METHOD OF SOLDERING A COMPRESSOR NOZZLE RING OF A GAS TURBINE

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ABSTRACT

Titanium-based metal parts (1, 3) are soldered by using as a filler metal (7) an aluminium alloy containing magnesium and virtually no silicon.

Application to the bonding of blades (3) to the inner shroud (1) of an aeronautical gas turbine engine compressor nozzle ring.
METHOD OF SOLDERING A COMPRESSOR NOZZLE RING OF A GAS TURBINE

[0001] The invention relates to a method of bonding titanium-based metal parts, in particular of the inner shroud and of the blades of a compressor nozzle ring of an aeronautical gas turbine engine.

[0002] Currently, the fixing of the titanium-alloy blades of a nozzle ring to the titanium-alloy inner shroud is effected by adhesion using cold-vulcanised silicone elastomers. The service life of these elastomers decreases when the operating temperature of the compressor increases. Thus, for new-generation compressors operating at temperatures close to 300° C. continuously in an atmosphere containing oil fumes, the silicone elastomer-based adhesives suffer embrittlement that limits their useful service life to 100 hours.

[0003] Furthermore, EP 1 148 208 A discloses a method of bonding the blades by soldering to the inner shroud of a nozzle ring, but without indicating the constituent materials of the parts and of the solder. The solders generally have a sufficiently long service life in the environment mentioned above. However, the prior art does not teach which filler metals to use which are adapted to the soldering of titanium-based metals.

[0004] The object of the invention is to fill this gap, and thus to eliminate the disadvantages of the known method of adhesion by silicone elastomers.

[0005] It has been found unexpectedly that commercially available aluminium alloys intended for machine construction or electrical soldering are suitable for soldering titanium-based metals.

[0006] The invention aims in particular at a method of the type defined in the introduction and provides that this comprises soldering under a gas pressure of less than 1.10⁻² Pa using as a filler metal an aluminium alloy containing magnesium and virtually no silicon.

[0007] The mechanical, physical and chemical properties of the bond obtained by the method according to the invention are an improvement on adhesive bonds. Moreover, soldering is less expensive than adhesion both in terms of its material and its implementation.

[0008] The presence of silicon in the filler metal is disadvantageous as it reduces the temperature at which the solder can be used and its resistance to corrosion.

[0009] Optional, complementary or alternative features of the invention are given below:

[0010] The aluminium alloy contains 0.5 to 8% magnesium by mass.

[0011] The aluminium alloy contains about 5% magnesium by mass.

[0012] The aluminium alloy contains no more than 0.3% silicon by mass.

[0013] The metal parts are composed of a titanium-based alloy containing 5.5 to 6.75% aluminium and 3.5 to 4.5% vanadium by mass.

[0014] The maximum temperature reached by the parts to be soldered during soldering is between about 660 and 670° C.

[0015] The duration of exposure of the parts to be soldered to temperatures of between about 660 and 670° C. is about 10 minutes.

[0016] The filler metal penetrates into an assembly gap or clearance between the parts to be soldered of a width of less than 0.8 mm.

[0017] The filler metal penetrates into a gap between the parts to be soldered of a width of at least 0.05 mm.

[0018] A quantity of filler metal is used which is between 1.5 and 2 times the volume of the said gap.

[0019] The aluminium alloy is applied in the form of a wire.

[0020] The wire has a diameter of about 0.5 to 2.5 mm.

[0021] The metal parts are an inner shroud and a plurality of gas turbine compressor nozzle ring blades, the blades being distributed in the circumferential direction and extending radially from the inner shroud to an outer shroud, each one passing through a corresponding aperture formed in the inner shroud.

[0022] End regions of the blades project radially inwards beyond the inner shroud.

[0023] The wire is placed in contact with the inner face of the inner shroud and along the profile of the blades.

[0024] The invention also relates to a gas turbine compressor nozzle ring comprising a titanium-based inner shroud, an outer shroud and a plurality of titanium-based blades distributed in the circumferential direction and extending radially from the inner shroud to the outer shroud, each blade passing through a corresponding aperture formed in the inner shroud, characterised in that the blades are fixed to the inner shroud by an aluminium-based solder containing magnesium and virtually no silicon, formed in particular by the method above.

[0025] The features and advantages of the invention are explained in more detail in the description below with reference to the attached drawings.

[0026] FIG. 1 is a partial view in axial section of a stage of an aeronautical gas turbine engine compressor nozzle ring, showing one blade connected to the inner shroud by the method according to the invention.

[0027] FIG. 2 is a detail in section showing an aluminium alloy wire positioned with a view to soldering the blade to the inner shroud.

[0028] FIG. 3 is a view similar to FIG. 2 showing the assembly obtained after soldering.

[0029] In FIGS. 2 and 3, for greater clarity, the shroud 1 and the blade 3 are shown diagrammatically in the form of plane plates of uniform thickness.

[0030] The nozzle ring stage partially shown comprises, conventionally, an inner shroud 1 and an outer shroud 2, both fixed, and a series of rectifying blades 3 extending in a generally radial direction from the inner shroud to the outer shroud. The blades 3 are distributed in the circumferential
direction, generally in a uniform manner. The inner shroud 1 is pierced with apertures 4 whose shape is adapted to the profile of the blades. Each aperture is traversed by a blade 3, one end region 5 of which projects in the axial direction of the engine beyond the aperture 4 and consequently beyond the inner face 6 of the shroud 1. The blades 3 are fixed to the outer shroud 2 e.g. by electron-beam soldering.

[0031] According to the invention, the blades 3 are fixed to the inner shroud 1 by solders 7 formed by using as a filler metal an aluminium alloy containing 0.5 to 8% magnesium by mass and virtually no silicon.

[0032] Advantageously, the aluminium alloy is realised as a wire of a diameter of about 2 mm.

[0033] An embodiment of the invention is given below by way of example for the soldering of blades to an inner shroud of a stage of an aerocentral gas turbine engine compressor nozzle ring, the blades and the inner shroud being made of the alloy TA6V, which is a titanium-based alloy containing 6% aluminium and 4% vanadium by mass.

[0034] The blades 3 are inserted into the apertures 4 formed in the wall of the inner shroud 1 and adapted to the transverse cross-section of the blades, in such a manner that an assembly gap or clearance 9 of a width of 0.35 mm is left around the blades between their surface and the opposite surface of the apertures 4. An end region 5 of each blade projects in the axial direction of the engine beyond the inner face 6 of the shroud 1. A wire 8 made of an aluminium-based alloy containing 5% magnesium and less than 0.3% silicon by mass and having a diameter of 2 mm is placed folded into a U around the region 5, so as to come into contact with the opposite faces thereof and with the face 6 of the shroud, as is shown in FIG. 2.

[0035] The assembly thus obtained is placed in a vacuum furnace wherein the pressure is reduced to below 1.10⁻² Pa. Then the following heating cycle is applied:

- [0036] increase from 20 to 40⁰ C. at 7° C./min
- [0037] maintain at 400° C. for 30 min
- [0038] increase to 600° C. at 7° C./min
- [0039] maintain at 600° C. for 10 min
- [0040] increase to 660° C. at 7° C./min
- [0041] maintain between 660 and 670° C. for 10 minutes
- [0042] cool under a vacuum to 400° C., then under a neutral gas.

[0043] During this treatment, the metal forming the wire 8 melts and penetrates by capillary action into the assembly gap or clearance 9, which it fills to form upon cooling a solder 7, which forms joining radii 10 on each side of the shroud and the blade.

[0044] The example given above is non-limiting. In particular, the filler metal can be realised in a form other than a wire, e.g. in the form of a strip, powder or paste, and can then be placed in the gap 9, preferably overflowing on the inside and/or outside of the shroud 1. The titanium-based metal forming the parts to be soldered may have a different composition from that of the alloy TA6V.

1. Method of bonding titanium-based metal parts (1, 3), characterised in that it comprises soldering under a gas pressure of less than 1.10⁻² Pa using as a filler metal an aluminium alloy containing magnesium and virtually no silicon.

2. Method according to claim 1, wherein the aluminium alloy contains 0.5 to 8% magnesium by mass.

3. Method according to claim 2, wherein the aluminium alloy contains about 5% magnesium by mass.

4. Method according to one of the preceding claims, wherein the aluminium alloy contains no more than 0.3% silicon by mass.

5. Method according to one of the preceding claims, wherein the metal parts (1, 3) consist of a titanium-based alloy containing 5.5 to 6.75% aluminium and 3.5 to 4.5% vanadium by mass.

6. Method according to one of the preceding claims, wherein the maximum temperature reached by the parts to be soldered (1, 3) during soldering is between 660 and 670° C.

7. Method according to claim 6, wherein the duration of exposure of the parts to be soldered (1, 3) to temperatures of between 660 and 670° C. is about 10 min.

8. Method according to one of the preceding claims, wherein the filler metal penetrates into an assembly gap or clearance (9) between the parts to be soldered (1, 3), the gap having a width of less than 0.8 mm.

9. Method according to one of the preceding claims, wherein the filler metal penetrates into a gap (9) between the parts to be soldered (1, 3), the gap having a width at least equal to 0.05 mm.

10. Method according to either of claims 8 or 9, wherein the quantity of filler metal used is between 1.5 and 2 times the volume of the gap.

11. Method according to one of the preceding claims, wherein the aluminium alloy is applied in the form of a wire (8).

12. Method according to claim 11, wherein the wire (8) has a diameter of about 0.5 to 2.5 mm.

13. Method according to one of the preceding claims, wherein the metal parts are an inner shroud (1) and a plurality of blades (3) of a gas turbine compressor nozzle ring, the blades being distributed in the circumferential direction and extending radially from the inner shroud to an outer shroud (2), each blade passing through a corresponding aperture (4) formed in the inner shroud (1).

14. Method according to claim 13, wherein end regions (5) of the blades (3) project radially inwards beyond the inner shroud (1).

15. Method according to either of claims 13 or 14, in combination with claim 11, wherein the wire (8) is placed in contact with the inner face (6) of the inner shroud (1) and along the profile of the blades (3).

16. Gas turbine compressor nozzle ring comprising a titanium-based inner shroud (1), an outer shroud (2) and a plurality of titanium-based blades (3) distributed in the circumferential direction and extending radially from the inner shroud to the outer shroud, each blade passing through a corresponding aperture (4) formed in the inner shroud, characterised in that the blades are fixed to the inner shroud by an aluminium-based solder (7) containing magnesium and virtually no silicon, formed by the method according to one of claims 1 to 15.

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