well as blades that have been weld repaired to restore damaged portions of the airfoil portion. The weld repair may be accomplished by any traditional weld repair method, such as SWET welding, TIG welding laser welding or any other well-known welding repair method to restore the airfoil portion of damaged new-make blades or blades removed from service. The blade undergoing metallurgical restoration, as discussed above, experiences rafting in the airfoil portion either as a result of in-service operation or as a result of weld repair, or both. In order to restore the microstructure of the blade to new-make conditions, typically an as-cast microstructure, rafting is eliminated from the airfoil portion by heating only the airfoil portion above the solutioning temperature, thereby resolutionizing it. The airfoil portion can then be precipitation-hardened to provide a preselected microstructure compatible with its intended future use.

According to one aspect of the present invention, there is provided an apparatus for restoring the microstructure of a portion of an article having a first section and a second section, comprising: a heat source, for heating at least a portion of the first section of the article to a preselected temperature; a source of cooling fluid; a fixture for supporting the article stationary therein, the fixture further comprising a material of high conductivity, a receptacle corresponding to a surface of the second section of the article for receiving at least a portion of the second section of the article and providing a means for transferring heat between the at least a portion of the second section of the article, when received in the fixture, an orifice having an inlet and an outlet, the inlet connected to the source of cooling fluid so that the cooling fluid passing through the orifice removes heat from the fixture transferred from the at least a portion of the second section of the article to the fixture; and a protective atmosphere applied around at least the portion of the first section of the article heated to the preselected temperature.

According to another aspect of the present invention, there is provided a method for using a fixture to differentially heat treat a superalloy turbine blade, comprising the steps of: providing a turbine blade having an airfoil portion, a platform portion, a shank portion below the platform portion and a dovetail portion below the shank portion; providing a source of cooling fluid; providing a fixture for supporting the turbine blade stationary therein, the fixture further comprising a material of high conductivity, a receptacle corresponding to at least a part of a blade surface below the platform portion of the turbine blade, the receptacle providing surface contact with at least the part of the blade surface below the platform surface when inserted therein so that at least the airfoil portion of the blade projects away from the fixture, an orifice having an inlet and an outlet, the inlet connected to the source of the cooling fluid; inserting at least a part of the blade surface below the platform portion into the receptacle of the fixture; establishing a flow of cooling fluid from the source of cooling fluid through the orifice; providing a heating source; utilizing the heating source to heat the airfoil portion of the blade projecting away from the fixture; and heating the airfoil portion of the blade to a solutioning temperature of the superalloy for a time sufficient to solution γ' prime precipitates, while maintaining at least the part of the blade below the platform in the receptacle of the fixture below the solutioning temperature, the fixture conducting heat away from the blade, and the cooling fluid conducting heat away from the fixture; wherein the step of providing a turbine blade further includes providing a turbine blade having internal cooling passageways, the step of providing a fixture further includes providing a fixture having a means for providing cooling fluid to the internal cooling passageways of the turbine blade, and the step of establishing a flow of cooling fluid further includes establishing a sufficient flow of cooling fluid through the means for providing cooling fluid to the internal cooling passageways so that the temperature of the internal passageways is maintained below an incipient melting temperature of an aluminide coating applied to the internal passageways of the superalloy turbine blade substrate.

The microstructure restoration ~~of the present invention~~ discussed above may also be~~is~~ accomplished by placing the turbine blade in a~~the~~ fixture ~~of the present invention. The fixture~~ comprise~~s~~sing a high conductivity material. The fixture includes a receptacle having a geometry for receiving the portion of the blade below the blade platform, at least the dovetail portion, and typically the shank as well. The portion of the blade below the platform is placed in the receptacle of the fixture so that heat from the airfoil portion solutioning operation can be transferred away from the blade below the platform by operation of the fixture. A portion of the blade, typically including the airfoil portion of the blade, extends from the fixture. The fixture further includes a means for removing heat from the blade and fixture while preventing fixture from overheating. Typically, a cooling fluid contacts a surface of the fixture to transfer heat away from the portion of the blade below the platform. Because the solutioning temperature for each specific alloy will vary, the solutioning temperature is dependent on alloy composition as well as the size and distribution of the γ' desired for a given application, but the solutioning temperature and time are selected so as to solution γ' precipitates. To further elaborate on the variability of solutioning temperature, Rene' N5 is a well-known superalloy composition used for turbine blade applications having a range of compositions. The solutioning temperature for alloy compositions falling

CLAIMS

1. Apparatus for restoring the microstructure of a portion of an article having a thin section and a thick section, comprising:

a heat source, the heat source to heat at least a portion of the article to a preselected temperature;

a source of cooling fluid;

a fixture for supporting the article, the fixture further comprising

a material of high conductivity,

a receptacle corresponding to a surface of the article for receiving a portion of the article and providing a means for transferring heat between the article, when inserted, and the fixture,

an orifice having an inlet and an outlet, the inlet connected to a source of cooling fluid which removes heat from the fixture; and

a protective atmosphere applied around at least the portion of the article heated to the preselected temperature,

wherein cooling fluid passing through the orifice removes heat from the fixture, the heat having been transferred from the article to the fixture.

2. The apparatus of claim 1 wherein the fixture comprising a material of high conductivity includes a material selected from the group consisting of copper and copper-based alloys.

3. The apparatus of claim 1 or 2 wherein the article is a turbine blade.

4. The apparatus of claim 3, wherein the turbine blade comprises an airfoil portion, a platform portion, a shank portion below the platform portion and a dovetail portion below the shank portion.

5. The apparatus of claim 3 or 4, wherein the turbine blade comprises a superalloy.

6. The apparatus of any one of claims 3 to 5, wherein the turbine blade further includes internal cooling passages.

7. The apparatus of claim 6, wherein the apparatus further includes means for providing cooling gas to the internal cooling passages.

8. The apparatus of any one of claims 1 to 7, wherein the heat source is selected from the group consisting of radiant light, an induction coil and a furnace.

9. The apparatus of any one of claims 1 to 8, wherein the source of cooling fluid is water.

10. The apparatus of any one of claims 1 to 9, wherein the protective atmosphere is a non-reactive atmosphere.

CLAIMS

1. Apparatus for restoring the microstructure of a portion of an article having a first section and a second section, comprising:

a heat source, for heating at least a portion of the first section of the article to a preselected temperature;

a source of cooling fluid;

a fixture for supporting the article stationary therein, the fixture further comprising

a material of high conductivity,

a receptacle corresponding to a surface of the second section of the article for receiving at least a portion of the second section of the article and providing a means for transferring heat between the at least a portion of the second section of the article, when received in the fixture,

an orifice having an inlet and an outlet, the inlet connected to the source of cooling fluid so that the cooling fluid passing through the orifice removes heat from the fixture transferred from the at least a portion of the second section of the article to the fixture; and

a protective atmosphere applied around at least the portion of the first section of the article heated to the preselected temperature.

2. The apparatus of claim 1 wherein the material of high conductivity includes a material selected from the group consisting of copper and copper-based alloys.

3. The apparatus of claim 1 wherein the article is a turbine blade.

4. The apparatus of claim 3, wherein the turbine blade comprises an airfoil portion, a platform portion, a shank portion below the platform portion and a dovetail portion below the shank portion.

5. The apparatus of claim 3, wherein the turbine blade comprises a superalloy.

6. The apparatus of claim 3, wherein the turbine blade further includes internal cooling passages.

7. The apparatus of claim 6, wherein the apparatus further includes means for providing cooling gas to the internal cooling passages.

8. The apparatus of claim 1, wherein the heat source is selected from the group consisting of radiant light, an induction coil and a furnace.

9. The apparatus of claim 1, wherein the source of cooling fluid is water.

10. The apparatus of claim 1, wherein the protective atmosphere is a non-reactive atmosphere.

11. A method for using a fixture to differentially heat treat a superalloy turbine blade, comprising the steps of:

providing a turbine blade having an airfoil portion, a platform portion, a shank portion below the platform portion and a dovetail portion below the shank portion;

providing a source of cooling fluid;

providing a fixture for supporting the turbine blade stationary therein, the fixture further comprising

a material of high conductivity,

a receptacle corresponding to at least a part of a blade surface below the platform portion of the turbine blade, the receptacle providing surface contact with at least the part of the blade surface below the platform surface when inserted therein so that at least the airfoil portion of the blade projects away from the fixture,

an orifice having an inlet and an outlet, the inlet connected to the source of the cooling fluid;

inserting at least a part of the blade surface below the platform portion into the receptacle of the fixture;

establishing a flow of cooling fluid from the source of cooling fluid through the orifice;

providing a heating source;

utilizing the heating source to heat the airfoil portion of the blade projecting away from the fixture; and

heating the airfoil portion of the blade to a solutioning temperature of the superalloy for a time sufficient to solution γ' prime precipitates, while maintaining at least the part of the blade below the platform in the receptacle of the fixture below the solutioning temperature, the fixture conducting heat away from the blade, and the cooling fluid conducting heat away from the fixture;

wherein the step of providing a turbine blade further includes providing a turbine blade having internal cooling passageways, the step of providing a fixture further includes providing a fixture having a means for providing cooling fluid to the internal cooling passageways of the turbine blade, and the step of establishing a flow of cooling fluid further includes establishing a sufficient flow of cooling fluid through the means for providing cooling fluid to the internal cooling passageways so that the temperature of the internal passageways is maintained below an incipient melting temperature of an aluminide coating applied to the internal passageways of the superalloy turbine blade substrate.

12. The method of claim 11 further including the additional steps of:

after solutioning, heating the blade to an aging temperature below the solutioning temperature, the aging temperature and time selected to produce a uniform distribution of γ' precipitates of a preselected size characteristic of the alloy in the solutioned portion of the blade, while not substantially affecting the size and distribution of γ' in the portion of the blade below the platform.

13. The method of claim 11 further including the additional step of providing a protective atmosphere over at least the airfoil portion of the blade during the step of heating to a solutioning temperature.

14. The method of claim 11 wherein the additional step of providing a protective atmosphere includes providing a protective atmosphere selected from the group consisting of an inert gas and a reducing gas.

15. The method of claim 11 further including the step of applying a high temperature conductive grease between the receptacle and the part of the blade below the platform portion in the receptacle, thereby increasing conductivity between the blade and the fixture.

16. The method of claim 11 wherein the step of providing a source of cooling fluid includes providing water.

17. The method of claim 11 wherein the step of heating at least the airfoil portion of the blade to a solutioning temperature of the superalloy for a time sufficient to solution γ' precipitates includes heating to a temperature in the range of from about 1900°-2400° F. for a time of about 0.25-24 hours.

18. The method of claim 11 wherein the step of providing a fixture comprising a material of high conductivity includes providing a fixture selected from the group consisting of copper and its alloys.

19. The method of claim 11 wherein the steps of providing a heating source and utilizing the heating source to heat the portion of the blade projecting away from the fixture includes providing quartz lamps and focusing the quartz lamps on the portion of the blade projecting away from the fixture.

20. The method of claim 11 wherein the steps of providing a heating source and utilizing the heating source to heat the portion of the blade projecting away from the fixture includes providing an induction coil and placing the induction coil around the portion of the blade projection away from the fixture.

21. The method of claim 11 wherein the step of establishing a flow of cooling fluid further includes providing a sufficient flow of cooling fluid to maintain the temperature of the internal passageways below about 2100° F.

22. The method of claim 11 wherein the step of providing a superalloy turbine blade includes providing a nickel-based superalloy turbine blade selected from the group consisting of Rene 142 and Rene N5, and wherein the step of establishing a flow of cooling fluid further includes providing a sufficient flow of cooling fluid to maintain the temperature of the internal passageways below about 2200° F.