

SYSTEM AND METHOD FOR SCALE REMOVAL FROM A NICKEL-BASED SUPERALLOY COMPONENT

RELATED APPLICATIONS

The present application claims the benefit of United States Provisional Patent Application No. 61/428,802 filed December 30, 2010 which is incorporated herein by reference.

BACKGROUND

The present invention generally relates to recovery of nickel superalloy components having scale deposits, and more particularly but not exclusively, relates to removing sulfidation and oxidation scale from components using an electrically charged molten salt bath and an acid removal step. The nickel superalloy components may be coated or uncoated, and/or may include a protective layer.

Ni-based superalloys are widely used in the manufacture of gas turbine engines and are often subjected to harsh operating environments. During operation the superalloy material cycles through various temperature ranges promoting an environment for sulfidation/oxidation scale to develop. The scale deposits promote various wear and failure mechanisms of the component. Ni-based superalloy components are expensive to manufacture, and it is desirable to clean and repair components for re-use.

Presently known approaches to sulfidation and oxidation scale removal suffer from a variety of drawbacks and limitations. For example, presently known processes have limited effectiveness cleaning scale deposits from internal passages and chambers in nickel superalloy components, and they can have deleterious effects on the base metal of the component. Further, some presently known processes use chemicals or process steps which are higher risk in terms of safety and environmental impact. Accordingly, further improvements in the cleaning and recovery of nickel superalloy components is desirable.

SUMMARY

One embodiment of the present invention is a unique galvanic molten salt descaling and acid pickling process for the removal of sulfidation and oxidation scale. Other embodiments include apparatuses, systems, devices, hardware, methods, and combinations for sulfidation and oxidation scale removal. Further embodiments, forms, features, aspects, benefits, and advantages of the present application shall become apparent from the description and figures provided herewith.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1 is a schematic diagram of a system for a scale removal from a nickel-based superalloy component.

DETAILED DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Any alterations and further modifications in the described embodiments, and any further applications of the principles of the invention as described herein are contemplated as would normally occur to one skilled in the art to which the invention relates.

Referencing Fig. 1, a system 100 for removing scale deposits from a nickel based superalloy component 124 is shown. The system 100 may be positioned within one or more housings (not shown), and may be provided as a closed or partially closed system. The system 100 is shown with a number of fluid vessels, where various operations are performed in the individual vessels. Additionally or alternatively, one or more fluids may share a vessel, with the component 124 remaining in a vessel and the fluids being changed. In the exemplary system 100, the component 124 is moved between vessels.

The exemplary system includes a molten salt, caustic alkaline solution (solution) 102. The solution is any type of electrically conductive molten salt known in the art. The caustic alkaline solution is any type of alkaline base known in the art that is compatible with the molten salt, including without limitation caustic soda. An exemplary solution 102 includes molten salt, caustic soda,

sodium hydride, and electrically-sensitive catalytic agents. The system 100 includes a first heating device 104 thermally coupled to the solution 102. The first heating device 104 heats the solution 102 sufficiently to provide the solution 102 as a molten salt, and/or the first heating device 104 heats the solution to at least 900° F. The exemplary system 100 includes one or more temperature sensors 106 to provide feedback to the heat exchanger 104, or to provide feedback to a controller (not shown) that operates the heat exchanger 104.

The system 100 further includes an electrical charging device 108 (illustrated as a voltage source) that is electrically coupled to the solution 102. An example electrical charging device 108, such as a rectifier, is electrically coupled to the solution through the positioning device 122, such as the power/voltage being dissipated through a lead attached to the molten salt tank, with the fixture/positioning device placed between the leads on the tank. In the example, the fixture containing the component is charged during processing while the caustic agents in the salt transfer electrons to the component 124. The electrical charging device 108 provides at least 3 V DC to the solution. The electrical charging device 108 operates at about 1000 amps, or according to the required current at the operating voltage and with the rectifier equipment present in the system 100 to provide the electrical power. In certain embodiments, the charging device 108 provides between 3 V DC and 6 V DC, and in certain embodiments the charging device 108 provides the electrical energy as a straight polarity device.

The exemplary system 100 further includes a soap and water solution 110, which may include an ammonia soap, and a second heating device 112 thermally coupled to the ammonia soap and water solution 110. The second heating device 112 heats the ammonia soap and water solution 110 to an elevated temperature, such as at least 160° F. The system 100 further includes an ultrasonic device 114 acoustically coupled to the ammonia soap and water solution 110. The ultrasonic device 114 may be any type of ultrasonic device known in the art, and the ultrasonic device 114 selectively operates during at least portions of the time when the component 124 is positioned within the ammonia soap and water solution 110 to provide ultrasonic cleaning of the component 124.

The system 100 further includes an acid solution 116 and a third heating device 118 thermally coupled to the acid solution 116. In certain embodiments, the third heating device 118 heats the acid solution 116 to an elevated temperature, such as at least 175° F. The system further includes an agitator 120 fluidly coupled to the acid solution 116. The exemplary system 100 includes an agitator 120 that is a magnetic stirrer, although a propeller or any other agitator known in the art may be used.

The system 100 further includes a component positioning device 122 that selectively contacts a Ni-based superalloy component 124 with the solution 102, the ammonia soap and water solution 110, and the acid solution 116. The exemplary positioning device 122 includes a basket, which may be a metallic electrically conductive basket. Any device that provides capability to selectively

position the component 124 within the various fluids 102, 110, 116 is contemplated herein. The device 122 may alternatively or additionally include manual aspects (e.g. an operator moving the component 124 during certain operations) and/or fluid control aspects. An exemplary fluid control aspect of the positioning device 122 includes emptying a vessel of a first fluid and filling the vessel with a second fluid while the component 124 remains in the vessel, thereby selectively positioning the component 124 within a selected fluid 102, 110, 116. The selected contacts may be performed in a sequence and according to durations defined by a scale removal operation.

In certain embodiments, the basket portion of the positioning device 122 engages fixtures within a vessel to ensure proper positioning of the component 124. In a further embodiment, the charging device 108 includes a ground clamp that directly couples to the basket, or to the fixtures in electrical contact with the basket, where the basket is a metallic, electrically conductive basket. In certain embodiments, the positioning device 122 is structured to position the component 124 within the basket, such that interior chambers or other features of the component 124 are likely to promote the best fluid circulation through the component 124. The positioning the component 124 within the basket may be the same within each fluid 102, 110, 116 or may be changed for one or more of the fluids 102, 110, 116.

An exemplary system 100 further includes a water immersion, that may be air agitated, and the positioning device 122 further selectively positions the component 124 within the water immersion. The water immersion may be

positioned between the solution 102 and the ammonia soap and water solution 110, and/or the water immersion may be performed in the same vessel as the ammonia soap and water solution 110, where the fluids are changed in the vessel during various operations of the system 100. In certain embodiments, the fluids may be within separate partitioned containers within the same vessel. Another exemplary system 100 further includes an acetone fluid 126, where the positioning device 122 selectively positions the component 124 within the acetone fluid 126 after the acid solution 126 treatment, and/or after a second treatment in the ammonia soap and water solution 110 that occurs after the acid solution 126 treatment.

In certain further embodiments, the Ni-based superalloy component 124 includes an internal chamber and/or an internal crevice, with scale formed in the chamber or crevice. The scale, in one example, includes sulfidation and/or oxidation scale. In certain embodiments, the acid solution 116 includes a 50% HNO_3 and 50% H_3PO_4 solution, by volume. The described acid mixture is an example only. It is a mechanical step for one of skill in the art to determine an acid mixture for a specific embodiment according to the type of scale. In certain embodiments, the acetone solution 126 is provided in the same vessel as the ammonia soap and water solution 110, for example within separate containers in the vessel, and/or the acetone solution 126 is provided in a vessel also having an ultrasonic device 114.

The descriptions which follow provide illustrative embodiments of performing procedures for removing scale from a nickel-based superalloy

component. Operations illustrated are understood to be exemplary only, and operations may be combined or divided, and added or removed, as well as re-ordered in whole or part, unless stated explicitly to the contrary herein. Certain operations illustrated may be implemented by a computer executing a computer program product on a computer readable medium, where the computer program product comprises instructions causing the computer to execute one or more of the operations, or to issue commands to other devices to execute one or more of the operations. Certain embodiments of the exemplary procedures described following may be performed in the context of a system such as that described in the section referencing Fig. 1.

An exemplary procedure for removing scale from a Ni-based superalloy component includes an operation to immerse a Ni-based superalloy component in a molten salt bath and an operation to electrically charge the molten salt bath to at least 3 V DC. The exemplary procedure further includes an operation to immerse the component in water after the molten salt bath, and/or an operation to rinse the component a first time. The example procedure includes agitating the water with air during the operation to immerse the component in water.

The operation to rinse the component a first time includes rinsing after the molten salt bath, and/or after the water immersion. The operation to rinse the component a first time includes rinsing in a soap and water solution and/or rinsing the component in an acetone solution. In certain embodiments, the soap and water solution is an ammonia-based soap solution. The operations to rinse in the soap and water solution and/or to rinse in the acetone solution include

applying ultrasonic energy to the rinse solution(s) during the rinse. The procedure further includes an operation to immerse the component in an agitated acid pickling solution after the rinsing, and an operation to rinse the component a second time in the soap and water solution and/or the acetone solution.

An exemplary agitated acid pickling solution includes 50% HNO_3 and 50% H_3PO_4 by volume, and an exemplary molten salt bath includes a caustic alkaline solution. In certain embodiments, the procedure includes an operation to heat the agitated acid pickling solution to 175°F, an operation to heat the molten salt bath to 900°F, and/or an operation to heat the soap and water solution and/or the acetone solution to 160°F. An exemplary procedure further includes an operation to perform the electrically charging by electrically charging to between 3V and 4V DC with straight polarity. A further exemplary procedure includes the operation to electrically charge the molten salt bath to 3.5 volts DC at 1000 Amps. Yet another exemplary operation includes rinsing the component with an acetone rinse after the operation to rinse the component the second time in the soap and water solution. Further example and non-limiting molten salt and acid pickle examples are included in Table 1.

Table 1. Example Molten salt bath and acid pickle times

Index	Time in Kolene Molten Salt Bath (hrs)	Time in Acid Pickle (hrs)	Applied voltage
1	2	1	5v
2	2	2	5v
3	2	3	5v
4	3	1	5v
5	3	2	5v
6	3	3	5v
7	4	2	5v
8	6	1	5v
9	6	2	5v
10	6	3	5v
11	6	4	5v
12	6	1	6v
13	6	2	6v
14	6	3	6v
15	6	4	6v

Experimental data was collected consistent with the formulations of Table 1. The results of the experimental data, and other data taken varying the applied voltages, have provided information sufficient to determine that a range of parameters are useful to recover certain components. Non-limiting examples of voltage parameters include 3V applied for 4 hours, 3.5 V applied for 4 hours, 4 V applied for 4 hours, 5 V applied for 2 to 6 hours, and 6 V applied for 6 hours. The provided ranges are exemplary and non-limiting. Application of the molten salt bath may be applied in certain embodiments for time periods of up to 6 hours. The agitated pickling solution may be applied from about 1 hour to about 4 hours.

Yet another exemplary set of embodiments includes a procedure for removing scale from a Ni-based superalloy component. The exemplary procedure includes immersing a Ni-based superalloy component in a molten salt bath comprising a caustic alkaline solution and electrically charging the molten salt bath to at least 3 V DC. The procedure includes an operation to immerse the

component in air-agitated water after the molten salt bath, and an operation to rinse the component a first time in an ammonia soap and water solution after the immersing the component in the air-agitated water. The procedure further includes an operation to immerse the component in an agitated acid pickling solution after the ammonia soap and water rinse, and an operation to rinse the component a second time in the ammonia soap and water solution after the agitated acid pickling.

Exemplary operations of the procedure further include performing the electrically charging for at least 4 hours, performing the immersing the component in air-agitated water for at least five (5) minutes, performing the immersing the component in the agitated acid pickling solution for at least four (4) hours, performing the rinsing the component the first time is performed for at least one hour, and/or performing the rinsing the component the second time is performed for at least 30 minutes. An exemplary procedure further includes an operation to rinse the component again in an ultrasonic acetone rinse for at least 30 minutes, after the rinsing in the ammonia soap and water solution for the second time.

Another exemplary procedure includes an operation to heat the molten salt bath to at least 900° F before the immersing the Ni-based superalloy component. Another exemplary procedure includes an operation to heat the agitated acid pickling solution to at least 175° F before the immersing the component in the agitated acid pickling solution. Yet another exemplary

procedure includes an operation to heat the ammonia soap and water solution to at least 160° F.

As is evident from the figures and text presented above, a variety of embodiments according to the present invention are contemplated.

An exemplary set of embodiments includes a system having a molten salt, caustic alkaline solution (solution) and a first heating device thermally coupled to the solution. The first heating device heats the solution to at least 900° F. The system further includes an electrical charging device that is electrically coupled to the solution, where the electrical charging device provides at least 3 V DC at 1000 amps. In certain embodiments, the charging device provides between 3 V DC and 4 V DC, and in certain embodiments the charging device provides the electrical energy as a straight polarity device. The exemplary system further includes an ammonia soap and water solution, and a second heating device thermally coupled to the ammonia soap and water solution. The second heating device heats the ammonia soap and water solution to at least 160° F. The system further includes an ultrasonic device acoustically coupled to the ammonia soap and water solution. The system includes an acid solution and a third heating device thermally coupled to the acid solution, where the third heating device heats the acid solution to at least 175° F. The system further includes an agitator fluidly coupled to the acid solution. Any agitator understood in the art may be utilized, and an exemplary agitator includes a magnetic stirrer. The system further includes a component positioning device that selectively contacts a Ni-based superalloy component with the solution, the ammonia soap and water

solution, and the acid solution. The selected contacts may be performed according to a scale removal operation.

In certain further embodiments, the Ni-based superalloy component includes an internal chamber and/or an internal crevice, with scale formed in the chamber or crevice. The scale, in one example, includes sulfidation and/or oxidation scale. In certain embodiments, the system further includes an acetone rinse, and the component positioning device further selectively contacts the Ni-based superalloy component with the acetone rinse. In certain embodiments, the acid solution includes a 50% HNO_3 and 50% H_3PO_4 solution, by volume.

Another exemplary set of embodiments includes a method for removing scale from a Ni-based superalloy component. The exemplary method includes the following operations performed in order: immersing a Ni-based superalloy component in a molten salt bath, electrically charging the molten salt bath to at least 3 V DC, immersing the component in water, rinsing the component a first time in a soap and water solution, immersing the component in agitated acid pickling solution, and rinsing the component a second time in the soap and water solution. An exemplary agitated acid pickling solution includes 50% HNO_3 and 50% H_3PO_4 by volume, and an exemplary molten salt bath includes a caustic alkaline solution.

In certain embodiments, the method includes heating the agitated acid pickling solution to 175°F, heating the molten salt bath to 900°F, and/or heating the soap and water solution to 160°F. An exemplary method further includes performing the electrically charging by electrically charging to between 3V and

4V DC with straight polarity. The electrically charging may further include electrically charging to 3.5 volts DC at 1000 Amps.

In certain embodiments, immersing the component in water further includes immersing the component in air agitated water. An exemplary operation includes providing the soap and water solution as an ammonia soap solution, and applying ultrasonic energy to the soap and water solution. Another exemplary operation includes rinsing the component in an acetone rinse after the operation to rinse the component a second time.

Yet another exemplary set of embodiments includes a method for removing scale from a Ni-based superalloy component. The method includes the operations of, in order, immersing a Ni-based superalloy component in a molten salt bath comprising a caustic alkaline solution, electrically charging the molten salt bath to at least 3 V DC, immersing the component in air-agitated water, rinsing the component a first time in an ammonia soap and water solution, immersing the component in agitated acid pickling solution, and rinsing the component a second time in the ammonia soap and water solution. Exemplary operations further include performing the electrically charging for between two (2) to six (6) hours, performing the immersing the component in air-agitated water for at least five (5) minutes, performing the immersing the component in the agitated acid pickling solution between one (1) and four (4) hours for at least four (4) hours, performing the rinsing the component the first time for at least one hour, and/or performing the rinsing the component the second time for at least 30 minutes. An exemplary method further includes rinsing the component again in

an ultrasonic acetone rinse for at least 30 minutes, after the rinsing the component the second time. The acetone rinse may be in addition to or in place of either the rinsing the first time or the rinsing the second time.

Further exemplary operations include heating the molten salt bath to at least 900° F before the immersing the Ni-based superalloy component. Another exemplar operation includes heating the agitated acid pickling solution to at least 175° F before the immersing the component in the agitated acid pickling solution. Yet another exemplary operation includes heating the ammonia soap and water solution to at least 160° F.

One aspect of the present application is a method including immersing a Ni-based superalloy component in a galvanic molten salt bath wherein the molten salt bath is at a first elevated temperature and wherein the molten salt bath has an electrical charge; immersing the component in water; and immersing the component in an acid pickling solution wherein the acid pickling solution is at a second elevated temperature.

The acid pickling solution may be an acid solution of 50v% HNO_3 + 50v% H_3PO_4 in further features of this embodiment. Other features include the second elevated temperature of the acid pickling solution being at least 175°F. The molten salt solution may be a caustic alkaline solution. The first elevated temperature of the molten salt bath may be at least 900°F. The electrical charge of the molten salt bath may be 3-6 volts DC with straight polarity. In certain embodiments, the electrical charge of the molten salt bath would be 3.5 volts DC, at a current of at least 800 Amps.

Rinsing the component with water may further include other features such as air agitated water. Further features may include an ultrasonic cleaning of the component in soap and water at 160°F following rinsing the component with air agitated water. This embodiment may further include ultrasonically cleaning the component in soap and water at 160°F following immersing the component in the acid pickling solution. This embodiment may still further include rinsing the component in an acetone rinse following the ultrasonic cleaning of the component following the immersion of the component in the acid pickling solution.

Another embodiment of the present invention is a method including immersing a component in a galvanic caustic alkaline solution where the caustic alkaline solution is at a first elevated temperature and where the caustic alkaline solution has an electrical charge; rinsing the component with air agitated water; ultrasonically cleaning the component; immersing the component in an acid pickling solution where the acid pickling solution is at a second elevated temperature and where the acid pickling solution is maintained in a state of agitation; ultrasonically cleaning the component; and rinsing the component in an acetone rinse.

An additional feature of this embodiment includes the acid pickling solution being an acid solution of 50v% HNO_3 + 50v% H_3PO_4 . The acid pickling solution may also be at a second elevated temperature of at least 175°F. Additionally, the elevated temperature of the caustic alkaline solution may be at least 900°F.

The electrical charge of the caustic alkaline solution may also be 3-6 volts DC with straight polarity.

Further features may include immersing the component in the caustic alkaline solution for between two and six hours, rinsing the component with the air agitated water for 5 to 10 minutes, ultrasonically cleaning the component for 60 minutes following the rinse with the air agitated water, immersing the component in the acid pickling solution for between one and four hours, and ultrasonically cleaning the component for 30 minutes following the immersion in the acid pickling solution.

Yet another embodiment is an apparatus which includes a first fixture to engage a Ni-based superalloy component; a first stand immersed in a molten salt bath; an electrical source; a second fixture to engage the component; and a second stand immersed in an acid pickling solution. The first fixture with the component engaged may be structured to be placed on the first stand immersed in the molten salt bath at 900°F and electrically coupled to the electrical source with 3-6 volts DC with straight polarity. The component may then be disengaged from the first fixture after being removed from the first stand immersed in the molten salt bath and decoupled from the electrical source. The component may be rinsed in air agitated water and subjected to a first ultrasonic cleaning. The second fixture engaged with the component may be structured to be placed on the second stand immersed in the acid pickling solution at 175°F with agitation. The component may be subjected to a second ultrasonic cleaning. The component may then be subjected to a third ultrasonic cleaning in acetone.

Feature of this embodiment may include the acid pickling solution being an acid solution of 50v% HNO_3 + 50v% H_3PO_4 and the molten salt bath being a galvanic caustic alkaline solution. An example system includes the acid solution comprises 50% to 80% HNO_3 and 20% to 50% H_3PO_4 by volume.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiments have been shown and described and that all changes and modifications that come within the spirit of the inventions are desired to be protected. It should be understood that while the use of words such as preferable, preferably, preferred or more preferred utilized in the description above indicate that the feature so described may be more desirable, it nonetheless may not be necessary and embodiments lacking the same may be contemplated as within the scope of the invention, the scope being defined by the claims that follow. In reading the claims, it is intended that when words such as “a,” “an,” “at least one,” or “at least one portion” are used there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. When the language “at least a portion” and/or “a portion” is used the item can include a portion and/or the entire item unless specifically stated to the contrary.

CLAIMS

WHAT IS CLAIMED IS:

1. A method comprising, in order:
immersing a Ni-based superalloy component in a molten salt bath;
electrically charging the molten salt bath to at least 3 V DC;
immersing the component in water;
rinsing the component a first time in at least one of a soap and water solution and an acetone solution;
immersing the component in agitated acid pickling solution; and
rinsing the component a second time in at least one of the soap and water solution and the acetone solution.
2. The method of claim 1, wherein the agitated acid pickling solution comprises 50% HNO₃ and 50% H₃PO₄ by volume.
3. The method of claim 2, further comprising heating the agitated acid pickling solution to at least 175°F.
4. The method of claim 1, wherein the molten salt bath is a caustic alkaline solution.
5. The method of claim 1, further comprising heating the molten salt bath to at least 900°F.
6. The method of claim 1, wherein the electrically charging comprises electrically charging to between 3V and 6V DC with straight polarity.

7. The method of claim 1, wherein the electrically charging comprises electrically charging to 3.5 volts DC at 1000 Amps.
8. The method of claim 1, wherein the electrically charging comprises electrically charging to 4 volts DC at 1000 Amps.
9. The method of claim 1, wherein the electrically charging comprises electrically charging to 5 volts DC at 1000 Amps.
10. The method of claim 1, wherein the electrically charging comprises electrically charging to 6 volts DC at 1000 Amps.
11. The method of claim 1, wherein the immersing the component in water further includes immersing the component in air agitated water.
12. The method of claim 1, wherein the soap and water solution comprises an ammonia soap solution, the method further comprising applying ultrasonic energy to the soap and water solution.
13. A method comprising, in order:
 - immersing a Ni-based superalloy component in a molten salt bath comprising a caustic alkaline solution;
 - electrically charging the molten salt bath to at least 3 V DC;
 - immersing the component in air-agitated water;
 - rinsing the component a first time in an ammonia soap and water solution;
 - immersing the component in agitated acid pickling solution; and
 - rinsing the component a second time in the ammonia soap and water solution, rinsing the component a second time in the acetone solution.

14. The method of claim 13, further comprising performing the electrically charging for at least 2 hours.
15. The method of claim 14, further comprising heating the molten salt bath to at least 900° F before the immersing the Ni-based superalloy component.
16. The method of claim 13, further comprising performing the immersing the component in air-agitated water for at least five (5) minutes.
17. The method of claim 13, further comprising immersing the component in the agitated acid pickling solution for at least one (1) hours.
18. The method of claim 17, further comprising heating the agitated acid pickling solution to at least 175° F before the immersing the component in the agitated acid pickling solution.
19. The method of claim 13, further comprising heating the ammonia soap and water solution to at least 160° F.
20. The method of claim 19, further wherein the rinsing the component the first time is performed for at least one hour, and wherein the rinsing the component the second time is performed for at least 30 minutes.
21. The method of claim 13, further including rinsing the component again in an ultrasonic acetone rinse for at least 30 minutes to at least 160° F.
22. A system, comprising:
 - a molten salt, caustic alkaline solution (solution) and a first heating device thermally coupled to the solution, the first heating device structured to heat the solution to at least 900° F;

an electrical charging device electrically coupled to the solution, the electrical charging device structured to provide at least 3 V DC at at least 800 amps;

an ammonia soap and water solution and a second heating device thermally coupled to the ammonia soap and water solution, the second heating device structured to heat the ammonia soap and water solution to at least 160° F;

an ultrasonic device acoustically coupled to the ammonia soap and water solution;

an acid solution and a third heating device thermally coupled to the acid solution, the third heating device structured to heat the acid solution to at least 175° F;

an agitator fluidly coupled to the acid solution; and

a component positioning device structured to selectively contact a Ni-based superalloy component with the solution, the ammonia soap and water solution, and the acid solution.

23. The system of claim 22, wherein the Ni-based superalloy component comprises at least one of an internal chamber and an internal crevice having a scale formed therein.

24. The system of claim 23, wherein the scale comprises one of a sulfidation and an oxidation scale.

25. The system of claim 22, further comprising an acetone rinse, and wherein the component positioning device is further structured to selectively contact the Ni-based superalloy component with the acetone rinse.

26. The system of claim 20, wherein the acid solution comprises 50% HNO_3 and 50% H_3PO_4 by volume.

27. The system of claim 20, wherein the acid solution comprises 50% to 80% HNO_3 and 20% to 50% H_3PO_4 by volume.