

A SYSTEM AND METHOD DETECTING METALLIC STRUCTURE DETERIORATION IN TRANSITION FIELD

TECHNICAL FIELD

- 5 [0001] The present disclosure relates generally to the field of non-destructive testing. In particular, the disclosure is about a system and method for testing any deterioration including early mainly in metallic pipe/tube/plate made of ferrous and alike materials by analysing obtained electromagnetic waves patterns.

BACKGROUND

- 10 [0002] Presently, plants and industries established several decades ago facing problems of maintaining assets of high value due to the gradual reduction in safety margins in various structures. As these plants have to run, safeguarding social and commercial impact is essential besides production. Therefore, it is essential to test structures of various machinery involving pipelines before they are put in operation for further use.
- 15 [0003] Non-destructive technology plays vital role in assessing of engineering structures to minimise breakdown of machinery and protecting men and materials. Non-destructive testing and evaluation is the process where material, products is inspected and tested in-situ or while in service. The inspection and testing involves checking of any deterioration including early like cracks, defects, and probable life expectancy. Capabilities
- 20 of the approaches for detection of defects anywhere in materials. While a lot has been achieved over this front in recent years, several methods for detecting defects in near field and remote field of a pipe, tube, or plate have come in prior arts like testing through eddy current.
- [0004] Patent Document US6002251A discloses an electromagnetic field-focusing
- 25 remote-field eddy current probe for inspecting anomalies in a conducting plate by electromagnetic energy released from an excitation coil allowing penetration through the plate twice, and also, the signals received by one or more receiver units have is passed twice through the plate wall, from one side of the plate at the excitation coil to the other side, then back to the original side at the receiver units. The probe detects flaws with good and
- 30 substantially equal sensitivity, irrespective of their depth in the plate.
- [0005] Another Patent Document US7015690B2 discloses omnidirectional eddy current probe and inspection system includes at least one eddy current channel having a first and a second sense coil that are offset in a first (x) and a second direction (y) and overlap in

at least one of the directions (x, y). At least one drive coil is configured to generate a probing field for the eddy current channel in a vicinity of the sense coils. An eddy current array probe that includes a first and a second sense coils with opposite polarities. Electrical connections perform differential sensing for respective eddy current channels. Corrective drive coils are
5 disposed at respective ends of the eddy current channels and generate probing fields. An eddy current instrument is connected to the omnidirectional eddy current array probe and receives differential sensing signals from the eddy current channels.

[0006] While the cited references discloses methods for detecting defects in metal plates in near, far or remote ends using eddy current principle which requires 90-95% fill
10 factor and highly cleaned surfaces under test, there is possibility to provide a better solution to the problem for defect detection in an early stages in pipe, tube, and plates likely to lead development of cracks.

[0007] There is, therefore, a need to provide a simple, efficient, and cost-effective system and method for detecting any deterioration including early in metallic structure mainly
15 ferrous and alike particularly tubes and pipes.

OBJECTS OF THE INVENTION

[0008] A general object of the present disclosure is to provide a non-destructive system and method for early stage detection in a metallic structure likely to lead cracks.

[0009] An object of the present disclosure is to provide a simple, efficient, and cost-effective system for detecting flaws in a material structure mainly pipe/tube/plate.
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[0010] Another object of the present disclosure is to provide non-destructive technology based on study of change in electromagnetic wave pattern detected during investigation.

[0011] Another object of the present disclosure is to provide detection of change in electromagnetic wave pattern showing continuity/discontinuity of domains in the metallic
25 structure at atomic level within the field of interest may indicates defect/no-defect in the metallic structure.

SUMMARY OF THE DISCLOSURE

[0012] Aspects of the present disclosure relate generally to the field of non-destructive testing. In particular, the disclosure is about a system and method for testing any deterioration
30 including early mainly in metallic pipe/tube/plate made of ferrous and alike materials by analysing obtained electromagnetic waves patterns.

[0013] In an aspect, the disclosure is about a system to detect change in electromagnetic waves patterns can includes one or more exciter coils placed in a metallic structure to generate electromagnetic waves when a predefined current with variable parameters is passed in one or more exciter coils; and one or more detector coils placed within a predefined distance from the one or more exciter coils in a field of interest within the metallic structure such that when the predefined current variable parameters is passed in one or more exciter coils, the set pattern of the electromagnetic wave is obtained indicating continuity of domains in the metallic structure at atomic level within the field of interest, and any change in electromagnetic wave pattern within the field of interest indicates an any deterioration including early in the metallic structure at atomic level likely to lead towards development of crack.

[0014] In an embodiment, the metallic structure taken is a pipe/tube/plate.

[0015] In an embodiment, the field of interest for the metallic structure under defect detection is a field defined as transition field, and the transition field is defined as the field between a near field and a remote field.

[0016] In an embodiment, the distance between the one or more exciter coils and the one or more detector coils placed within the field of interest is kept between 40mm to 90mm.

[0017] In an embodiment, the one or more exciter coils includes coil of high conducting material, wounded around a cylindrical core.

[0018] In an embodiment, the predefined current of the variable parameters passed in the one or more exciter coils to generate electromagnetic waves taken with voltage amplitude between 15 volts to 100 volts.

[0019] In an embodiment, the variable parameters of the current includes change in intensity and frequency of the current,

[0020] In an embodiment, the predefined frequency at which electromagnetic waves are induced is taken between 10Hz to 10 KHz.

[0021] Another aspect of the disclosure is a method for detecting change in electromagnetic waves patterns including steps for placing one or more exciter coils within a metallic structure under defect detection; placing one or more detector coils within a predefined distance from the one or more exciter coils in a field of interest within the metallic structure; determining input parameters for the metallic structure and one or more exciter coils placed in the metallic structure; passing predefined current of variable parameters within predefined range in the one or more exciter coils for generating electromagnetic waves

patterns; detecting, by one or more detector coils, change in set patterns of the electromagnetic wave within the field of interest confirming an any deterioration including early in the metallic structure likely to be leading towards development of crack.

5 [0022] In an embodiment, the method is applied for detecting any deterioration including early within the field of interest in the metallic structure mainly taken as ferrous and alike materials, and the input parameters for the metallic structure includes type of metal, geometrical shape, and material properties.

10 [0023] Various objects, features, aspects and advantages of the inventive subject matter will become more apparent from the following detailed description of preferred embodiments, along with the accompanying drawing figures in which like numerals represent like components.

BRIEF DESCRIPTION OF THE DRAWINGS

15 [0024] The accompanying drawings are included to provide a further understanding of the present disclosure and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the present disclosure and, together with the description, serve to explain the principles of the present disclosure.

[0025] FIG. 1A illustrates an exemplary electromagnetic wave pattern generated in a metallic structure for detecting deterioration by the proposed system, in accordance with a first embodiment of the present disclosure.

20 [0026] FIG. 1B illustrates electrical and magnetic components of the electromagnetic wave in any metallic structure.

[0027] FIG. 2 illustrates an exemplary view depicting a field of interest for detecting deterioration in the structure of the metallic pipe, in accordance with a first embodiment of the present disclosure.

25 [0028] FIG. 3 illustrates an exemplary method block diagram for detecting change in electromagnetic waves generated in a structure of a metallic pipe/tube/plate, in accordance with a first embodiment of the present disclosure.

DETAILED DESCRIPTION

30 [0029] In the following description, embodiments of the invention are described in sufficient detail and in the accompanying drawings to enable those skilled in the art to practice the invention and it is understood that other embodiments may be utilized and that logical changes may be made without departing from the spirit or scope of the invention.

However, the amount of detail offered is not intended to limit the anticipated variations of embodiments; on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present disclosure as defined by the appended claim.

5 **[0030]** Embodiments explained herein relate generally to the field of non-destructive testing. In particular, the disclosure is about a system and method for testing e any deterioration including early mainly in metallic pipe/tube/plate made of ferrous and alike materials by analysing obtained electromagnetic waves patterns.

10 **[0031]** Embodiment of the present disclosure is about a system and method to detect change in electromagnetic waves patterns in a metallic structure can includes one or more exciter coils to generates electromagnetic waves; and one or more detector coils placed within a predefined distance from the one or more exciter coils in a field of interest within the metallic structure which is a pipe/tube/plate made of ferrous and alike materials, such that any change in electromagnetic wave pattern indicates any deterioration including early in the
15 metallic structure at atomic level likely to lead towards development of crack. The field of interest is a transition field, defined as the field between a near field and a remote field. The distance between the one or more exciter coils and the one or more detector coils, are kept between 40mm to 90mm. The variable parameters include change in voltage and frequency of the current.

20 **[0032]** Referring to FIG. 1A where an exemplary electromagnetic wave pattern 108 generated in a metallic structure 102 for detecting deterioration in the structure is shown.

25 **[0033]** In an embodiment, the system 100 to detect change in electromagnetic waves 108 patterns can includes one or more exciter coils 104 placed in a metallic structure 102 to generate electromagnetic waves 108 when a predefined current with variable parameters is passed in one or more exciter coils 104; and one or more detector coils 106 placed within a predefined distance from the one or more exciter coils 104 in a field of interest within the metallic structure 102.

30 **[0034]** In an aspect, a metallic structure is primarily a crystalline structure consisting of closely packed atoms arranged in regular pattern. There is a strong electrostatic force of attraction between them. The metallic structure 102 selected in the disclosure is a pipe, tube, or plate and the metal of the metallic structure 102 can be ferrous and alike for detecting any deterioration including early in the structure that may lead to cracks.

[0035] In an embodiment, the electromagnetic wave 108 inside the pipe wall depicts two regions with same pattern when there is no change in the metallic structure 102 in terms of structure is noticed. In the vicinity of the one or more exciter coils 104, the wave patterns 108 are encircling the exciter coil 104 depicting initial wave pattern. There is another area at a larger distance where the wave lines are directed away from the exciter coil 104.

[0036] In an embodiment, the one or more exciter coils 104 includes coil of high conducting material, wound around a cylindrical core. A predefined alternating current with variable parameters is passed in the one or more exciter coils 104 that generate electromagnetic waves 108. The exciter coil 104 that can be less than 50% the diameter of the pipe and need not to be placed closed to the wall of the pipe. The voltage is kept between 15 volts to 100 volts.

[0037] In an embodiment, the one or more detector coils 106 are also simple and small and the diameter of the detector coils 106 can be easily adjusted to match the pipe diameter. The distance between the one or more exciter coils 104 and the one or more detector coils 106 is kept between 40mm to 90mm to detect one or more patterns of the electromagnetic wave 108, and need not to be placed closed to the wall of the pipe to achieve even minor change in wave pattern, sensitivity, and accuracy. However, the placement of the one or more detector coils 106 is in the field of interest 204, the transition field.

[0038] In an embodiment, when the predefined alternating current is passed in the one or more exciter coils 104 generates initial pattern of electromagnetic waves 108 in the metallic structure 102. The current is an alternating current having low frequency with sinusoidal characteristics. This is detected by the one or more detector coils 106 placed in the pipe. The electromagnetic wave pattern 108 is obtained here depicts initial and normal state of the pipe. This indicates normal state of the metallic structure 102.

[0039] In an embodiment, when passing variable current at varying frequencies within predefined range in one or more exciter coils 104, the electromagnetic wave 108 are indirectly coupled to the detector coils 106. The voltage which carries information of the pipe wall condition is measured for the difference along with the change in amplitude and phase lag of the electromagnetic wave 108 and correlated to the presence of the defects.

[0040] In an embodiment, the one or more detector coils 106 are moved to detect change in initial pattern of the electromagnetic wave 108 throughout the pipe or tube length with varying intensity of current and frequency for better results for the deformation in structure

showing discontinuity of domains in the metallic structure 102 at atomic level indicating any deterioration including early in the metallic structure 102.

[0041] In an embodiment, predefined frequency at which transition field 110 electromagnetic waves 108 are induced is between 10Hz to 10 KHz.

5 [0042] FIG. 1B illustrates electrical and magnetic components of the electromagnetic wave 108 in any metal structure.

[0043] Electromagnetic waves 108 are transverse in nature as they propagate by varying the electric and magnetic fields such that the two fields are perpendicular to each other. Accelerated charges are responsible to produce electromagnetic waves 108.

10 [0044] In an aspect, the inherent characteristics of the electromagnetic wave 108 are its frequency. Their frequencies remain unchanged but their wavelength changes when the wave travels from one medium to another, and the same characteristics is used here as the any crack changes the medium as crack is filled with air and the propagation of the electromagnetic waves 108 needs to travel from metal to air and then air to metal making
15 closed loops.

[0045] FIG. 2 illustrates an exemplary view 200 depicting the field of interest which is the transition field 204.

[0046] In an embodiment, the field of interest 204 for the metallic structure 102 under defect detection is a field defined as transition field, and the transition field is defined as the
20 field between a near field 202 and a remote field 206.

[0047] In an embodiment, the electromagnetic waves will propagate in axial direction inside pipe as well as in wall of the pipe and a secondary field will be generated which will be weak in comparison of the inside wall primary field, and this can be measured outside the pipe. The direction of the energy flow from inside to outside and this area is called near field
25 202.

[0048] Furthermore, at some axial distances from the exciter coil 104 and at some points the secondary field will be stronger than the primary field and the area is called remote field 206. The area between the near field 202 and the remote field 206 is called transition field 204 which is till now unlooked in the prior arts. The field of interest 204, in the disclosure is
30 transition field 204 where change in electromagnetic is the direction of the energy flow is reverted. The transition field 204 will have the sharp separation between the near field 202 and the remote field 206.

[0049] In an embodiment, the distance between the one or more exciter coils 104 and the one or more detector coils 106 placed within the field of interest 204 is kept between 40mm to 90mm.

5 [0050] In an embodiment, the variable parameters of the current comprising change in intensity and frequency of the current. The predefined frequency at which electromagnetic waves 108 are induced is taken between 10Hz to 10 KHz.

[0051] In an embodiment, initially, the electromagnetic waves 108 are generated as soon as the current is flown in the one or more exciter coils 104. The variable parameters like intensity and the frequency of the current is varied to obtain various electromagnetic wave
10 108 patterns using the one or more detector coils 106 for references from a flawless pipe piece similar to the piece under test.

[0052] In an embodiment, the properties of the variable current fed to the one or more exciter coils 104 are passed one by one. The change in electromagnetic wave 108 patterns in the transition field 204. In case a change in electromagnetic wave 108 pattern is obtained, the
15 same is interpreted with the reference pattern obtained earlier from the flawless pipe. The difference in pattern, when interpreted, reveal disturbed pattern of atom structure of the wall of the pipe indicating deterioration in the pipe that can extend to a crack.

[0053] FIG. 3 illustrates an exemplary method block diagram 300 for detecting change in electromagnetic waves 108 patterns generated in a structure 102 of a metallic pipe/tube/plate.
20 The method 300 is based on change in electromagnetic wave 108 pattern indicates any deterioration including early in metallic structure 102 leading to development of crack.

[0054] In an embodiment, the method 300 including step 302 for placing one or more exciter coils 104 within a metallic structure 102 under defect detection, and as per step 304, placing one or more detector coils 106 within a predefined distance from the one or more
25 exciter coils 104 in a field of interest 204 within the metallic structure 102.

[0055] In an embodiment, according to step 306, determining input parameters for the metallic structure 102 and one or more exciter coils 104 placed in the metallic structure 102, and as per step 308, passing predefined current of variable parameters within predefined range in the one or more exciter coils 104 for generating electromagnetic waves 108 patterns.
30 According to step 310, detecting, by one or more detector coils 106, change in set patterns of the electromagnetic wave 108 within the field of interest 204 confirming any deterioration including early in the metallic structure 102 likely to be leading towards development of crack.

[0056] It is obvious that no method used for non-destructive testing is the best method. The human factors like time frame, cost, and accuracy also determine the actual results by the used method. The accuracy is mostly dependent on conductivity and permeability of the pipe material and human interpretation.

- 5 [0057] Thus, compared with other methods, the disclosed method 300 is able to detect flaws in the transition field using electromagnetic wave patterns. The method 300 is simple, cost-effective as not many apparatus are used, and the used coils are cheap and easy in construction.

- 10 [0058] While the foregoing describes various embodiments of the invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof. The scope of the invention is determined by the claims that follow. The invention is not limited to the described embodiments, versions or examples, which are included to enable a person having ordinary skill in the art to make and use the invention when combined with information and knowledge available to the person having ordinary skill in the art.

15 **ADVANTAGES OF THE INVENTION**

[0059] The present disclosure provides a non-destructive system and method for early stage detection in a metallic structure likely to lead cracks.

[0060] The present disclosure provides a simple, efficient, and cost-effective system for detecting flaws in a material structure mainly pipe/tube/plate.

- 20 [0061] The present disclosure provides non-destructive technology based on study of change in electromagnetic wave pattern detected during investigation.

[0062] The present disclosure provides detection of change in electromagnetic wave pattern showing continuity/discontinuity of domains in the metallic structure at atomic level within the field of interest may indicates defect/no-defect in the metallic structure.

We Claim:

1. A system (100) to detect change in electromagnetic waves (108) patterns, the system (100) characterized by comprising:
 - 5 one or more exciter coils (104) placed in a metallic structure (102) to generate electromagnetic waves (108) when a predefined current with variable parameters is passed in one or more exciter coils (104); and
 - one or more detector coils (106) placed within a predefined distance from the one or more exciter coils (104) in a field of interest (204) within the metallic structure
 - 10 (102),
 - wherein the distance between the one or more exciter coils (104) and the one or more detector coils (106) placed within the field of interest (204) is kept between 40mm to 90mm,
 - wherein when the predefined variable parameters current is passed in one or
 - 15 more exciter coils (104), the set pattern of the electromagnetic wave (108) is obtained indicating continuity of domains in the metallic structure (102) at atomic level within the field of interest, wherein any change in electromagnetic wave (108) patterns within the field of interest (204) indicates any deterioration including early in the metallic structure (102) at atomic level likely to be leading towards development of
 - 20 crack.
2. The system as claimed in claim1, wherein the metallic structure (102) is a pipe/tube/plate.
3. The system as claimed in claim1, wherein the field of interest (204) for the metallic structure (102) under defect detection is a field defined as transition field, wherein the
- 25 transition field is defined as the field between a near field (202) and a remote field (206).
4. The system as claimed in claim1, wherein the one or more exciter coils (104) comprise coil of high conducting material, wound around a cylindrical core.
5. The system as claimed in claim1, wherein the predefined current of the variable
- 30 parameters passed in the one or more exciter coils (104) to generate electromagnetic waves (108) taken with voltage amplitude between 15 volts to 100 volts.
6. The method as claimed in claim 6, wherein the variable parameters of the current comprising change in intensity and frequency of the current,

7. The system as claimed in claim 1, wherein the predefined frequency at which electromagnetic waves (108) are induced is taken between 10Hz to 10 KHz.
8. A method (300) for detecting change in electromagnetic waves (108) patterns, the method (300) comprising steps for:
- 5 placing one or more exciter coils (104) within a metallic structure (102) under defect detection;
- placing one or more detector coils (106) within a predefined distance from the one or more exciter coils (104) in a field of interest (204) within the metallic structure (102);
- 10 determining input parameters for the metallic structure (102) and one or more exciter coils (104) placed in the metallic structure (102);
- passing predefined current of variable parameters within predefined range in the one or more exciter coils (104) for generating electromagnetic waves (108) patterns;
- detecting, by one or more detector coils (106), change in set patterns of the
- 15 electromagnetic wave (108) within the field of interest (204) confirming any deterioration including early in the metallic structure (102),
- wherein the distance between the one or more exciter coils (104) and the one or more detector coils (106) placed within the field of interest (204) is kept between 40mm to 90mm.
- 20 9. The method as claimed in claim 8, wherein the method (300) is applied for detecting any deterioration including early within the field of interest (204) in the metallic structure (102) mainly taken as ferrous and alike materials, wherein the input parameters for the metallic structure (102) comprising type of metal, geometrical shape, and material properties.