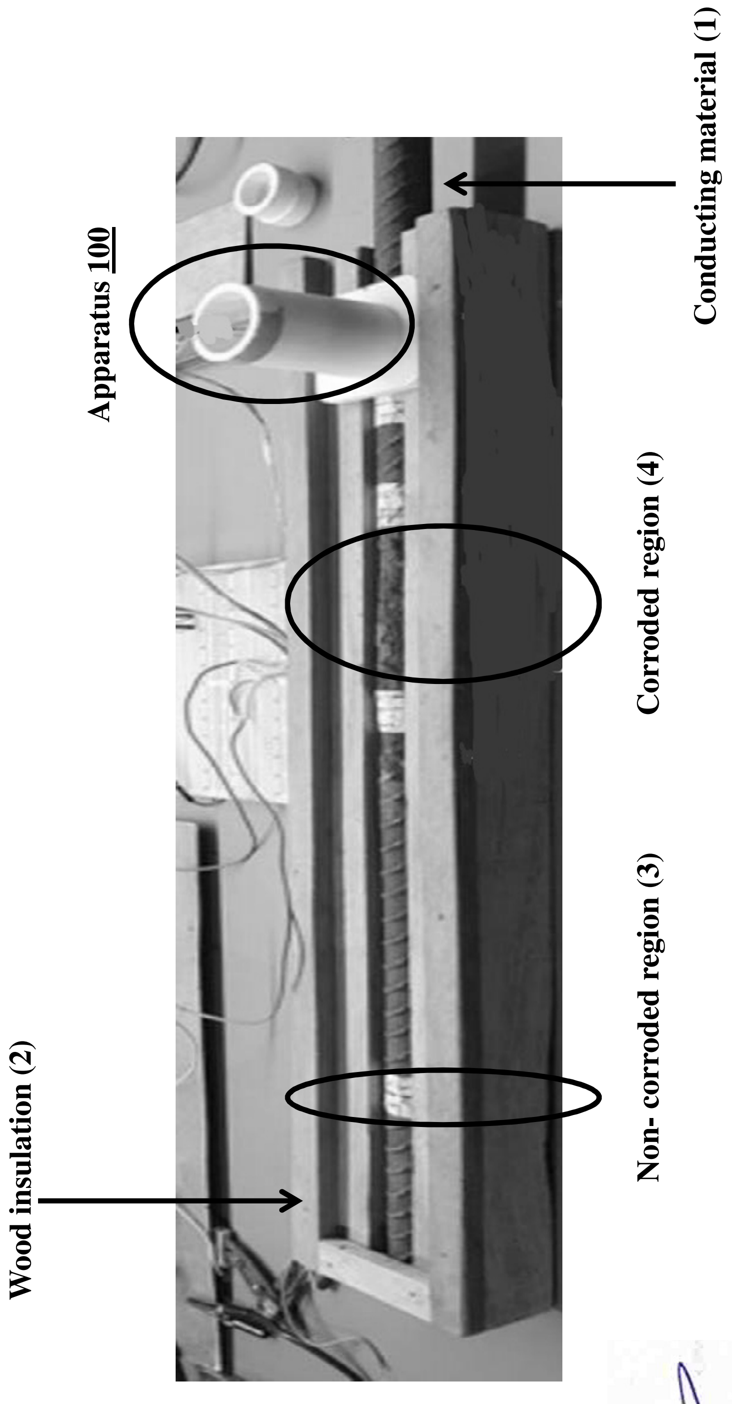

FIG. 2

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Total No Of Sheets: 6

Application Number: **Sheet No.: 3/6**

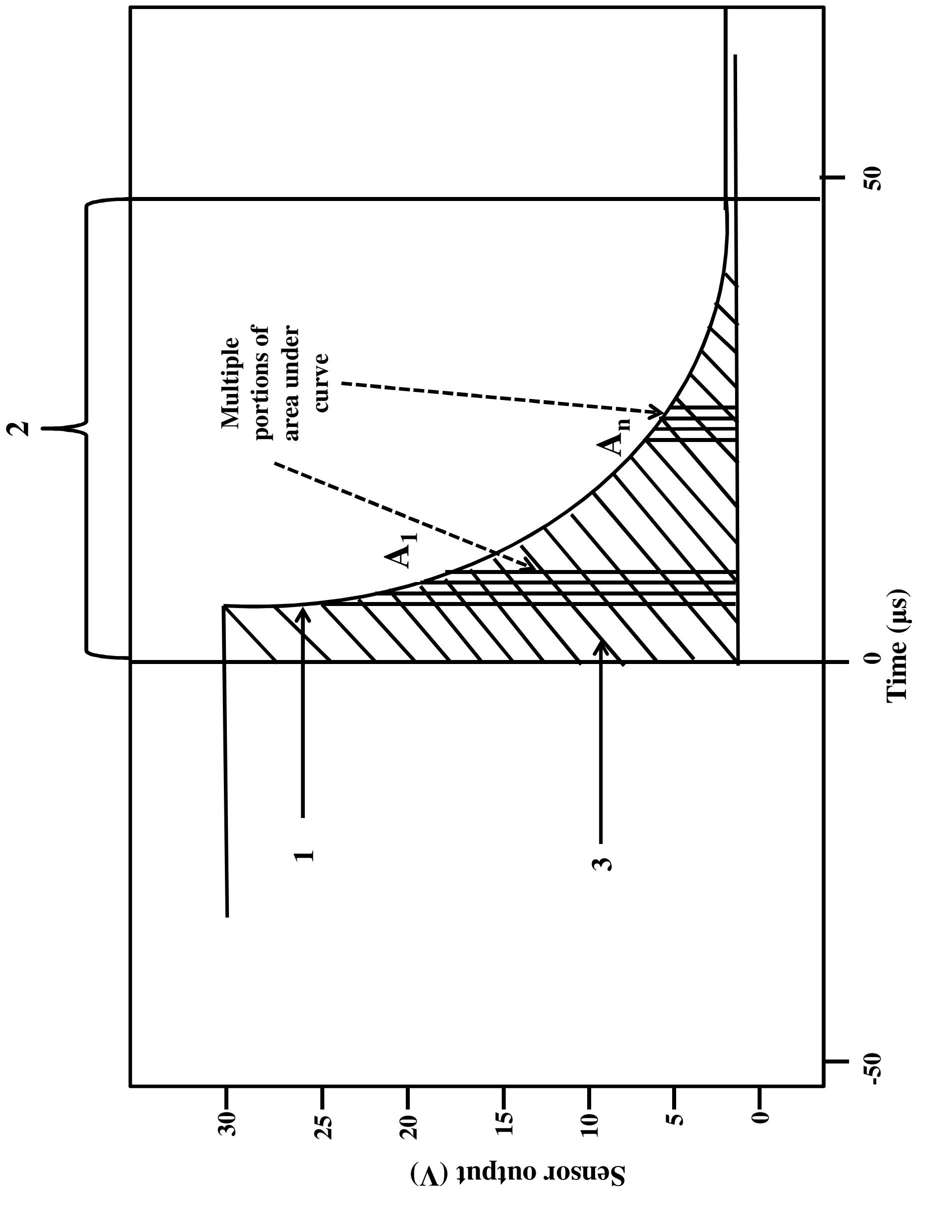

FIG. 3

Arun Kishore Narasani
Patent Agent : IN/PA 1049

Name of the Applicant: Indian Institute of Technology Bombay and Sanrachana Structural Strengthening Private Limited

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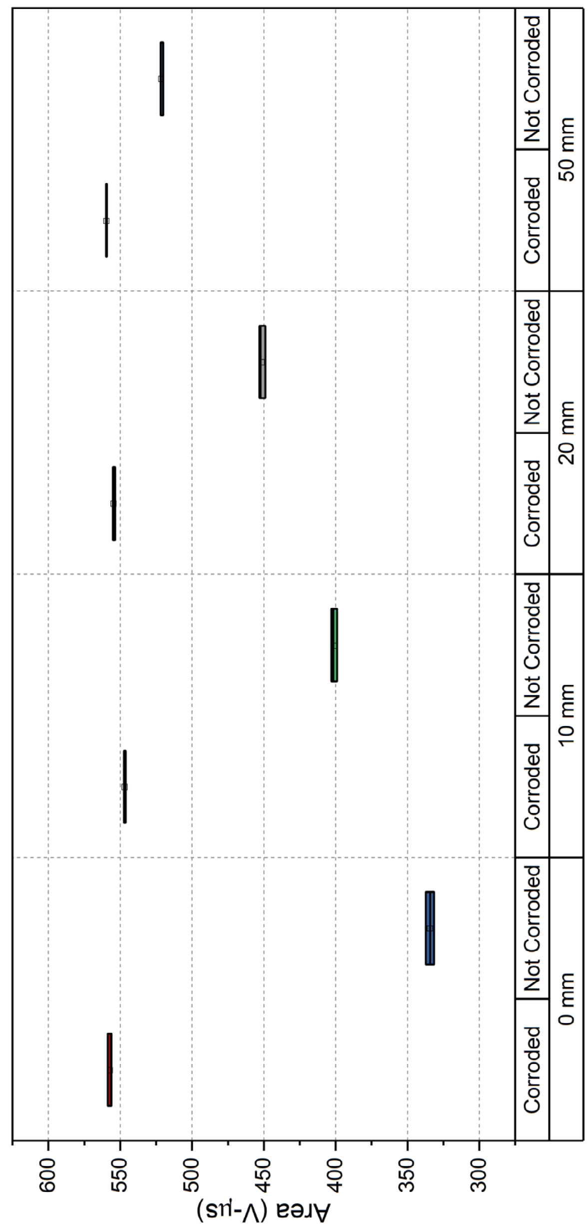

FIG. 4

Arun Kishore Narasani
Patent Agent : IN/PA 1049

Name of the Applicant: Indian Institute of Technology Bombay and Sanrachana Structural Strengthening Private Limited

Application Number:

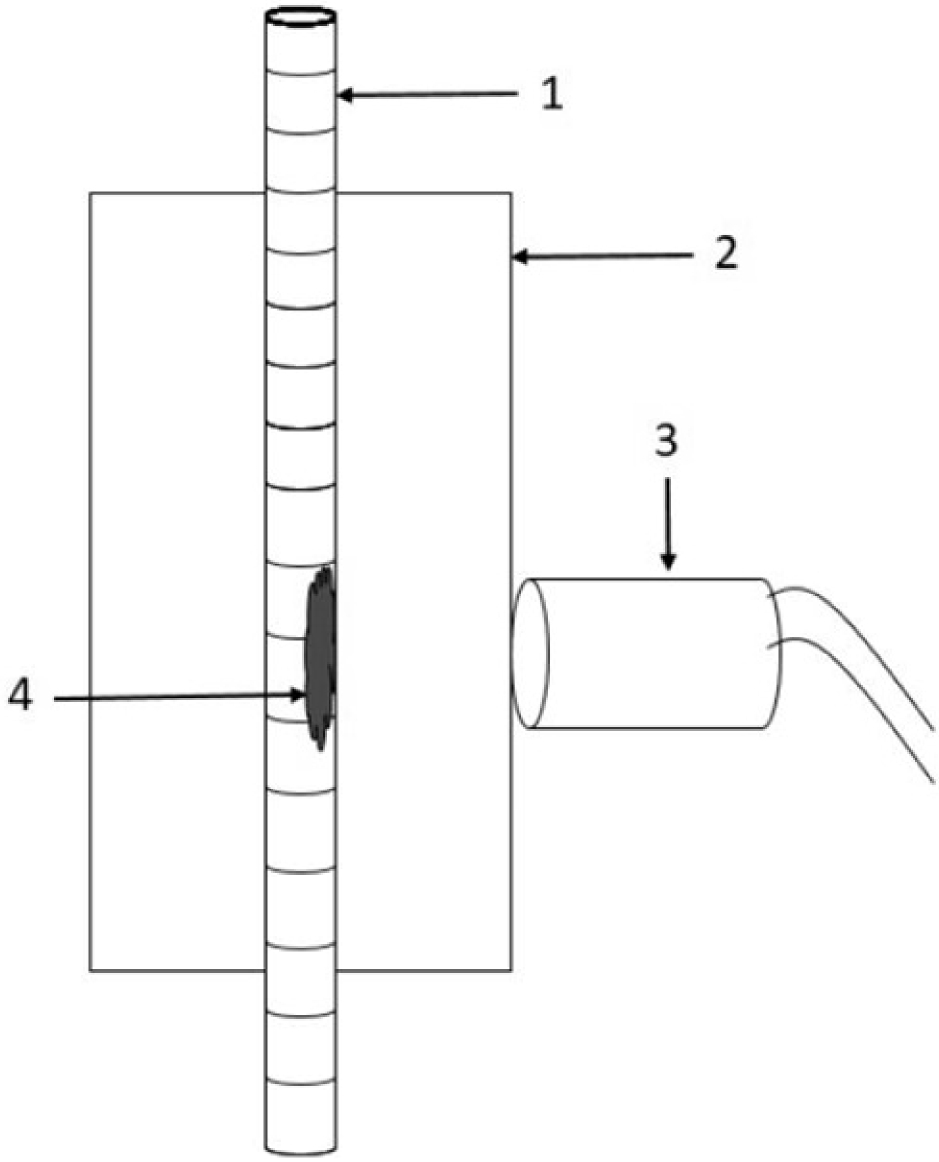

FIG. 5

Arun Kishore Narasani
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Name of the Applicant: Indian Institute of Technology Bombay and Sanrachana Structural Strengthening Private Limited

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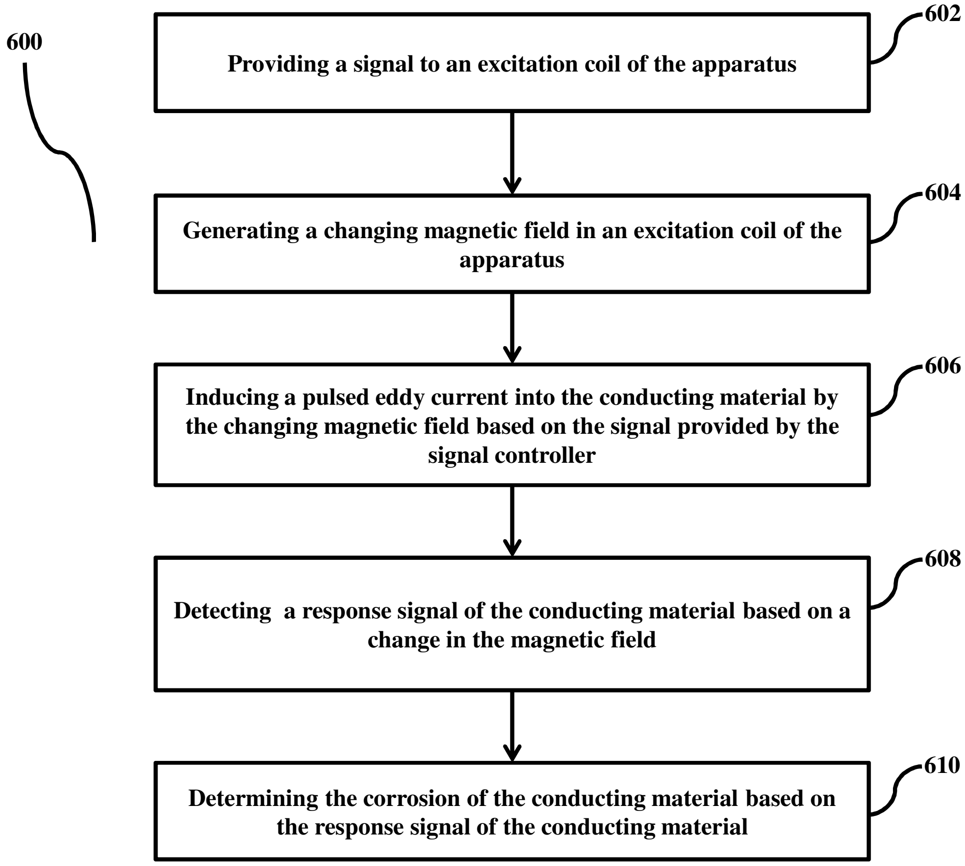

FIG. 6

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