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(54) **SYSTEMS AND METHODS FOR REMOVAL OF DIFFUSION COATING FROM AIRFOILS**

(57) A method of removing an aluminide diffusion coating from a gas turbine engine component (192, 194, 196, 198) having a nickel alloy base material may comprise: disposing the gas turbine engine component (192, 194, 196, 198) in a solution (206), the solution (206) including an acid between 5% and 15% vol./vol. and water between 85% and 95% vol./vol.; placing the gas turbine engine component (192, 194, 196, 198) in electrical contact with a graphite plate (204); and removing the aluminide diffusion coating from the gas turbine engine component (192, 194, 196, 198) in response to placing the gas turbine engine component (192, 194, 196, 198) in electrical contact with the graphite plate (204) and disposing the gas turbine engine component in the solution (206).

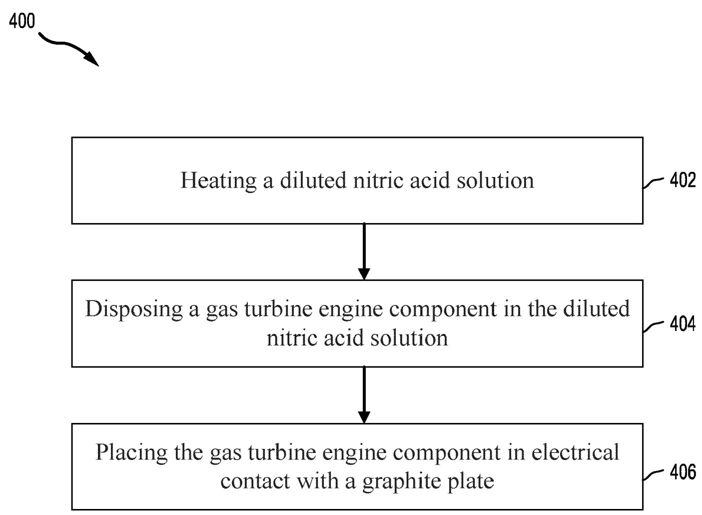

FIG. 4

Processed by Luminess, 75001 PARIS (FR)

Description

FIELD

[0001] The disclosure relates generally to airfoils in gas turbine engines and systems and methods for removing diffusion coatings from airfoils of gas turbine engines.

BACKGROUND

[0002] Removal of diffusion coatings from gas turbine engine airfoils may be performed during a repair process or during a manufacturing process for various reasons. During manufacturing, an airfoil may not meet a desired geometric dimension(s) and tolerancing for a respective application with an original diffusion coating, so the diffusion coating may be removed and re-applied to meet the desired specification of the airfoil. During a repair process, an airfoil may be removed from service after a specified time on wing of an aircraft.

[0003] To repair the airfoil to an original specification, a diffusion coating may be removed, the airfoil restored, and a new diffusion coating re-applied prior to returning the airfoil to service. Typical systems and methods for removing a diffusion coating from an airfoil include a high-temperature concentrated acid solution with heavy capital equipment investments. Additionally, typical systems and methods are susceptible to damaging the airfoil resulting in significant costs when an airfoil is scrapped due to excess removal of the component's base material.

SUMMARY

[0004] The foregoing features and elements may be combined in various combinations without exclusivity, unless expressly indicated herein otherwise. These features and elements as well as the operation of the disclosed embodiments will become more apparent in light of the following description and accompanying drawings.

[0005] A method of removing an aluminide diffusion coating from a gas turbine engine component having a nickel alloy base material is disclosed herein. The method may comprise: disposing the gas turbine engine component in a solution, the solution including an acid between 5% and 15% vol./vol. and water between 85% and 95% vol./vol.; placing the gas turbine engine component in electrical contact with a graphite plate; and removing the aluminide diffusion coating from the gas turbine engine component in response to placing the gas turbine engine component in electrical contact with the graphite plate and disposing the gas turbine engine component in the solution.

[0006] In various embodiments, the method may further comprise increasing a reaction rate of the solution in response to generating a voltage differential between the solution and the aluminide diffusion coating. The method may further comprise reducing the reaction rate in response to the aluminide diffusion coating being removed and the solution contacting the nickel alloy base material. The method may further comprise heating the solution between 80 °F (27 °C) and 140 °F (60 °C). The gas turbine engine component may include an airfoil. The method may further comprise placing the gas turbine engine component in direct contact with the graphite plate. The method may further comprise electrically coupling the gas turbine engine component is electrically coupled to the graphite plate. The acid may be a nitric acid. A method of removing an aluminide diffusion coating from a gas turbine engine component having a nickel alloy base material via a coating removal system is disclosed herein. The method may comprise: enhancing, via the coating removal system, a reaction rate of a diluted acid solution in response to generating a localized redox reaction between the aluminide diffusion coating and the diluted acid solution; removing, via the coating removal system, the aluminide diffusion coating from the nickel alloy base material in response to generating the localized redox reaction; and reducing, via the coating removal system, the reaction rate of the diluted acid solution in response to the aluminide diffusion coating being removed.

[0007] In various embodiments, a first electromotive force produced during the enhancing the reaction rate of the diluted acid solution is greater than a second electromotive force produce during reducing the reaction rate of the diluted acid solution. The diluted acid solution may be an acid between 5% and 15% vol./vol. and water between 85% and 95% vol./vol. The diluted acid may be a solution with a temperature between 80 °F (27 °C) and 140 °F (60 °C). The acid may be nitric acid. The coating removal system may include a graphite plate in electrical communication with the gas turbine engine component. The graphite plate may be disposed in the diluted acid solution.

[0008] A system for removing an aluminide diffusion coating is disclosed herein. The system may comprise: a diluted nitric acid solution comprising nitric acid between 5% and 15% vol./vol. and water between 85% and 95% vol./vol; and a graphite plate disposed in the diluted nitric acid solution, the graphite plate configured to be in electrical communication with a gas turbine engine component during removal of the aluminide diffusion coating.

[0009] In various embodiments, the system may further comprise a heater, wherein the heater is configured to heat the diluted nitric acid solution to a temperature between 80 °F (27 °C) and 140 °F (60 °C). The system may further comprise the gas turbine engine component disposed in the diluted nitric acid solution, the gas turbine engine component comprising a base material and the aluminide diffusion coating, the base material comprising a nickel-based superalloy. A reaction rate of the diluted nitric acid solution may be increased in response to an electromotive force generated from a voltage differential between the diluted nitric acid solution and the aluminide diffusion coating. The reaction rate of the diluted nitric acid solution may be decreased in response to the aluminide diffusion coating being removed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The subject matter of the present disclosure is particularly pointed out and distinctly claimed in the concluding portion of the specification. A more complete understanding of the present disclosures, however, may best be obtained by referring to the detailed description and claims when considered in connection with the drawing figures, wherein like numerals denote like elements.

FIG. 1 illustrates a schematic view of a gas turbine engine, in accordance with various embodiments;
FIG. 2A illustrates a schematic view of a diffusion coating removal system, in accordance with various embodiments;
FIG. 2B illustrates a schematic view of a diffusion coating removal system, in accordance with various embodiments;
FIG. 3A illustrates a perspective view of an airfoil element, in accordance with various embodiments;
FIG. 3B illustrates a cross-sectional view of a portion of an airfoil element, in accordance with various embodiments; and
FIG. 4 illustrates a method of removing a diffusion coating from a gas turbine engine component, in accordance with various embodiments.

DETAILED DESCRIPTION

[0011] The detailed description of exemplary embodiments herein makes reference to the accompanying drawings, which show exemplary embodiments by way of illustration and their best mode. While these exemplary embodiments are described in sufficient detail to enable those skilled in the art to practice the disclosures, it should be understood that other embodiments may be realized and that logical, chemical, and mechanical changes may be made without departing from the scope of the disclosures. Thus, the detailed description herein is presented for purposes of illustration only and not of limitation. For example, the steps recited in any of the method or process descriptions may be executed in any order and are not necessarily limited to the order presented. Furthermore, any reference to singular includes plural embodiments, and any reference to more than one component or step may include a singular embodiment or step. Also, any reference to attached, fixed, connected or the like may include permanent, removable, temporary, partial, full and/or any other possible attachment option. Additionally, any reference to without contact (or similar phrases) may also include reduced contact or minimal contact.

[0012] In various embodiments, aluminide diffusion coating removal systems and methods are disclosed herein. The systems and methods correspond to removal of an aluminide diffusion coating from a nickel-base, or cobalt-base, superalloy. In various embodiments, the methods and systems disclosed herein may reduce capital intensive equipment for diffusion coating removal, mitigate air permits, water sampling, outfall samplings, emissions, and discharge exposure to concentrated acids for diffusion coating removal, reduce an amount of base material removed from a gas turbine engine component during diffusion coating removal, enhance a life of a restored gas turbine engine component, and/or reduce a cost of the removal methods and system.

[0013] Referring to FIG. 1, a gas turbine engine 100 (such as a turbofan gas turbine engine) is illustrated according to various embodiments. Gas turbine engine 100 is disposed about axial centerline axis 120, which may also be referred to as axis of rotation 120. Gas turbine engine 100 may comprise a fan 140, compressor sections 150 and 160, a combustion section 180, and a turbine section 190. Air compressed in the compressor sections 150, 160 may be mixed with fuel and burned in combustion section 180 and expanded across turbine section 190. Turbine section 190 may include high pressure rotors 192 and low pressure rotors 194, which rotate in response to the expansion. Turbine section 190 may comprise alternating rows of rotary airfoils or blades 196 and static airfoils or vanes 198. A plurality of bearings 115 may support spools in the gas turbine engine 100. Any parts in gas turbine engine 100 may comprise a metallic diffusion or overlay coating to improve high temperature performance. For example, high pressure rotors 192, low pressure rotors 194, blades 196, or vanes 198 may be coated with an aluminum-based overlay or diffusion coating. FIG. 1 provides a general understanding of the sections in a gas turbine engine and is not intended to limit the disclosure. The present disclosure may extend to all types of turbine engines, including turbofan gas turbine engines and turbojet engines, for all types of applications

[0014] Gas turbine engine components, such as high pressure rotors 192, low pressure rotors 194, blades 196, or vanes 198 may be manufactured with a protective coating disposed thereon. In various embodiments, the protective coating is an aluminized diffusion coating. After an extended time on wing, a protective coating as disclosed herein may degrade to a point where the protective coating provides reduced protection to an airfoil of the gas turbine engine component. Thus, during a repair process, any remainder of the protective coating may be removed, and the gas turbine engine component may be re-coated.

[0015] Referring now to FIG. 2A, a system 200 for removing a diffusion coating (e.g., an aluminide diffusion coating), is illustrated, in accordance with various embodiments. In various embodiments, the system includes a tank 202, a graphite plate 204, and a solution 206. The graphite plate 204 and the solution 206 are both disposed in the tank 202. In various embodiments, the graphite plate 204 is a low Sulphur graphite plate (e.g., container Sulphur of less than 550 ppm). The graphite plate 204 may be configured to be electrically coupled (i.e., either directly, or indirectly through a conductive path as discussed further herein) to a base material of a gas turbine engine component (e.g., high pressure rotors 192, low pressure rotors 194, blades 196, or vanes 198 from FIG. 1) having an aluminide diffusion coating disposed thereon. For example, as shown in FIG. 2A, a graphite plate 204 may be disposed proximate a bottom of tank 202 and be configured to receive a base material of a gas turbine engine component placed directly thereon. In this regard, based on the contact between the base material of the gas turbine engine component and the graphite plate 204, the graphite plate 204 and the base material would be in electrical communication. Similarly, as illustrated in FIG. 2B, system 250 for removing a diffusion coating may comprise graphite plates 208, 210 placed on sides of a tank 202 with electrical wires 212, 214 configured to electrically couple the graphite plates 208, 210 to a respective base material of a gas turbine engine component, in accordance with various embodiments.

[0016] An aluminide diffusion coating removal system (i.e., system 200) may comprise solution 206 which is a highly diluted acidic solution comprising an acid diluted in water (e.g., between 5-15 % vol./vol. total acid), in accordance with various embodiments. Based on a base material and a diffusion coating material, various acids are within the scope of this disclosure. For example, the acid base may include, but are not limited to, one or more organic acids of any molecular weight, one or more mineral acids (inorganic acids), and mixtures thereof. Organic acids may include mono-carboxylic acids, di-carboxylic acids, or tri-carboxylic acids, and may be saturated or may have any degree of unsaturation. For example, organic acids for use in various embodiments of the composition in accordance to the present disclosure may include, but are not limited to, formic acid, carbonic acid, acetic acid, lactic acid, oxalic acid, propionic acid, valeric acid, enanthic acid, pelargonic acid, butyric acid, lauric acid, docosahexaenoic acid, eicosapentaenoic acid, pyruvic acid, acetoacetic acid, benzoic acid, salicylic acid, aldaric acid, fumaric acid, glutaconic acid, traumatic acid, muconic acid, malonic acid, malic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, abietic acid, pimaric acid, sebacic acid, phthalic acid, isophthalic acid, terephthalic acid, maleic acid, citric acid, and combinations thereof. For example, mineral acids for use in various embodiments of the solution in accordance to the present disclosure may include, but are not limited to hydrochloric acid, phosphoric acid, sulfuric acid, nitric acid, and combinations thereof. In various embodiments, nitric acid is used as the only acid for the solution disclosed herein for base material (e.g., for high pressure rotors 192, low pressure rotors 194, blades 196, or vanes 198 from FIG. 1) having a nickel-base or cobalt-base superalloy.

[0017] In various embodiments, the solution 206 comprises between 5 % and 15 % vol./vol. nitric acid with a remainder vol./vol. being water. In various embodiments, the total acidity may be significantly less than typical aluminide diffusion coating removal systems. For example, total acidity of typical systems may typically range from around 30% vol./vol. to 50 % vol./vol. When typical concentrated acids are used in the 30% vol./vol. to 50% vol./vol. range, after the diffusion coating is stripped off, the solution may begin to attack the base material. Thus, typical concentrated acids are susceptible to removal of too much base material, especially for a thin walled gas turbine component, or the like, which may result in a gas turbine component having to be scrapped. In various embodiments, by having a less acidic solution between 5 % and 15 % and using the methods disclosed further herein, a reaction rate for removing a diffusion coating may be maintained or increased resulting in more consistent removal at a reduced cost.

[0018] In various embodiments, the solution 206 of system 200 may be a heated solution. For example, the solution 206 may be heated to a temperature between 80 °F (27 °C) and 140 °F (60 °C), or between 95 °F (35 °C) and 140 °F (60 °C), or between 110 °F (43 °C) and 140 °F (60 °C). Typically, a lowering of an acidic solution by 10 ° F (6 °C) may result in a doubling of a reaction rate (i.e., removal of the diffusion coating would be substantially longer for every 10 °F (6 °C) the temperature is lowered relative to a typical removal solution). In this regard, typical heated solutions for removal of aluminide diffusion coatings are in excess of 160 °F (71 °C) to main a sufficient reaction rate. However, unexpectedly, with the solution 206 being below 140 °F (60 °C) and utilizing the removal method disclosed herein, a reaction rate at or above typical reaction rates of acidic solutions heated above 160 °F (71 °C) for removal of aluminide diffusion coatings may be maintained, and/or exceeded. In this regard, with greater dilution and lower temperatures for solution 206, the methods disclosed herein may reduce removal of the base material during the removal process, reduce a cost of the removal process, mitigate air permits, water sampling, outfall sampling, emissions, and/or discharge exposures to concentrated acids, or the like, in accordance with various embodiments.

[0019] Referring now to FIG. 3A, an airfoil element 300 is illustrated schematically in the form of a rotor blade 306 from a turbine section, such as, for example, one of high pressure rotors 192 or low pressure rotors 194 from FIG. 1. In various embodiments, the rotor blade 306 includes an airfoil section 310, a root section 312 (*e.g.*, a firtree root) and a blade tip 314. A platform 316 may be disposed between the airfoil section 310 and the root section 312. The airfoil section 310 typically extends in a spanwise direction between the platform 316 and the blade tip 314 and in a chordwise direction between a leading edge 318 and a trailing edge 320.

[0020] Further, the airfoil section 310 typically defines a pressure side surface 322 and a suction side surface 324. In various embodiments, the rotor blade 306 includes an internal cooling passage system that includes a plurality of leading edge outlets 326, a plurality of trailing edge outlets 328, a plurality of pressure side surface outlets 330, a plurality of suction side surface outlets 332 and a plurality of blade tip outlets 334. The various pluralities of outlets provide openings for a cooling fluid circulating through various internal passageways within the rotor blade 306 to exit.

[0021] Referring now to FIG. 3B, a cross-sectional view of a portion of airfoil element 300 from FIG. 1B is illustrated in accordance with various embodiments. In various embodiments, airfoil element 300 includes a base material 350 and a diffusion coating 360. The base material 350 may comprise a nickel-based superalloy (e.g., an austenitic nickel-chromium-based alloy such as that sold under the trademark Inconel® which is available from Special Metals Corporation of New Hartford, New York, USA), a cobalt-based superalloy, or the like. The diffusion coating 360 may comprise an aluminide diffusion coating. In various embodiments, the diffusion coating 360 may include a diffusion layer and an additive layer.

[0022] In various embodiments, the diffusion coating 360 is disposed on an external surface 352 of the base material 350. In various embodiments, the diffusion coating 360 is configured to protect the base material 350 from the environment of the base material 350 during gas turbine engine operation. For example, during operation of the gas turbine engine 100 from FIG. 1, hot combustion gases may be directed by the airfoil element 300 and subjected to severe attack by oxidation corrosion and erosion. In various embodiments, the diffusion coating 360 protects against these events and may erode overtime.

[0023] Referring now to FIG. 4, a method 400 of removing an aluminide diffusion coating is illustrated, in accordance with various embodiments. In various embodiments, the method 400 comprises heating a diluted nitric acid solution to a predetermined temperature (step 402). The diluted nitric acid solution may be in accordance with the solution 206 from FIGs. 2A-2B. For example, the diluted nitric acid solution may contain between 5% and 15 % vol./vol. nitric acid and between 85% and 95% vol./vol. water. In this regard, the diluted nitric acid solution may be significantly more diluted relative to typical diffusion coating removal processes. In various embodiments, the predetermined temperature is between 80 °F (27 °C) and 140 °F (60 °C), or between 95 °F (35 °C) and 140 °F (60 °C), or between 110 °F (43 °C) and 140 °F (60 °C).

[0024] In various embodiments, the method 400 further comprises disposing a gas turbine engine component in the diluted nitric acid solution (step 404) and placing the gas turbine engine component in electrical contact with a graphite plate (step 406). In various embodiments, the gas turbine engine component may be in accordance with airfoil element 300 from FIGs. 3A and 3B. In various embodiments, the graphite plate is disposed in a tank in accordance with system 200 or system 250 from FIGs. 2A and 2B. In various embodiments, the graphite plate is placed in electrical contact with the base material of the gas turbine engine component. In various embodiments, the graphite plate is place in electrical contact.

[0025] In various embodiments, in response to steps 404 and 406, a localized redox reaction occurs allowing for the chemical stripping of the aluminide diffusion coating in the heated solution from step 402. In particular, the combination of the graphite plate 204 from FIGs. 2A-B, the base material (e.g., base material 350 from FIG. 3B), the diffusion coating (e.g., diffusion coating 360 from FIG. 3B), and the heated solution (e.g., solution 206 from FIGs. 2A-B) essentially create an electrical circuit. In various embodiments, due to the dissimilar material between the coating (e.g., diffusion coating 360) and the base material (e.g., the base material 350) of the gas turbine engine component, a voltage differential may be generated between the graphite plate and the coating that is significantly greater than a voltage created between the graphite plate and the base material. In this regard, the voltage created by electrically coupling the graphite plate to the gas turbine engine component essentially increases the reaction rate of the solution with respect to the coating and returns to a negligible, or nearly negligible effect once the coating is removed. Thus, in various embodiments, the graphite plate may act as an electrical contact point for the system that allows the redox reaction to take place.

[0026] In various embodiments, by electrically coupling the gas turbine engine component to the graphite plate, a reaction rate of the solution towards the diffusion coating may be enhanced based on a voltage created due to the differential material (namely the aluminum in the coating and the nickel in the base material). Additionally, once the coating is removed, the voltage may become negligible and return the solution to a significantly lower reaction rate without the voltage differential. In this regard, the systems and methods disclosed herein may be configured to prevent additional base material from being removed during a diffusion coating removal process, in accordance with various embodiments. This may allow for gas turbine engine components with thinner walls to utilize the removal process without a high risk of creating a component that has to be scrapped due to not meeting specifications.

[0027] Benefits, other advantages, and solutions to problems have been described herein with regard to specific embodiments. Furthermore, the connecting lines shown in the various figures contained herein are intended to represent exemplary functional relationships and/or physical couplings between the various elements. It should be noted that many alternative or additional functional relationships or physical connections may be present in a practical system. However, the benefits, advantages, solutions to problems, and any elements that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as critical, required, or essential features or elements of the disclosures.

[0028] The scope of the disclosures is accordingly to be limited by nothing other than the appended claims, in which reference to an element in the singular is not intended to mean "one and only one" unless explicitly so stated, but rather "one or more." Moreover, where a phrase similar to "at least one of A, B, or C" is used in the claims, it is intended that the phrase be interpreted to mean that A alone may be present in an embodiment, B alone may be present in an embodiment, C alone may be present in an embodiment, or that any combination of the elements A, B and C may be present in a single embodiment; for example, A and B, A and C, B and C, or A and B and C. Different cross-hatching is used throughout the figures to denote different parts but not necessarily to denote the same or different materials.

[0029] Systems, methods and apparatus are provided herein. In the detailed description herein, references to "one embodiment", "an embodiment", "an example embodiment", etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described. After reading the description, it will be apparent to one skilled in the relevant art(s) how to implement the disclosure in alternative embodiment

[0030] Furthermore, no element, component, or method step in the present disclosure is intended to be dedicated to the public regardless of whether the element, component, or method step is explicitly recited in the claims. As used herein, the terms "comprises", "comprising", or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus.

Claims

1. A method of removing an aluminide diffusion coating from a gas turbine engine component having a nickel alloy base material, the method comprising:

   disposing the gas turbine engine component in a solution, the solution including an acid between 5% and 15% vol./vol. and water between 85% and 95% vol./vol.;
   placing the gas turbine engine component in electrical contact with a graphite plate; and
   removing the aluminide diffusion coating from the gas turbine engine component in response to placing the gas turbine engine component in electrical contact with the graphite plate and disposing the gas turbine engine component in the solution.

2. The method of claim 1, further comprising increasing a reaction rate of the solution in response to generating a voltage differential between the solution and the aluminide diffusion coating.

3. The method of claim 2, further comprising reducing the reaction rate in response to the aluminide diffusion coating being removed and the solution contacting the nickel alloy base material.

4. The method of any preceding claim , further comprising:

   heating the solution between 80 °F (27 °C) and 140 °F (60 °C), and / or
   placing the gas turbine engine component in direct contact with the graphite plate, and / or
   electrically coupling the gas turbine engine component to the graphite plate.

5. The method of any preceding claim, wherein the gas turbine engine component includes an airfoil.

6. The method of any preceding claim, wherein the acid is nitric acid.

7. A method of removing an aluminide diffusion coating from a gas turbine engine component having a nickel alloy base material via a coating removal system, the method comprising:

   enhancing, via the coating removal system, a reaction rate of a diluted acid solution in response to generating a localized redox reaction between the aluminide diffusion coating and the diluted acid solution;
   removing, via the coating removal system, the aluminide diffusion coating from the nickel alloy base material in response to generating the localized redox reaction; and
   reducing, via the coating removal system, the reaction rate of the diluted acid solution in response to the aluminide diffusion coating being removed.

8. The method of claim 7, wherein a first electromotive force produced during the enhancing the reaction rate of the diluted acid solution is greater than a second electromotive force produce during reducing the reaction rate of the diluted acid solution.

9. The method of claim 7 or 8, wherein the diluted acid solution is an acid between 5% and 15% vol./vol.

and water between 85% and 95% vol./vol.

10. The method of claim 9, wherein a temperature of the diluted acid solution is between 80 °F (27 °C) and 140 °F (60 °C), wherein, optionally, the acid is nitric acid.

11. The method of any of claims 7 to 10, wherein the coating removal system includes a graphite plate in electrical communication with the gas turbine engine component,
wherein, optionally, the graphite plate is disposed in the diluted acid solution.

12. A system for removing an aluminide diffusion coating, the system comprising:

a diluted nitric acid solution comprising nitric acid between 5% and 15% vol./vol. and water between 85% and 95% vol./vol; and
a graphite plate disposed in the diluted nitric acid solution, the graphite plate configured to be in electrical communication with a gas turbine engine component during removal of the aluminide diffusion coating.

13. The system of claim 12, further comprising a heater, wherein the heater is configured to heat the diluted nitric acid solution to a temperature between 80 °F (27 °C) and 140 °F (60 °C).

14. The system of claim 12 or 13, further comprising the gas turbine engine component disposed in the diluted nitric acid solution, the gas turbine engine component comprising a base material and the aluminide diffusion coating, the base material comprising a nickel-based superalloy.

15. The system of claim 14, wherein a reaction rate of the diluted nitric acid solution is increased in response to an electromotive force generated from a voltage differential between the diluted nitric acid solution and the aluminide diffusion coating,
wherein, optionally, the reaction rate of the diluted nitric acid solution is decreased in response to the aluminide diffusion coating being removed.

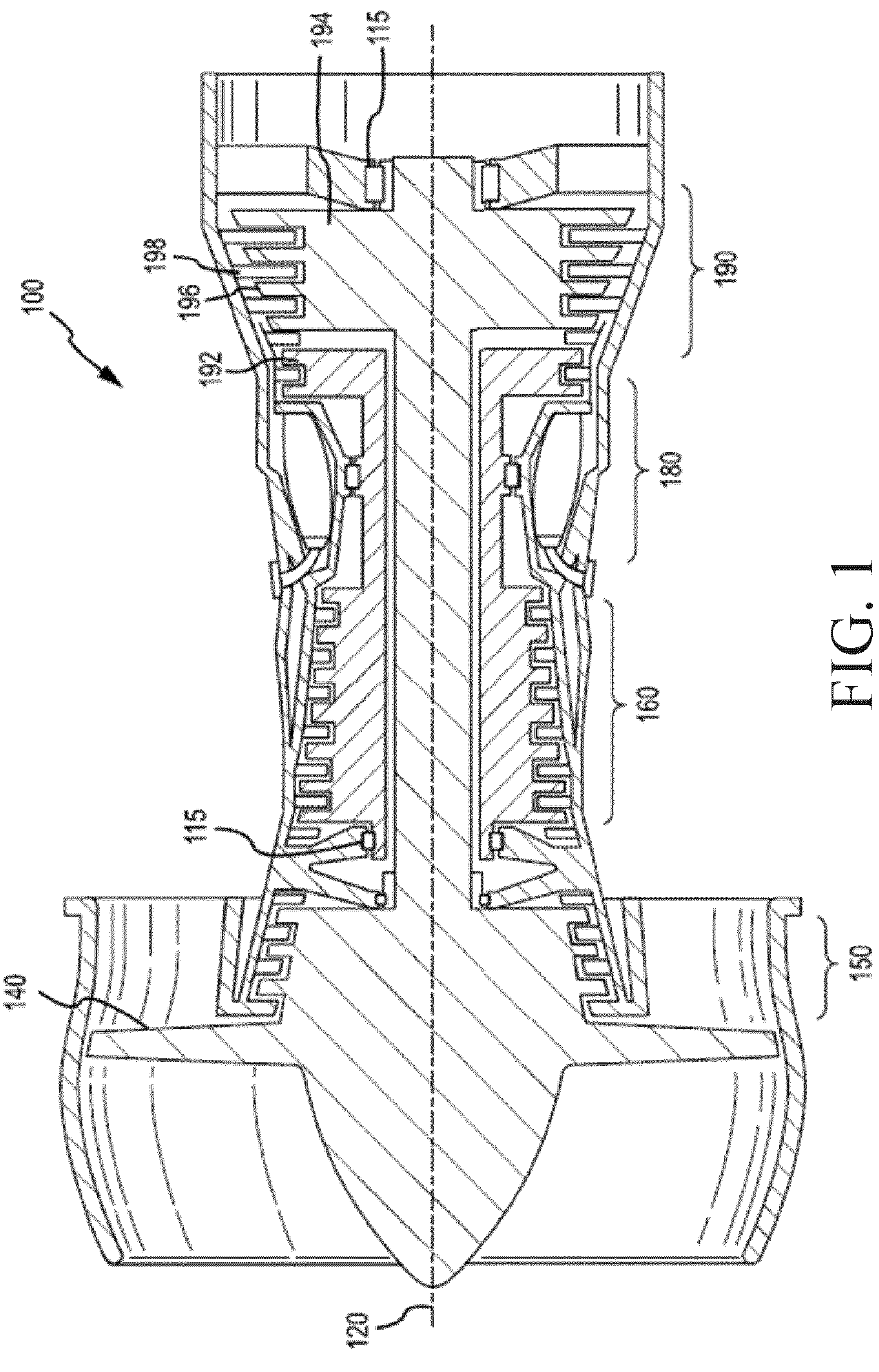

FIG. 1

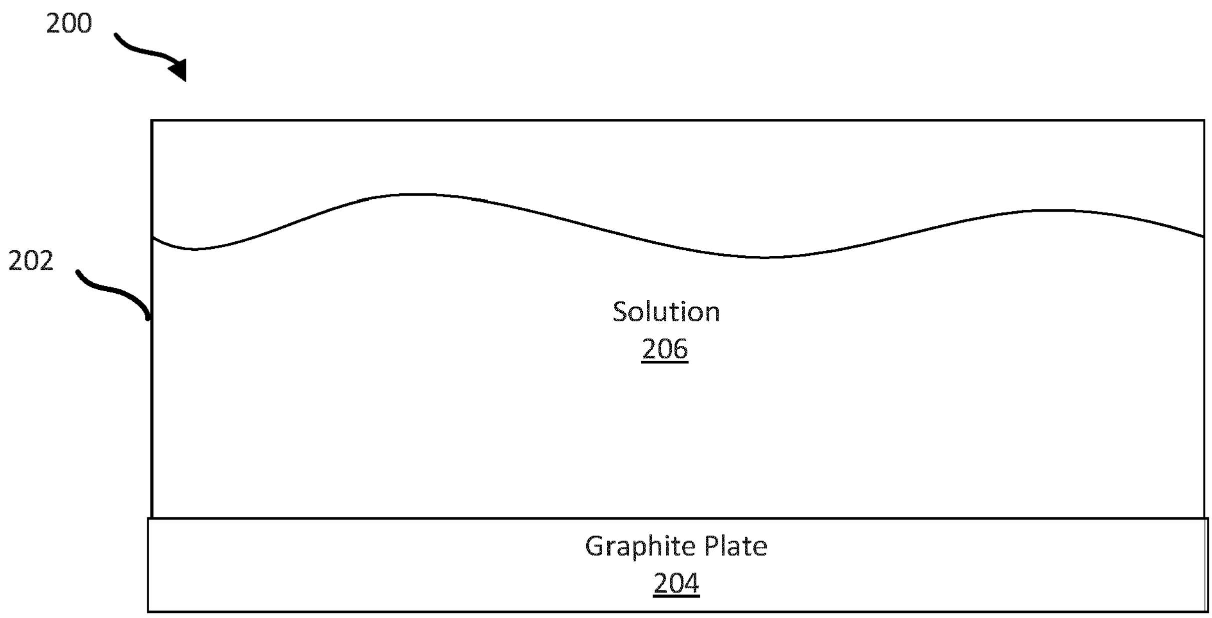
200
202
Solution
206
Graphite Plate
204

FIG. 2A

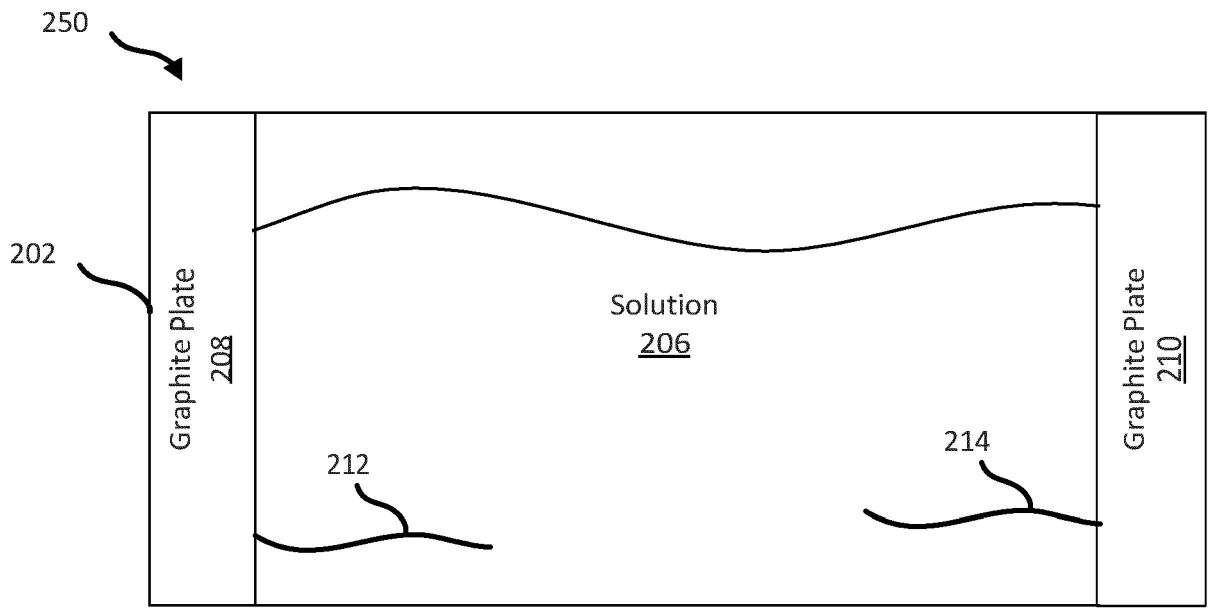
250
202
Graphite Plate
208
Solution
206
Graphite Plate
210
212
214

FIG. 2B

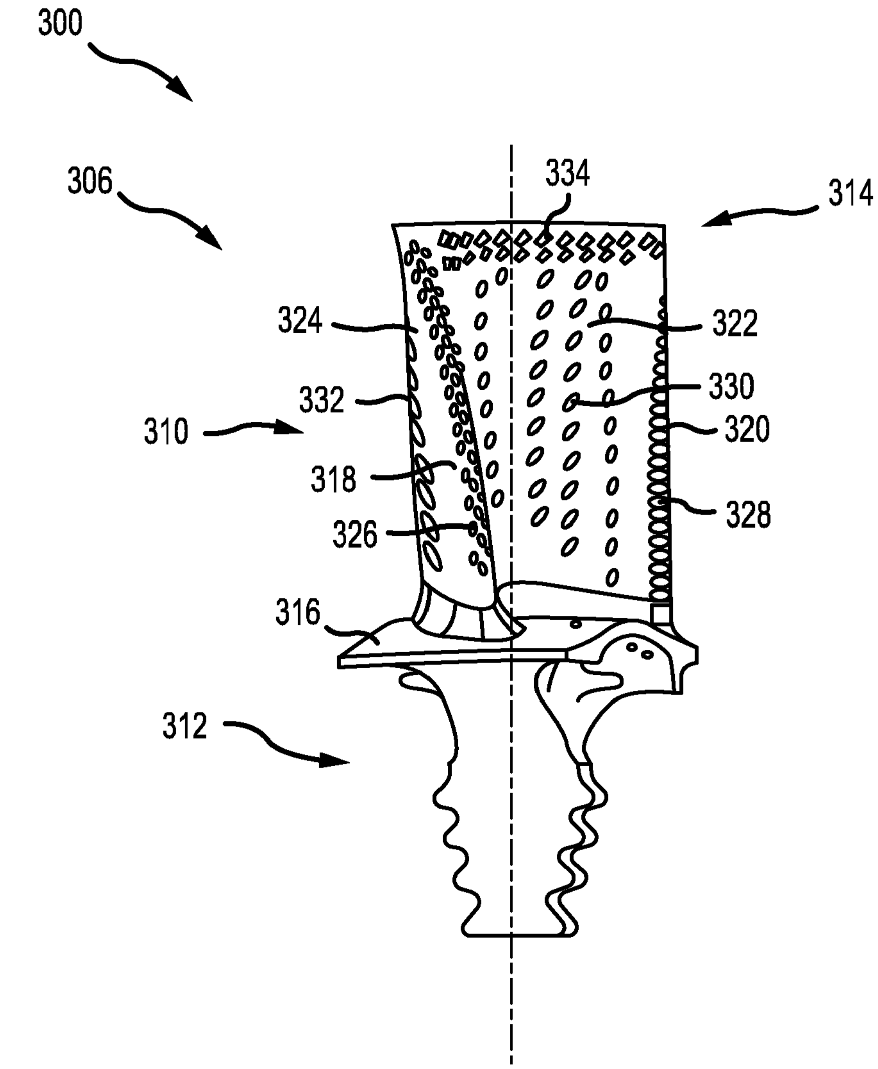
300
306
314
334
324
322
332
330
310
320
318
328
326
316
312

FIG. 3A

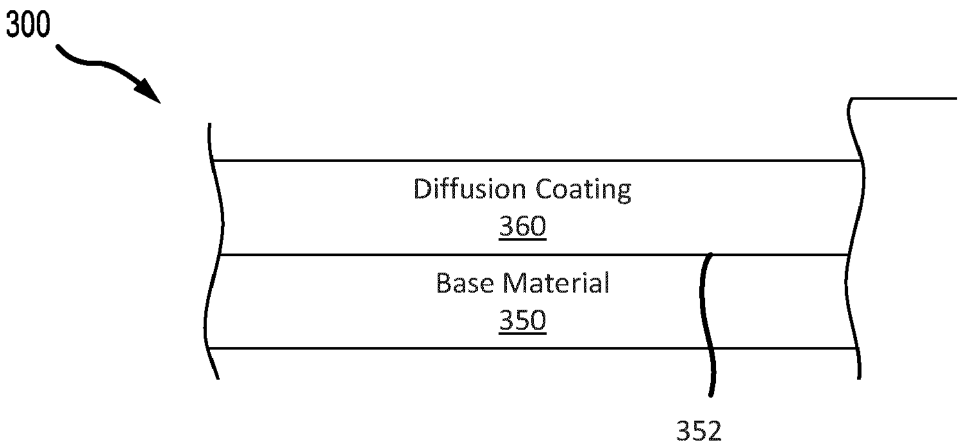
300
Diffusion Coating
360
Base Material
350
352

FIG. 3B

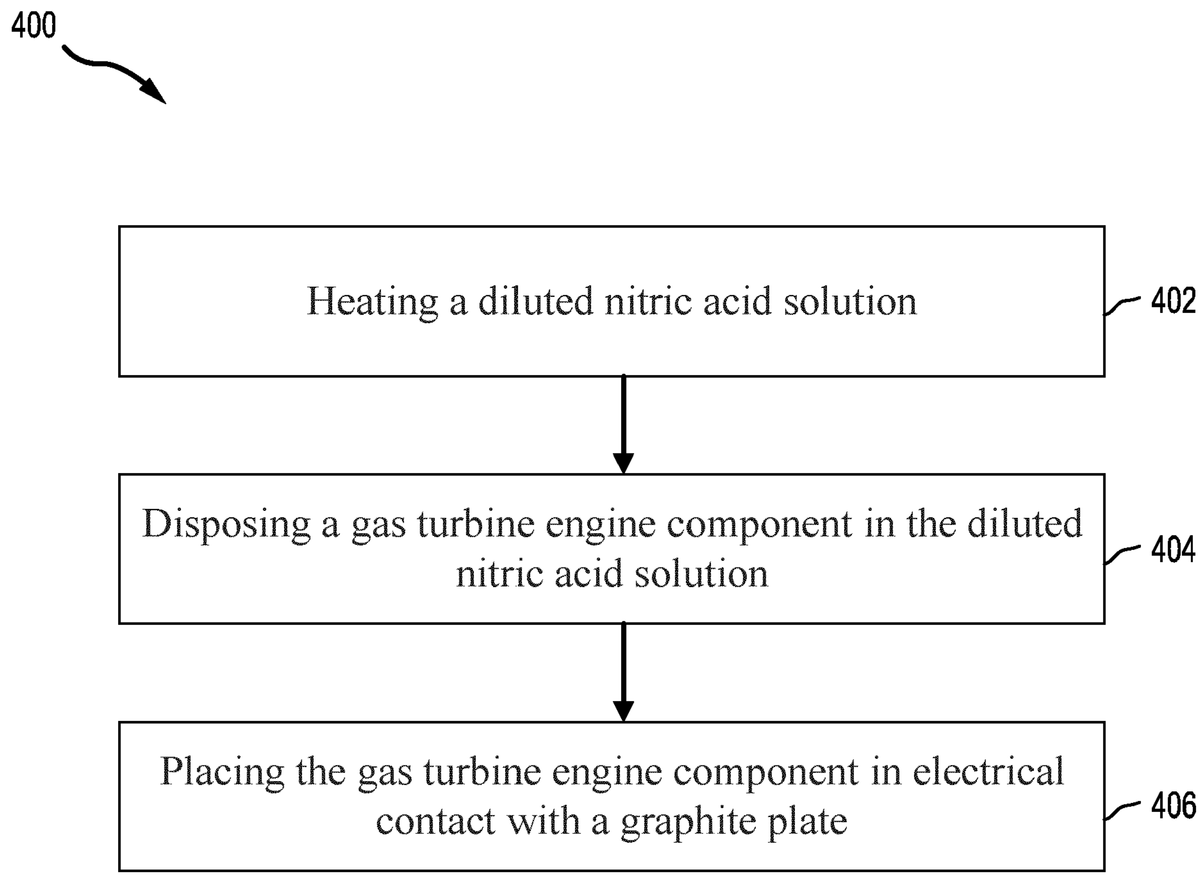
400
Heating a diluted nitric acid solution
402
Disposing a gas turbine engine component in the diluted nitric acid solution
404
Placing the gas turbine engine component in electrical contact with a graphite plate
406

FIG. 4