(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 June 2017 (29.06.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/109641 A1

(51) International Patent Classification:
C23C 22/62 (2006.01) *F16L 58/00* (2006.01)
B08B 9/055 (2006.01) *C23C 22/00* (2006.01)

(21) International Application Number:
PCT/IB2016/057588

(22) International Filing Date:
13 December 2016 (13.12.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/270,962 22 December 2015 (22.12.2015) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

(54) Title: METHOD OF STEEL PASSIVATION

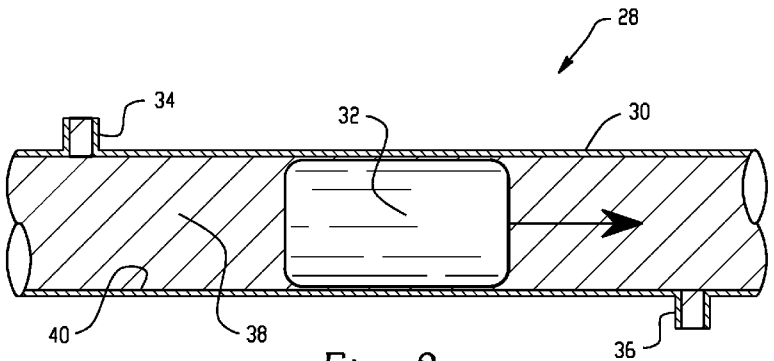

Fig. 2

(57) Abstract: A method of stainless steel re-passivation includes: passing a first mechanical cleaning device through a pipe wherein the first mechanical cleaning device displaces a contaminated acetic acid remaining after previous transportation from the pipe; passing a passivation solution comprising water, a base, and an oxidizer through the pipe; maintaining an ambient temperature within the pipe for greater than or equal to 1 hour; passing a second mechanical cleaning device through the pipe wherein the second mechanical cleaning device displaces the used passivation solution from the pipe; passing warm air; maintaining it within the pipe for greater than or equal 1 hour; and passing nitrogen gas through the pipe.

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METHOD OF STEEL PASSIVATION

BACKGROUND

[0001] Generally, passivation involves the formation of a thin surface film (e.g., layer) on metal that protects against corrosion. Passivation is an important method used in the chemical industry. For example, passivation is used to form a protective layer on the inner surface of pipes that transport chemical products. These protective films often become damaged during the lifetime of the pipe. For example, routine pipe construction, acidic chemical products containing high amount of chlorides and bromides, and long periods of stagnation can all contribute to the damage of a passive film causing localized corrosion. A damaged passive film is problematic for many reasons, including the contamination of the transported product with corrosion products. Therefore, there is a need to restore (i.e., re-passivate) the damaged passive film or upgrade metallurgy of the pipe. The conventional solution to such damage and contamination involves the use of highly expensive corrosion resistant materials and overly complex re-passivation methods. For example, conventional re-passivation methods require waste tanks, pumps, on-site sources of heat and electricity, highly concentrated acids that are hazardous to the environment, and large volumes of clean water. Such conventional re-passivation methods become even more impractical when the corroded pipe is in a remote geographic location. For example, chemical transport pipelines must often traverse long distances over desert terrain.

[0002] Thus, there is a need for a re-passivation method that is greatly simplified, inexpensive, non-hazardous to the environment, and effective when applied in remote geographic locations.

SUMMARY

[0003] Disclosed, in various embodiments, are method of steel passivation.

[0004] A method of stainless steel re-passivation, comprises: passing a first mechanical cleaning device through a pipe wherein the first mechanical cleaning device displaces a material from the pipe; passing a solution comprising water, a base, and an oxidizer through the pipe; maintaining an ambient temperature within the pipe for greater than or equal to 1 hour; passing a second mechanical cleaning device through the pipe wherein the second mechanical cleaning device displaces the solution from the pipe; and passing nitrogen gas through the pipe.

[0005] A method of stainless steel re-passivation, comprises: passing a first pig device comprising polytetrafluoroethylene through a pipe wherein the first pig device displaces a material from the pipe; allowing the material to exit the pipe through a drain located in the pipe;

passing a solution comprising demineralized water, 0.3% to 0.5% sodium carbonate, and 0.5% to 1% sodium nitrite through the pipe; maintaining an ambient temperature within the pipe for 12 hours to 14 hours; passing a second pig device comprising foam material through the pipe wherein the second pig device displaces the solution from the pipe; allowing the solution to exit the pipe through a drain located in the pipe; passing air at a temperature of 40°C to 50°C (as additional passivation stage) through the pipe for greater than or equal to 12 hours; and passing nitrogen gas through the pipe.

[0006] These and other features and characteristics are more particularly described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The following is a brief description of the drawings wherein like elements are numbered alike and which are presented for the purposes of illustrating the exemplary embodiments disclosed herein and not for the purposes of limiting the same.

[0008] FIG. 1 is a flowchart representing a sequence of steps for a steel passivation method.

[0009] FIG. 2 is a simplified schematic diagram representing re-passivation of a pipeline.

DETAILED DESCRIPTION

[0010] The method disclosed herein can provide a re-passivation method that is greatly simplified, inexpensive, non-hazardous to the environment, and effective when applied in remote geographic locations. For example, the method disclosed herein can be effective in remote geographic locations such as deserts and forests. The method disclosed herein can utilize mechanical cleaning methods, such as pigging devices, eliminating the use of chemical cleaning methods. The method disclosed herein does not use of highly acidic materials, such as citric and nitrous acids, which can be hazardous to the environment. The method disclosed herein can be highly effective while utilizing a low volume of clean water. The method disclosed herein can accomplish both passivation and neutralization in a single step, thereby greatly increasing the efficiency of the process. The method disclosed herein also takes advantage of ambient temperatures found in the surrounding environment, thus minimizing the need for utilities such as heat and electricity. For example, with the use of the method disclosed herein there is no need heat exchanger and a pump. The protective passive layer (e.g., film) provided by the method can effectively transport acidic chemicals, such as acetic acid, while remaining resistant to corrosion. The restored protective passive layer can also transport a chemical while preserving the purity of

the chemical. For example, the re-stored protective film can protect the transported chemical, particularly glacial acetic acid from corrosive products contamination. For example, a chemical, such as, including, but not limited to, glacial acetic acid, transported can comprise less than or equal to 1 parts per million (ppm) iron.

[0011] The method disclosed herein for stainless steel passivation can include passing a first mechanical cleaning device through a pipe wherein the first mechanical cleaning device can displace a material (e.g., remaining contaminated acetic acid (RCAA) after a prior transportation/shipping) from the pipe. For example, the first mechanical cleaning device can be a pigging device and the material displaced from the pipe can be acetic acid. Material can be allowed to exit the pipe through drainage locations in the pipe. A proposed passivation solution can then be passed through the pipe wherein the solution can comprise water, sodium carbonate, and sodium nitrite. The pipe can be maintained at ambient temperature for greater than or equal to 1 hour. A second mechanical cleaning device can then be passed through the pipe wherein the second mechanical cleaning device can displace the solution from the pipe. Air, (e.g., warm air) can be passed through the pipe to provide additional passivation. Nitrogen gas can then be passed through the pipe.

[0012] The method disclosed herein for stainless steel re-passivation can include passing or transporting materials through a pipeline. For example, the method disclosed herein can include transporting chemical products from a chemical production facility to a destination. For example, chemical products can be transported to a harbor or any other type of transport facility for shipping purposes. The chemical products to be transported can include acids. For example, glacial acetic acid can be transported through the pipeline. . The pipeline can comprise a steel pipe. For example, the pipe can comprise stainless steel. For example, the pipe can comprise 316L grade stainless steel. The pipe can be any diameter. For example, the pipe can be 12 to 30 centimeters (cm) in diameter, for example, 12 to 25 cm, for example, 12.7 to 25.4 cm, for example, 20 cm in diameter. For example, the pipe can be 20.32 cm in diameter. The pipeline can be any length. For example, the pipeline can be greater than or equal to 5 kilometers in length. For example, the pipeline can be 5 kilometers to 15 kilometers or more in length. For example, the pipeline can be 9 kilometers in length. The pipeline can traverse remote geographic locations. For example, a section of pipe can be located in a desert, forest, tundra, or a combination comprising at least one of the foregoing.

[0013] The method described herein for stainless steel re-passivation can include the use of a first mechanical cleaning device. For example, the first mechanical cleaning device can be passed through a pipe. The first mechanical cleaning device can be a pig device. For example,

the method described herein can include pigging a pipe by passing the pig device through the pipe. The pig device can be introduced to the pipe from a launching station that can be connected to the pipe. The pig can be propelled through the pipe by a gaseous medium. For example, the pig can be propelled through the pipe by air, nitrogen gas, or a combination comprising at least one of the foregoing. The pig device can exit the pipe at a receiver station that can be connected to the pipe. The diameter of the pig device can be greater than an inside diameter of the pipe. For example, an outer surface of the pig device can contact or scrape an inner surface of the pipe.

[0014] For example, a material (e.g., RCAA) within the pipe can be effectively displaced by the pig device when the pig device is passed through the pipe. For example, the pig device can displace acetic acid from the pipe. Material within the pipe can be allowed to exit the pipe through drains located in the pipe. The pig device can comprise a soft material. For example, the pig device can comprise polytetrafluoroethylene, polyurethane, steel, foam or sponge material, or a combination comprising at least one of the foregoing. For example, the pig device can comprise steel wire brush, polytetrafluoroethylene wire brush, or a combination comprising at least one of the foregoing. The first mechanical cleaning device can be a pig device comprising polytetrafluoroethylene. The method disclosed herein does not use chemical cleaning methods. The method disclosed herein does not use environmentally hazardous chemicals such as citric acid or nitrous acid.

[0015] The method disclosed herein for stainless steel re-passivation can include passing a solution through a pipe. For example, the solution can include water. For example, the water can be demineralized water. The method disclosed herein can be highly effective while utilizing a low volume of water. The solution can include a base. For example, the base can include sodium carbonate, trisodium phosphate, sodium silicate, ethanolamine, or a combination comprising at least one of the foregoing. The base can accomplish neutralization within the pipe. The solution can include an oxidizer. For example, the oxidizer can include sodium nitrite, molybdate, chromate, borate, vanadate, or a combination comprising at least one of the foregoing. The oxidizer can accomplish passivation within the pipe. The solution can include water, a base, an oxidizer, or a combination comprising at least one of the foregoing. For example, the solution can include demineralized water, sodium carbonate, sodium nitrite, or a combination comprising at least one of the foregoing. For example, the solution can comprise 0.3 weight percent (wt.%) to 0.5 wt.% sodium carbonate and 0.5 wt.% to 1 wt.% sodium nitrite. The solution can be passed through the pipe subsequent to passing the first mechanical cleaning device through the pipe. Passing the solution through the pipe can accomplish both passivation and neutralization in a single step, thereby increasing the efficiency of the process. Passing the

solution through the pipe creates a passive film along an inner surface of the pipe. This passive film can protect the pipe from corrosion damage.

[0016] The method disclosed herein for stainless steel re-passivation can include maintaining an ambient temperature within the pipe. For example, ambient temperature can be maintained within the pipe for greater than or equal to 1 hour. For example, ambient temperature can be maintained for 10 hours to 15 hours. For example, ambient temperature can be maintained for 12 hours to 14 hours. The use of ambient temperature can take advantage of the naturally occurring temperatures in the surrounding environment where the pipe is located. For example, naturally occurring desert temperatures can be utilized if the pipe is located in a desert region. The use of ambient temperatures reduces the need for utilities such as heat and electricity. Maintaining an ambient temperature within the pipe can contribute to forming a protective film along an inner surface of the pipe. The maintenance of an ambient temperature within the pipe can take place subsequent to passing a solution through the pipe.

[0017] The method disclosed herein for stainless steel re-passivation can include the use of a second mechanical cleaning device. For example, the second mechanical cleaning device can be passed through a pipe. The second mechanical cleaning device can be a pig device. For example, the method described herein can include pigging a pipe by passing the pig device through the pipe. The pig device can be introduced to the pipe from a launching station that can be connected to the pipe. The pig can be propelled through the pipe by a gaseous medium. For example, the pig can be propelled through the pipe by air, nitrogen gas, or a combination comprising at least one of the foregoing. The pig device can exit the pipe at a receiver station that can be connected to the pipe. The diameter of the pig device can be greater than an inside diameter of the pipe. For example, an outer surface of the pig device can contact or scrape an inner surface of the pipe.

[0018] For example, a material within the pipe can be effectively displaced by the pig device when the pig device is passed through the pipe. For example, the pig device can displace a solution comprising water, sodium carbonate, and sodium nitrite from the pipe. Material within the pipe can be allowed to exit the pipe through drains located in the pipe. The pig device can comprise polytetrafluoroethylene, polyurethane, steel, foam or sponge material, or a combination comprising at least one of the foregoing. For example, the pig device can comprise steel wire brush, polytetrafluoroethylene wire brush, or a combination comprising at least one of the foregoing. The second mechanical cleaning device can be a pig device comprising foam material. The method disclosed herein does not require the use of ordinary chemical cleaning methods. The method disclosed herein does not require the use of environmentally hazardous

chemicals such as citric acid or nitrous acid. The second mechanical cleaning device can be passed through the pipe subsequent to maintenance of an ambient temperature within the pipe.

[0019] The method disclosed herein for stainless steel re-passivation can include passing air (e.g., warm air) through a pipe. Passing warm air through the pipe can provide additional passivation. For example, passing air through the pipe can contribute to forming a protective passive film along an inner surface of the pipe. Air can be passed through the pipe subsequent to passing a second mechanical cleaning device through the pipe. The air passed through the pipe can have a temperature greater than or equal to 30°C. For example, the air passed through the pipe can have a temperature of 30°C to 60°C. For example, the air can have a temperature of 40°C to 50°C. Air can be passed through the pipe for a time of greater than or equal to 1 hour. For example, air can be passed through the pipe for 10 hours to 15 hours. For example, air can be passed through the pipe for 12 hours to 14 hours.

[0020] The method disclosed herein for stainless steel re-passivation can include passing nitrogen gas through a pipe. Nitrogen gas can be passed through the pipe subsequent to passing a second mechanical cleaning device through the pipe.

[0021] A more complete understanding of the components, processes, and apparatuses disclosed herein can be obtained by reference to the accompanying drawings. These figures (also referred to herein as "FIG.") are merely schematic representations based on convenience and the ease of demonstrating the present disclosure, and are, therefore, not intended to indicate relative size and dimensions of the devices or components thereof and/or to define or limit the scope of the exemplary embodiments. Although specific terms are used in the following description for the sake of clarity, these terms are intended to refer only to the particular structure of the embodiments selected for illustration in the drawings, and are not intended to define or limit the scope of the disclosure. In the drawings and the following description below, it is to be understood that like numeric designations refer to components of like function.

[0022] Referring now to FIG. 1 and FIG. 2, the method disclosed herein for stainless steel re-passivation can follow a sequence of steps 10 that is carried out using a chemical transport pipeline 28. The chemical transport pipeline 28 can be located in a remote desert location. The method disclosed herein can include a first mechanical cleaning step 12. The first mechanical cleaning step 12 can include passing a mechanical cleaning device 32 through a pipe 30. The mechanical cleaning device 32 can be a pig device comprising polytetrafluoroethylene. The pipe 30 can comprise stainless steel. The mechanical cleaning device 32 can scrape the inner surface 40 of the pipe 30, thus displacing a material 38 that is passing through the pipe 30. For example, the mechanical cleaning device 32 can displace acetic acid from the pipe 30.

[0023] The method disclosed herein for stainless steel re-passivation can include a first draining step 14 that can occur subsequent to the first mechanical cleaning step 12. The first draining step 14 can include allowing the material 38 to exit the pipe 30 through a drain 36. The pipe 30 can comprise greater than or equal to 1 drain 36.

[0024] The method disclosed herein for stainless steel re-passivation can include a solution step 16 that can occur subsequent to the first draining step 14. The solution step 16 can include passing a material 38 through the pipe 30. For example, the material 38 can be a solution comprising water, sodium carbonate, and sodium nitrite. The material 38 can be introduced to the pipe 30 through an inlet 34. The solution step 16 can form a protective passive film on an inner surface 40 of the pipe 30.

[0025] The method disclosed herein for stainless steel re-passivation can include an ambient temperature step 18 that can occur subsequent to the solution step 16. The ambient temperature step 18 can include maintaining a temperature within the pipe 30 at an ambient temperature. For example, an ambient temperature can be maintained for 12 hours to 14 hours. The ambient temperature step 18 can take advantage of the naturally occurring temperatures in the surrounding environment where the pipe 30 is located.

[0026] The method disclosed herein for stainless steel re-passivation can include a second mechanical cleaning step 20 that can occur subsequent to the ambient temperature step 18. The second mechanical cleaning step 20 can include passing a mechanical cleaning device 32 through a pipe 30. For example, the mechanical cleaning device 32 can be a pig device comprising foam material. The pipe 30 can comprise stainless steel. The mechanical cleaning device 32 can scrape the inner surface 40 of the pipe 30, thus displacing a material 38 that is passing through the pipe 30. For example, the mechanical cleaning device 32 can displace a passivation solution comprising water, sodium carbonate, and sodium nitrite from the pipe 30.

[0027] The method disclosed herein for steel passivation can include a second draining step 22 that can occur subsequent to second mechanical cleaning step 20. The second draining step 22 can include allowing the material 38 to exit the pipe 30 through a drain 36. The pipe 30 can comprise greater than or equal to 1 drain 36.

[0028] The method disclosed herein for stainless steel re-passivation can include an air passivation step 24 that can occur subsequent to the second draining step 22. The air passivation step 24 can include passing a material 38 through pipe 30. For example, material 38 can be air at a temperature of 40°C to 50°C. Air can be passed through the pipe for 12 hours to 14 hours. The material 38 can be introduced to the pipe 30 through an inlet 34. The air passivation step 24 can form a protective coating on an inner surface 40 of the pipe 30.

[0029] The method disclosed herein for stainless steel re-passivation can include a nitrogen gas step 26 that can occur subsequent to the air passivation step 24. The nitrogen gas step 26 can include passing a material 38 through pipe 30. For example, material 38 can be nitrogen gas. The material 38 can be introduced to the pipe 30 through an inlet 34. Nitrogen gas can optionally be used to decrease probability of atmospheric (e.g., marine) corrosion if the pipe is out of service for long periods of time (e.g., several months).

[0030] The following example is merely illustrative of the stainless steel re-passivation method disclosed herein and is not intended to limit the scope hereof.

EXAMPLES

Example 1

[0031] A method for stainless steel re-passivation in accordance with the present disclosure, and as illustrated in Figure 1 and Figure 2, was used for the purposes of this example. A 316L stainless steel pipe was used. The pipe was 20.32 centimeters in diameter and 9 kilometers in length. The pipe contained 227 metric tons of glacial acetic acid with a purity level of greater than 99.7%. The RCAA from previous shipping/transportation was displaced from the pipe by a pig device comprising polytetrafluoroethylene. Remaining acetic acid was drained from the pipe from drainage locations in the pipe. A solution comprising demineralized water, 0.3 wt.% to 0.5 wt.% sodium carbonate, and 0.5 wt.% to 1 wt.% sodium nitrite was passed through the pipe. The pipe was then maintained at ambient temperature for 12 to 14 hours. The solution was then displaced from the pipe by a pig device comprising sponge material. Remaining solution was drained from the pipe from drainage locations in the pipe. Air was then passed through the pipe for 12 to 14 hours at a temperature of 40°C to 50°C. Nitrogen gas was then passed through the pipe. The pipe was used to transport glacial acetic acid and was analyzed on a weekly basis for a period of greater than 1.5 years. The acetic acid transported by the pipe maintained an impurity level of less than 1 part per million iron (which is a specification requirement) during that time.

[0032] The processes disclosed herein include(s) at least the following embodiments:

[0033] Embodiment 1: A method of stainless steel re-passivation, comprising: passing a first mechanical cleaning device through a pipe wherein the first mechanical cleaning device displaces a material from the pipe; passing a solution (e.g., a passivation solution) comprising water, a base, and an oxidizer through the pipe; maintaining an ambient temperature within the pipe for greater than or equal to 1 hour; passing a second mechanical cleaning device through the pipe wherein the second mechanical cleaning device displaces the solution from the pipe; and passing nitrogen gas through the pipe.

[0034] Embodiment 2: The method of Embodiment 1, wherein the first mechanical cleaning device is a pig device comprising polytetrafluoroethylene, preferably wherein the pig device comprises polytetrafluoroethylene.

[0035] Embodiment 4: The method of any of the preceding claims, wherein the second mechanical cleaning device is a pig device comprising foam material.

[0036] Embodiment 5: The method of any of the preceding embodiments, wherein the pipe comprises stainless steel.

[0037] Embodiment 6: The method of any of the preceding embodiments, wherein a material to be transported through the pipe is acetic acid, preferably wherein the material is glacial acetic acid.

[0038] Embodiment 7: The method of Embodiment 6, wherein the material contains less than or equal to 1 part per million impurities as corrosion products after transportation through the pipe.

[0039] Embodiment 8: The method of Embodiment 7, wherein the impurities comprise iron as the main corrosion product.

[0040] Embodiment 9: The method of any of Embodiments 6-8, further comprising allowing the material to exit the pipe through a drain located in the pipe, prior to passing the solution through the pipe.

[0041] Embodiment 10: The method of any of the preceding embodiments, further comprising allowing the solution to exit the pipe through a drain located in the pipe, prior to passing the nitrogen gas through the pipe.

[0042] Embodiment 11: The method of any of the preceding embodiments, wherein the water is demineralized.

[0043] Embodiment 12: The method of any of the preceding embodiments, wherein the base comprises sodium carbonate, trisodium phosphate, sodium silicate, ethanolamine, or a combination comprising at least one of the foregoing.

[0044] Embodiment 13: The method of any of the preceding embodiments, wherein the oxidizer comprises sodium nitrite, molybdate, chromate, borate, vanadate, or a combination comprising at least one of the foregoing.

[0045] Embodiment 14: The method of any of the preceding embodiments, wherein the solution comprises demineralized water, sodium carbonate, sodium nitrite, or a combination comprising at least one of the foregoing.

[0046] Embodiment 15: The method of any of the preceding embodiments, wherein the solution comprises 0.3% to 0.5% sodium carbonate by weight.

[0047] Embodiment 16: The method of any of the preceding embodiments, wherein the solution comprises 0.5% to 1% sodium nitrite by weight.

[0048] Embodiment 17: The method of any of the preceding embodiments, wherein the ambient temperature within the pipe is maintained for 10 hours to 15 hours.

[0049] Embodiment 18: The method of any of the preceding embodiments, further comprising passing air at a temperature of 40°C to 50°C through the pipe for 12 hours to 14 hours, prior to passing the nitrogen gas through the pipe.

[0050] Embodiment 19: A method of stainless steel re-passivation, comprising: passing a first pig device comprising polytetrafluoroethylene through a pipe wherein the first pig device displaces a material from the pipe; allowing the material to exit the pipe through a drain located in the pipe; passing a passivation solution comprising demineralized water, 0.3% to 0.5% sodium carbonate, and 0.5% to 1% sodium nitrite through the pipe; maintaining an ambient temperature within the pipe for 12 hours to 14 hours; passing a second pig device comprising foam material through the pipe wherein the second pig device displaces the passivation solution from the pipe; allowing the passivation solution to exit the pipe through a drain located in the pipe; passing warm air at a temperature of 40°C to 50°C through the pipe for greater than or equal to 12 hours; and passing nitrogen gas through the pipe.

[0051] Embodiment 20: The method of Embodiment 19, wherein the pipe comprises stainless steel.

[0052] Embodiment 21: The method of any of Embodiments 19-20, wherein the material to be transported through the pipe is acetic acid, preferably wherein the material is glacial acetic acid.

[0053] Embodiment 22: The method of Embodiment 21, wherein the acetic acid contains less than or equal to 1 part per million iron impurities after transportation through the pipe.

[0054] Embodiment 23: The method of any of Embodiments 19-22, wherein the warm air at a temperature of 40°C to 50°C is passed through the pipe for 12 hours to 14 hours.

[0055] In general, the invention may alternately comprise, consist of, or consist essentially of, any appropriate components herein disclosed. The invention may additionally, or alternatively, be formulated so as to be devoid, or substantially free, of any components, materials, ingredients, adjuvants or species used in the prior art compositions or that are otherwise not necessary to the achievement of the function and/or objectives of the present invention. The endpoints of all ranges directed to the same component or property are inclusive and independently combinable (e.g., ranges of "less than or equal to 25 wt%, or 5 wt% to 20 wt%," is inclusive of the endpoints and all intermediate values of the ranges of "5 wt% to 25

wt%," etc.). Disclosure of a narrower range or more specific group in addition to a broader range is not a disclaimer of the broader range or larger group. "Combination" is inclusive of blends, mixtures, alloys, reaction products, and the like. Furthermore, the terms "first," "second," and the like, herein do not denote any order, quantity, or importance, but rather are used to denote one element from another. The terms "a" and "an" and "the" herein do not denote a limitation of quantity, and are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. "Or" means "and/or." The suffix "(s)" as used herein is intended to include both the singular and the plural of the term that it modifies, thereby including one or more of that term (e.g., the film(s) includes one or more films). Reference throughout the specification to "one embodiment", "another embodiment", "an embodiment", and so forth, means that a particular element (e.g., feature, structure, and/or characteristic) described in connection with the embodiment is included in at least one embodiment described herein, and may or may not be present in other embodiments. In addition, it is to be understood that the described elements may be combined in any suitable manner in the various embodiments.

[0056] The modifier "about" used in connection with a quantity is inclusive of the stated value and has the meaning dictated by the context (e.g., includes the degree of error associated with measurement of the particular quantity). The notation "$\pm$ 10%" means that the indicated measurement can be from an amount that is minus 10% to an amount that is plus 10% of the stated value. The terms "front", "back", "bottom", and/or "top" are used herein, unless otherwise noted, merely for convenience of description, and are not limited to any one position or spatial orientation. "Optional" or "optionally" means that the subsequently described event or circumstance can or cannot occur, and that the description includes instances where the event occurs and instances where it does not. Unless defined otherwise, technical and scientific terms used herein have the same meaning as is commonly understood by one of skill in the art to which this invention belongs. A "combination" is inclusive of blends, mixtures, alloys, reaction products, and the like.

[0057] Unless otherwise indicated, each of the foregoing groups can be unsubstituted or substituted, provided that the substitution does not significantly adversely affect synthesis, stability, or use of the compound. The term "substituted" as used herein means that at least one hydrogen on the designated atom or group is replaced with another group, provided that the designated atom's normal valence is not exceeded. When the substituent is oxo (i.e., =O), then two hydrogens on the atom are replaced. Combinations of substituents and/or variables are permissible provided that the substitutions do not significantly adversely affect synthesis or use

of the compound. Exemplary groups that can be present on a "substituted" position include, but are not limited to, cyano; hydroxyl; nitro; azido; alkanoyl (such as a C_{2-6} alkanoyl group such as acyl); carboxamido; C_{1-6} or C_{1-3} alkyl, cycloalkyl, alkenyl, and alkynyl (including groups having at least one unsaturated linkages and from 2 to 8, or 2 to 6 carbon atoms); C_{1-6} or C_{1-3} alkoxys; C_{6-10} aryloxy such as phenoxy; C_{1-6} alkylthio; C_{1-6} or C_{1-3} alkylsulfinyl; C1-6 or C_{1-3} alkylsulfonyl; aminodi(C_{1-6} or C_{1-3})alkyl; C_{6-12} aryl having at least one aromatic rings (e.g., phenyl, biphenyl, naphthyl, or the like, each ring either substituted or unsubstituted aromatic); C_{7-19} arylalkyl having 1 to 3 separate or fused rings and from 6 to 18 ring carbon atoms; or arylalkoxy having 1 to 3 separate or fused rings and from 6 to 18 ring carbon atoms, with benzyloxy being an exemplary arylalkoxy.

[0058] All cited patents, patent applications, and other references are incorporated herein by reference in their entirety. However, if a term in the present application contradicts or conflicts with a term in the incorporated reference, the term from the present application takes precedence over the conflicting term from the incorporated reference

[0059] While particular embodiments have been described, alternatives, modifications, variations, improvements, and substantial equivalents that are or may be presently unforeseen may arise to applicants or others skilled in the art. Accordingly, the appended claims as filed and as they may be amended are intended to embrace all such alternatives, modifications variations, improvements, and substantial equivalents.

CLAIMS

What is claimed is:

1. A method of stainless steel re-passivation, comprising:

passing a first mechanical cleaning device through a pipe wherein the first mechanical cleaning device displaces a material from the pipe;

passing a solution comprising water, a base, and an oxidizer through the pipe;

maintaining an ambient temperature within the pipe for greater than or equal to 1 hour;

passing a second mechanical cleaning device through the pipe wherein the second mechanical cleaning device displaces the solution from the pipe; and

passing nitrogen gas through the pipe.

2. The method of Claim 1, wherein the first mechanical cleaning device is a pig device comprising polytetrafluoroethylene, preferably

wherein the pig device comprises polytetrafluoroethylene.

3. The method of any of the preceding claims, wherein the second mechanical cleaning device is a pig device comprising foam material.

4. The method of any of the preceding claims, wherein a material to be transported through the pipe is acetic acid, preferably wherein the material is glacial acetic acid.

5. The method of Claim 4, wherein the material contains less than or equal to 1 part per million impurities as corrosion products after transportation through the pipe.

6. The method of Claim 5, wherein the impurities comprise iron as the main corrosion product.

7. The method of any of Claims 4-6, further comprising allowing the material to exit the pipe through a drain located in the pipe, prior to passing the solution through the pipe.

8. The method of any of the preceding claims, further comprising allowing the solution to exit the pipe through a drain located in the pipe, prior to passing the nitrogen gas through the pipe.

9. The method of any of the preceding claims, wherein the water is demineralized.

10. The method of any of the preceding claims, wherein the base comprises sodium carbonate, trisodium phosphate, sodium silicate, ethanolamine, or a combination comprising at least one of the foregoing.

11. The method of any of the preceding claims, wherein the oxidizer comprises sodium nitrite, molybdate, chromate, borate, vanadate, or a combination comprising at least one of the foregoing.

12. The method of any of the preceding claims, wherein the solution comprises demineralized water, sodium carbonate, sodium nitrite, or a combination comprising at least one of the foregoing.

13. The method of any of the preceding claims, wherein the solution comprises 0.3% to 0.5% sodium carbonate by weight.

14. The method of any of the preceding claims, wherein the solution comprises 0.5% to 1% sodium nitrite by weight.

15. The method of any of the preceding claims, wherein the ambient temperature within the pipe is maintained for 10 hours to 15 hours.

16. The method of any of the preceding claims, further comprising passing air at a temperature of 40°C to 50°C through the pipe for 12 hours to 14 hours, prior to passing the nitrogen gas through the pipe.

17. A method of stainless steel re-passivation, comprising:

passing a first pig device comprising polytetrafluoroethylene through a pipe wherein the first pig device displaces a material from the pipe;

allowing the material to exit the pipe through a drain located in the pipe;

passing a passivation solution comprising demineralized water, 0.3% to 0.5% sodium carbonate, and 0.5% to 1% sodium nitrite through the pipe;

maintaining an ambient temperature within the pipe for 12 hours to 14 hours;

passing a second pig device comprising foam material through the pipe wherein the second pig device displaces the passivation solution from the pipe;

allowing the passivation solution to exit the pipe through a drain located in the pipe;

passing air at a temperature of 40°C to 50°C through the pipe for greater than or equal to 12 hours; and

passing nitrogen gas through the pipe.

18. The method of any of Claims 17, wherein the material to be transported through the pipe is acetic acid, preferably wherein the material is glacial acetic acid.

19. The method of Claim 18, wherein the acetic acid contains less than or equal to 1 part per million iron impurities, after transportation through the pipe.

20. The method of any of Claims 18-19, wherein the air at a temperature of 40°C to 50°C is passed through the pipe for 12 hours to 14 hours.

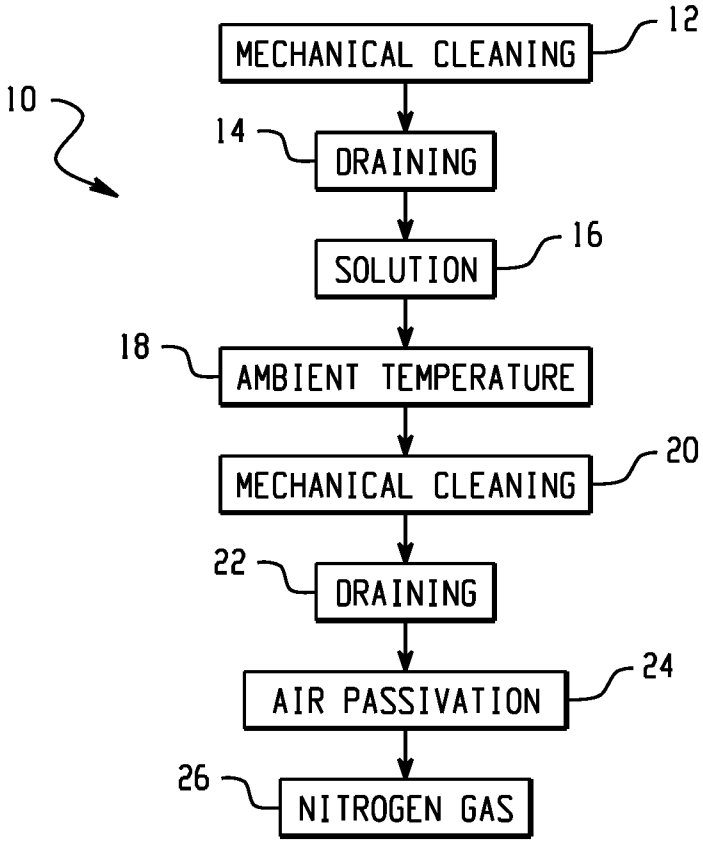
10
MECHANICAL CLEANING
12
14
DRAINING
SOLUTION
16
18
AMBIENT TEMPERATURE
MECHANICAL CLEANING
20
22
DRAINING
AIR PASSIVATION
24
26
NITROGEN GAS

Fig. 1

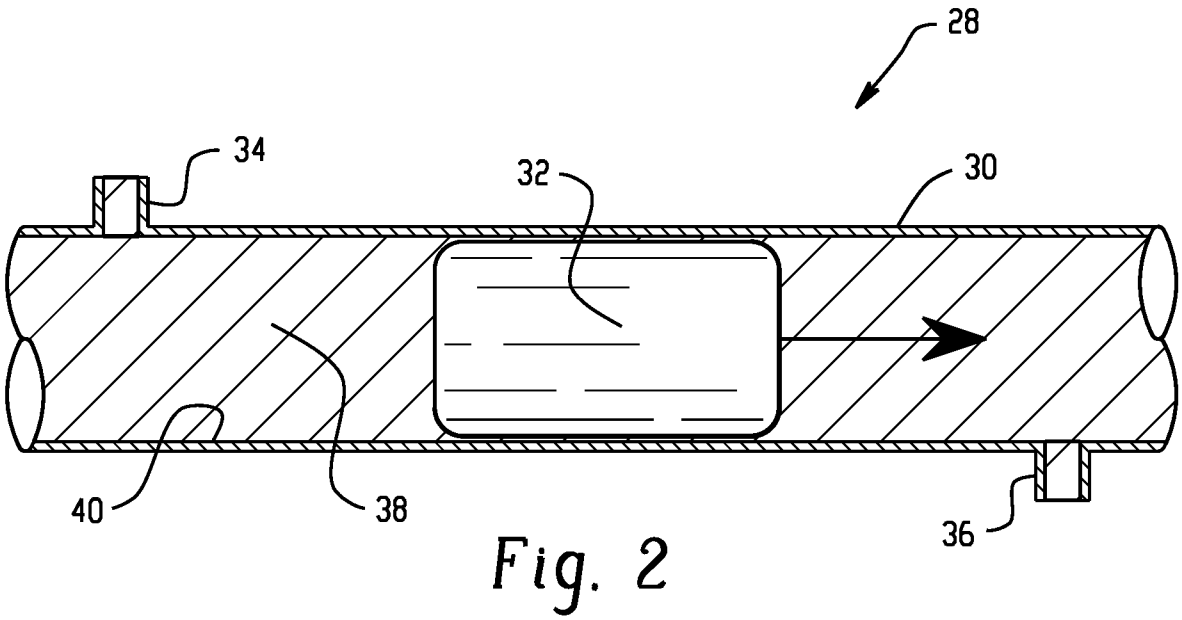
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Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2016/057588

A. CLASSIFICATION OF SUBJECT MATTER
INV. C23C22/62 B08B9/055 F16L58/00 C23C22/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C23C B08B F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	CN 104 307 821 A (CHINA NAT CHEM ENG 3RD CONSTR) 28 January 2015 (2015-01-28) paragraph [0002]; claims; figure 3 paragraphs [0035] - [0064]	1,3-16 2,17-20
Y	DE 195 13 104 A1 (PFEIFFER CHEMIE ARMATUREN [DE]) 10 October 1996 (1996-10-10) claims	2,17-20
A	US 3 415 692 A (ARMENTANO JOSEPH A) 10 December 1968 (1968-12-10) the whole document	1-20
A	CN 203 333 774 U (ZHONG SHI CHEMICAL ENGINEERING CONSTRUCTION CO LTD) 11 December 2013 (2013-12-11) abstract	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 March 2017	29/03/2017

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2016/057588

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