[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.

[00029] The composite welding wires described herein can be produced by coating or painting of commercially available standard welding wires/rods with B and Si. The coatings may be followed by a heat treatment. The use of standard welding wires minimizes

production costs. Therefore the present concept results in lower costs and high productivity with these filler wires.

[00030] Surface alloying of core wire with B and Si reduces the melting temperature and incrementally increases the solidification range also referred to as the melting interval. It was found that upon solidification any cracks that form self-heal due to the presence of lower solidus temperature eutectic alloys that are formed between dendrites during the solidification of the weld pool. Additionally there is no observed deterioration of properties in repaired components.

[00031] Si and B in new composite welding wires did not reduce ductility of welds allowing use of the developed welding wires for buttering.

[00032] Tensile strength of welded joints produced using composite B and Si modified welding wires on similar and dissimilar materials was often superior to the strength of welds produced using similar materials and some parent materials at a temperature of 982 Deg. C (1800 Deg. F).

[00033] We observed the elimination of HAZ cracking on Inconel 738 and other difficult to weld superalloys that are prone to cracking while welded at an ambient temperature.

[00034] We observed the reduction of the cost of a repair of turbine engine components and other articles.

[00035] As per another 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] Disclosed herein is a method of a manufacturing of the composite filler material 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 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.

DESCRIPTION OF DRAWINGS

[00040] FIGURE 1 depicts the cross section of the composite weld wire and includes ductile core wire 10, outer surface layer 102 that is enriched with melting point depressants

~~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.

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