NICKEL ALLOY FOR REPAIRS

BACKGROUND

(1) Field of the Invention

[0001] The present invention relates to a nickel base repair alloy which may be used to repair workpieces, such as turbine engine components, and to methods for repairing such workpieces.

(2) Prior Art

[0002] Current materials used for repairing workpieces or components formed from a nickel based alloy used in turbine engines typically permit a maximum 0.010 inch wide crack to be repaired. Thus, there is a need for a repair material which can be used to repair wide gap cracks greater than about 0.010 inch wide.

SUMMARY OF THE INVENTION

[0003] In accordance with the present invention, there is provided a nickel base repair alloy comprising a blend of about 40 to 60 wt% of a first nickel based braze alloy containing boron, about 15 to 35 wt% of a first nickel based filler material, and the remainder consisting of a blend of a second nickel based filler material and a low melting eutectic braze nickel based alloy.

[0004] Further in accordance with the present invention, there is provided a method for repairing cracks in a workpiece comprising: applying a nickel base repair alloy to a cracked area on said workpiece, said nickel base repair alloy comprising a blend of about 40 to 60 wt% of a first nickel based braze alloy containing boron, about 15 to 35 wt% of a first nickel based filler material, and the remainder consisting of a blend

of a second nickel based filler material and a low melting eutectic braze nickel based alloy.

[0005] Still further in accordance with the present invention, there is provided a material for repairing a crack in a nickel based alloy component, said material consisting essentially of about 7.0 to 10.0 wt% chromium, about 4.0 to 7.0 wt% tungsten, about 3.0 to 6.0 wt% aluminum, about 1.0 to 5.0 wt% tantalum, about 0.5 to 3.0 wt% boron, about 9.0 to 11.0 wt% cobalt, about 0.5 to 2.0 wt% molybdenum, up to about 2.5 wt% rhenium, about 0.5 to 2.5 wt% hafnium, up to 0.03 yttrium, and the balance nickel.

[0006] Other details of the nickel alloy for repairs of the present invention, as well as other objects and advantages attendant thereto, are set forth in the following detailed description.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0007] As noted above, the present invention relates to a blend of powders which are used to form a nickel based alloy which can be used to repair turbine engine components having cracks with wide gaps in the range of about 0.010 to 0.040 inches wide. The present invention also relates to processes for repairing components having such cracks and to the repair material itself.

[0008] The repair material is a nickel based alloy preferably formed from four metallic powders mixed in a binder. The powders are mixed together and suspended in a typical industry flux free organic based brazing binder that is capable of burning off without leaving an undesirable residue when paste is heated to not higher than 1000°F. A suitable binder is NicroBraz S binder or Vitta Braz Binder Gel. The amount of binder used will vary from manufacturer to manufacturer. For a paste form, 8 to 15 wt% should be the binder. The four metallic powders may comprise a

first nickel based braze alloy containing boron, a first nickel based filler material, a second nickel based filler material, and a low melting eutectic braze nickel based alloy. A suitable blend may contain about 40 to 60 wt% of a first nickel based braze alloy containing boron, about 15 to 35 wt% of a first nickel based filler material, and the remainder consisting of a blend of a second nickel based filler material and a low melting eutectic braze nickel based alloy.

[0009] In a preferred embodiment of the present invention, the first nickel based braze alloy may contain about 6.0 to 6.8 wt% chromium, about 1.175 to 1.225 wt% boron, about 0.080 to 0.12 wt% carbon, about 5.7 to 6.1 wt% aluminum, about 0.04 to 0.12 wt% zirconium, about 12.1 to 13.0 wt% cobalt, about 1.5 to 1.9 wt% molybdenum, about 6.0 to 6.8 wt% tungsten, about 2.75 to 3.25 wt% rhenium, about 3.75 to 4.24 wt% tantalum, about 1.0 to 2.0 wt% hafnium, and the balance nickel.

[0010] Further in a preferred embodiment, the first nickel based filler material may contain about 0.13 to 0.17 wt% carbon, about 8.0 to 8.8 wt% chromium, about 9.0 to 11.0 wt% cobalt, about 0.5 to 0.8 wt% molybdenum, about 2.8 to 3.3 wt% tantalum, about 0.9 to 1.2 wt% titanium, about 9.5 to 10.5 wt% tungsten, about 5.3 to 5.7 wt% aluminum, about 0.010 to 0.020 wt% boron, about 1.2 to 1.6 wt% hafnium, about 0.03 to 0.08 wt% zirconium, and the balance nickel.

[0011] Further in a preferred embodiment, the second nickel base filler material may contain 14 wt% chromium, 10 wt% cobalt, 3.5 wt% aluminum, 2.75 wt% boron, 2.5 wt% tantalum, 0.1 wt% yttrium, and the balance nickel. A suitable material is a product commercially known as DF-4B.

[0012] Still further in a preferred embodiment, the low melting eutectic braze nickel based alloy may contain about 13.5 to 16.0 wt% chromium, about 3.25 to 4.0 wt% boron, and the balance

nickel. A suitable material is a product commercially known as NICROBRAZ 150.

[0013] The four powders may be blended with the binder using any suitable technique known in the art. While it is preferred that the blended nickel base repair alloy be in powder form, if desired, the blend may take the form of a paste or a paint. Alternatively, any suitable technique known in the art may be used to convert a powder form of the blend into a plate form.

[0014] The repair material has a composition consisting essentially of about 7.0 to 10.0 wt% chromium, about 4.0 to 7.0 wt% tungsten, about 3.0 to 6.0 wt% aluminum, about 1.0 to 5.0 wt% tantalum, about 0.5 to 3.0 wt% boron, about 9.0 to 11.0 wt% cobalt, about 0.5 to 2.0 wt% molybdenum, up to about 2.5 wt% rhenium, about 0.5 to 2.5 wt% hafnium, up to 1.0 wt% titanium, up to 0.03 wt% yttrium, and the balance nickel. In a preferred embodiment, the repair material has a chromium content in the range of about 8.5 to 9.5 wt%, a tungsten content in the range of about 5.0 to 6.2 wt%, an aluminum content in the range of about 4.0 to 5.0 wt%, a titanium content in the range of about 0.15 to 0.4 wt%, a tantalum content in the range of about 3.0 to 4.0 wt%, a boron content in the range of about 1.0 to 1.5 wt%, a cobalt content in the range of about 10 wt% to 11 wt%, a molybdenum content in the range of about 0.9 to 1.3 wt%, a rhenium content in the range of about 1.0 to 2.0 wt%, a hafnium content in the range of 1.0 to 1.3 wt%, and a yttrium content in the range of 0.01 to 0.02 wt%. The rhenium improves high temperature creep, while yttrium is a grain boundary strengthener.

[0015] In order to effect a repair, the repair area on the component to be repaired may first be cleaned to remove any loose debris and/or contaminants in the repair area. Any suitable technique known in the art may be used to clean the

repair area. Thereafter, the nickel base repair alloy may be applied to the repair area so that the repair alloy fills any crack in the area. Following the application step, the component and the repair alloy are preferably subjected to a melt cycle for a time period of about 15 to 30 minutes at a temperature greater than the melt temperature of the blended nickel base repair alloy. Following the melt cycle, the component with the melted repair alloy may be subjected to a diffusion cycle at a temperature of about 2200 to 2300°F, preferably about 2200 to 2250°F, for a time period of about 5.0 to 25 hours, preferably about 10 to 20 hours. After the diffusion cycle has been completed, the component with the repair material may be allowed to cool to room temperature. If necessary, the component with the repair material may be subjected to further processing to remove any bumps or other distortions.

[0016] After the diffusion process, the microstructure of the repair alloy is generally isothermal with small amounts of athermal. Extending the diffusion time may reduce the amount of athermal phases.

[0017] If desired, the repair alloy of the present invention may be used in conjunction with other nickel based repair alloys.

[0018] The repair alloy of the present invention may be used to repair cracks about 0.010 to 0.040 inches wide. The repair alloy of the present invention enables these wide cracks or gaps to achieve complete or almost complete isothermal solidification during the repair process, which is not possible with some current repair alloy mixtures. The repair material may be used to repair a wide variety of turbine engine components, especially those formed from equiaxed and directionally solidified nickel based alloys.

CLAIMS:

1. A nickel based repair alloy comprising a blend of about 40 to 60 wt% of a first nickel based braze alloy containing boron, about 15 to 35 wt% of a first nickel based filler material, and the remainder consisting of a blend of a second nickel based filler material and a low melting eutectic braze nickel based alloy, wherein

said first nickel based braze alloy contains 6.0 to 6.8 wt% chromium, 1.175 to 1.225 wt% boron, 0.080 to 0.12 wt% carbon, 5.7 to 6.1 wt% aluminum, 0.04 to 0.12 wt% zirconium, 12.1 to 13.0 wt% cobalt, 1.5 to 1.9 wt% molybdenum, 6.0 to 6.8 wt% tungsten, 2.75 to 3.25 wt% rhenium, 3.75 to 4.24 wt% tantalum, 1.0 to 2.0 wt% hafnium, and the balance nickel,

said first nickel based filler material contains 0.13 to 0.17 wt% carbon, 8.0 to 8.8 wt% chromium, 9.0 to 11.0 wt% cobalt, 0.5 to 0.8 wt% molybdenum, 2.8 to 3.3 wt% tantalum, 0.9 to 1.2 wt% titanium, 9.5 to 10.5 wt% tungsten, 5.3 to 5.7 wt% aluminum, 0.010 to 0.020 wt% boron, 1.2 to 1.6 wt% hafnium, 0.03 to 0.08 wt% zirconium, and the balance nickel, and wherein

said nickel based repair alloy consists essentially of 8.5 to 9.5 wt% chromium, 5.0 to 6.2 wt% tungsten, 4.0 to 5.0 wt% aluminum, 3.0 to 4.0 wt% tantalum, 1.0 to 1.5 wt% boron, 10 to 11 wt% cobalt, 0.9 to 1.3 wt% molybdenum, 1.0 to 2.0 wt% rhenium, 1.0 to 1.3 wt% hafnium, 0.15 to 0.4 wt% titanium, 0.01 to 0.02 wt% yttrium, and the balance nickel.

2. The nickel base repair alloy of claim 1, wherein said second nickel base filler material contains 14 wt% chromium, 10 wt% cobalt, 3.5 wt% aluminum, 2.75 wt% boron, 2.5 wt% tantalum, 0.1 wt% yttrium, and the balance nickel.

3. The nickel base repair alloy of claim 1 or 2, wherein said low melting eutectic braze nickel based alloy contains 13.5 to 16.0 wt% chromium, 3.25 to 4.0 wt% boron, and the balance nickel.

4. The nickel base repair alloy of claim 1, 2 or 3, further comprising said blend being mixed in a binder.

5. The nickel base repair alloy of any preceding claim, wherein each of said first nickel based braze alloy, said first nickel based filler material, said second nickel based filler material, and said low melting eutectic braze nickel based alloy are in powder form.

6. A process for repairing a crack in a nickel based alloy component comprising:

applying a nickel base repair alloy to a cracked area on said nickel based alloy component, said nickel base repair alloy comprising a blend of 40 to 60 wt% of a first nickel based braze alloy containing boron, 15 to 35 wt% of a first nickel based filler material, and the remainder consisting of a blend of a second nickel based filler material and a low melting eutectic braze nickel based alloy, wherein

said first nickel based braze alloy contains 6.0 to 6.8 wt% chromium, 1.175 to 1.225 wt% boron, 0.080 to 0.12 wt% carbon, 5.7 to 6.1 wt% aluminum, 0.04 to 0.12 wt% zirconium, 12.1 to 13.0 wt% cobalt, 1.5 to 1.9 wt% molybdenum, 6.0 to 6.8 wt% tungsten, 2.75 to 3.25 wt% rhenium, 3.75 to 4.24 wt% tantalum, 1.0 to 2.0 wt% hafnium, and the balance nickel,

said first nickel based filler material contains 0.13 to 0.17 wt% carbon, 8.0 to 8.8 wt% chromium, 9.0 to 11.0 wt% cobalt, 0.5 to 0.8 wt% molybdenum, 2.8 to 3.3 wt% tantalum, 0.9 to 1.2 wt% titanium, 9.5 to 10.5 wt% tungsten, 5.3 to 5.7 wt% aluminum, 0.010 to 0.020 wt% boron, 1.2 to 1.6 wt% hafnium, 0.03 to 0.08 wt% zirconium, and the balance nickel, and wherein

said nickel based repair alloy consists essentially of 8.5 to 9.5 wt% chromium, 5.0 to 6.2 wt% tungsten, 4.0 to 5.0 wt% aluminum, 3.0 to 4.0 wt% tantalum, 1.0 to 1.5 wt% boron, 10 to 11 wt% cobalt, 0.9 to 1.3 wt% molybdenum, 1.0 to 2.0 wt% rhenium, 1.0 to 1.3 wt% hafnium, 0.15 to 0.4 wt% titanium, 0.01 to 0.02 wt% yttrium, and the balance nickel.

7. The process according to claim 6, wherein said applying step comprises applying said nickel base repair alloy in paste form to said cracked area.

8. The process according to claim 6, wherein said applying step comprises applying said nickel base repair alloy in paint form to said cracked area.

9. The process according to claim 6, wherein said applying step comprises applying said nickel base repair alloy in powder form to said cracked area.

10. The process according to claim 6, wherein said applying step comprises forming a plate from said nickel base repair alloy and applying said plate to said cracked area.

11. The process according to any of claims 6 to 10, further comprising:

subjecting said component to a melt cycle for about 15 to 30 minutes and heating said component with said nickel base repair alloy to a temperature of 2000 to 2300 degrees Fahrenheit (1204 to 1260 degrees Celsius) for about 5.0 to 25 hours.

12. The process according to claim 11, further comprising:

heating said component with said nickel base repair alloy to a temperature of about 2000 to 2250 degrees Fahrenheit (1204 to 1232 degrees Celsius) for about 10 to 20 hours.

13. A material for repairing a crack in a nickel based alloy component consisting essentially of 8.5 to 9.5 wt% chromium, 5.0 to 6.2 wt% tungsten, 4.0 to 5.0 wt% aluminum, 3.0 to 4.0 wt% tantalum, 1.0 to 1.5 wt% boron, 10 to 11 wt% cobalt, 0.9 to 1.3 wt% molybdenum, 1.0 to 2.0 wt% rhenium, 1.0 to 1.3 wt% hafnium, 0.15 to 0.4 wt% titanium, 0.01 to 0.02 wt% yttrium, and the balance nickel.