AMS 4777 is commercially available in form of brazing cast rods. However, due to the low melting temperature of these rods, they are not suitable for repair of high pressure turbine (HPT) engine components.

[00026] Based on the foregoing it would advantageous to develop an effective composite welding wire for fusion welding and TIG (GTAW) braze-welding on precipitation hardening superalloys that are prone to cracking in the HAZ and that were exposed previously to brazing, LPM™ or ADH repairs.

BRIEF DESCRIPTION OF THE INVENTION

[00027] According to an aspect of the present invention, there is provided a composite welding wire for fusion welding of components manufactured of superalloys, the composite weld wire comprises: an inner core wire; a surface layer applied and bonded to the inner core wire; the surface layer includes alloying elements selected from among B and Si with a total bulk content of B and Si in the composite welding wire of 0.1 to 10 wt. %.

We have found that a composite welding wire constituting a ductile core wire that comprises at least one of Ni, Co, Fe group base alloys and an outer surface layer that is enriched with a melting point depressants selected of a group containing B, Si, or mixture of B and Si successfully produced welding on LPM™, ADH and a variety of a difficult to weld superalloys and brazed joints. The total B and Si in the core and outer surface, referred to herein as the bulk content of melting point depressant, in the composite welding wire ranges approximately between 0.1-10 wt %.

[00028] The Composite welding wire described herein is readily made by a combination of cold/hot drawing of the ductile core wire followed by the physical deposition and bonding of the required amount of B and Si only to the surface layer. Prior art attempts to include higher contents of B and Si is limited due to the severe reduction in ductility caused by the B and Si additions. As a result, welding wires with high contents of melting point depressants could only be manufactured by casting or sintering, which is not commercially cost effective. Additionally, these attempts did little to address the occurrence of HAZ cracking.

[00035] As per another ~~preferable~~ embodiment, the filler wire may include a transition layer between the ductile core wire and the surface layer, wherein the content of the melting point depressant is gradually reduced from maximum on the outer surface to the level originally present at the interface of the ductile core wire material and outer surface layer.

[00036] Tubular filler wires with a diameter exceeding of 4 mm may include melting point depressants deposited on an inner surface as well.

[00037] In accordance with another embodiment, tubular filler wires and rods may contain filler powder that include the melting point depressants and at least one of Ni, Co, Fe base and alloying elements selected of a group of Al, Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, W, Cu, Y, Re, C, N elements.

[00038] ~~A~~Disclosed herein is a method of a manufacturing of the composite filler material ~~includes~~including the steps of preparation of the surface of the ductile core wire by chemical cleaning or other means, application of a slurry containing melting point depressant to the ductile core wire, drying the slurry followed by a heat treatment in a protective atmosphere or vacuum at a temperature above 900° C but below the incipient melting temperature of the ductile core wire material for a period of time that is determined for each combination of a ductile core wire and melting point depressant by experiment, calculation or other means, following by cooling to an ambient temperature.

[00039] In accordance with other ~~preferable~~ embodiments, the enrichment of the surface layer with the melting point depressant is produced by boriding also known as boronizing using one of the following processes: electrolytic boriding, liquid boriding, pack boriding, gas boriding, plasma boriding, fluidized bed boriding, by a chemical vapour deposition (CVD), by a Physical Vapour Deposition (PVD), by Electron Beam Physical Vapour Deposition.

WE CLAIM:

1. A composite welding wire for fusion welding of components manufactured of superalloys, the composite weld wire comprises:

a) an inner core wire;

b) a surface layer applied and bonded to the inner core wire;

c) the surface layer includes alloying elements selected from among B and Si with a total bulk content of B and Si in the composite welding wire of 0.1 to 10 wt. %.

2. The welding wire claimed in claim 1 wherein the total bulk content of B is less than 4 wt. %.

3. The welding wire claimed in claim 1 wherein the surface layer comprises from 5 to 95 wt.% of the alloying elements selected from among B and Si.

4. The welding wire claimed in claim 1 wherein the surface layer comprises from 5 to 50 wt.% of the alloying elements selected from among B and Si together with an organic binder.

5. The welding wire claimed in claim 1 wherein the surface layer comprises more than 50% of the bulk content of the alloying elements selected from among B and Si.

~~6. The welding wire claimed in claim 1 wherein the surface layer comprises more than 75% of the bulk content of the alloying elements selected from among B and Si.~~

~~7. The welding wire claimed in claim 1 wherein the thickness T of surface layer being less than 25% of the total diameter D of the weld wire.~~

~~8~~6. The welding wire claimed in claim 1 wherein the surface layer is ~~adhesively~~ bonded to the inner core, by selecting from among adhesive bond, by sintering in the solid state.

~~9. The welding wire claimed in claim 1 wherein the surface layer is bonded to the inner core by sintering in the solid state.~~

~~10~~7. The welding wire claimed in claim 1 wherein the surface layer is metallurgically bonded to the inner core wire by diffusion bonding.

~~11~~8. The welding wire claimed in claim ~~10~~7 further including a transition layer sandwiched between the inner core wire and the surface layer.

~~12~~9. The welding wire claimed in claim ~~10~~7 wherein the surface layer is metallurgically bonded to the inner core by diffusion bonding of B into the inner core wire.

~~13~~10. The welding wire claimed in claim ~~10~~7 wherein the surface layer is metallurgically bonded to the inner core wire by diffusion bonding of Si into the inner core wire.

~~14. The welding wire claimed in claim 1 wherein the surface layer is metallurgically bonded to the inner core by a diffusion bonding method selected from among; solid diffusion, solid-liquid diffusion, and liquid diffusion.~~

~~15. The welding wire claimed in claim 8 wherein the adhesive bonding is carried out in a temperature range from 30° C to 500° C.~~

~~16. The welding wire claimed in claim 9 wherein the sintering bonding is carried out in a temperature range from 500° C to 900° C.~~

~~17. The welding wire claimed in claim 10 wherein the metallurgical bonding is carried out in a temperature range from 900° C to 1400° C and below of a melting temperature of the inner core wire.~~

~~18~~11. The welding wire claimed in claim 1 wherein the inner core composition is selected from among nickel based alloys, nickel based superalloys, cobalt based alloys, cobalt based superalloys, iron based alloys, iron based superalloys.

~~19~~12. The welding wire claimed in claim 1 wherein the inner core wire is a solid wire and the surface layer is an outer surface layer.

~~20~~13. The welding wire claimed in claim 1 wherein the inner core wire is a hollow tubular wire.

~~21~~14. The welding wire claimed in claim ~~20~~10 wherein the surface layer is selected from among an outer surface layer, an inner surface layer, and inner surface layer and an outer surface layer.

~~22. The welding wire claimed in claim 20 wherein the surface layer is an inner surface layer.~~

~~23. The welding wire claimed in claim 20 wherein the surface layer is an inner surface layer and an outer surface layer.~~

~~24. The welding wire claimed in claim 20 wherein the inner and outer surface layers are adhesively bonded to the inner core.~~

~~25. The welding wire claimed in claim 20 wherein the inner and outer surface layers are bonded to the inner core by sintering in the solid state.~~

~~26. The welding wire claimed in claim 20 wherein the inner and outer surface layers are metallurgically bonded to the inner core wire by diffusion bonding.~~

~~27~~15. The welding wire claimed in claim 4 wherein the binder is selected from among synthetic or natural resins namely: acrylics, polyesters, epoxy, vinyl-acrylics, vinyl acetate-ethylene (VAE), melamine resins, epoxy, alkyds, and oils.

~~28~~16. The welding wire claimed in claim 1 wherein the surface layer is applied using a method selected from among; painting, electrostatic powder painting, slurry coating, boriding, chemical vapour depositing, physical vapour depositing, electron beam depositing, and electron beam physical vapour depositing.

~~29. A method of manufacturing a composite weld wire, the weld wire for fusion welding of superalloy components, the method comprising steps of:~~

~~a) preparing an inner core wire for receiving a surface layer;~~

~~b) depositing onto the wire a surface layer, the surface layer including elements selected from among B and Si such that the total bulk content of B and Si in the composite weld wire is between 0.1 to 10 wt. %.~~

~~c) bonding the surface layer to the inner core wire.~~

~~30. The method claimed in claim 29 further wherein the surface layer includes a binder.~~

~~31. The method claimed in claim 29 further including the step of depositing a surface layer selected from among a painting, slurry coating, a electrostatic powder coating, boriding, chemical vapour depositing, physical vapour depositing, electron beam depositing, and electron beam physical vapour depositing.~~

~~32. The method claimed in claim 29 further including the step of cleaning the surface of the inner core wire.~~

~~33. The method of manufacturing of a weld wire as per claim 29, wherein the bonding step includes heat treating the weld wire for adhesive bonding of the surface layer to the inner core is carried out in a temperature range from 30° C to 500° C.~~

~~34. The method of manufacturing of a solid weld wire as per claim 29, wherein the bonding step includes heat treating the wire for sintering bonding of the surface layer to the inner core is carried out in a temperature range from 500° C to 900° C.~~

~~35. The method of manufacturing of a solid weld wire as per claim 29, wherein the bonding step includes heat treating wire for metallurgical bonding of the surface layer to the inner core is carried out in a temperature range from 900° C to 1400° C but below of a melting temperature of the inner core wire to allow elements selected from among B and Si to diffuse into the inner core thereby metallurgicaly bonding the inner core to the surface layer.~~

~~36. The method claimed in claim 1 wherein the total bulk content of B is less than 4 wt. %.~~

~~37. The method claimed in claim 29 wherein the inner core composition is selected from among nickel based alloys, nickel based superalloys, cobalt based alloys, cobalt based superalloys, iron based alloys, iron based superalloys.~~