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(54) IMPROVEMENTS IN OR RELATING TO DIFFUSION BRAZING

(71) We, SOCIETE NATIONALE D'ETUDE ET DE CONSTRUCTION DE MOTEURS D'AVIATION, a French Body Corporate, of 2, boulevard Victor 75015 Paris, France, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the joining of parts by diffusion brazing and more particularly relates to the joining of parts having complex shapes.

Joining by diffusion in the solid state, under vacuum and employing a high pressure to hold the parts together, poses problems which limit the application of diffusion. The tolerances with regard to the condition of the surfaces to be joined and the necessary pressures acting on the parts have hitherto prevented the application of the diffusion method to the connection of complex parts.

The technique of welding by diffusion in the solid state has been improved by combining it with brazing techniques. The two operations take place, in general, under vacuum or other non-reactive atmosphere and the metal used for brazing is provided in the form of powder, ribbon, foil, or by deposition. A pressure is applied to the parts to be assembled to enable the flow of the liquid transitory phase and the subsequent formation of a homogeneous connection by diffusion.

The invention envisages the adaption of diffusion brazing to the production of parts of complex shape and to reduce the pressure required for clamping the parts whilst at the same time providing good distribution of the joining metal between the parts.

According to the present invention, there is provided a method of joining metallic parts by diffusion brazing comprising the steps of providing at least one reservoir containing powdered brazing metal in at least one of the surfaces to be joined, providing a layer of brazing metal distinct from the reservoir brazing metal on one of or between the surfaces to be joined, applying pressure to the two parts so that a pressure is also applied to at least a proportion of the surfaces to be joined, placing the assembly of parts in a chamber with a non-reactive atmosphere, heating the assembly within the chamber for a first period to cause the reservoir and layer brazing metal to melt and be distributed between the surfaces and for a second period to cause diffusion of the distributed brazing metal into the said surfaces of the parts, and removing the joined parts from the chamber.

Further according to the present invention there is provided a method of joining metallic parts comprising the steps of providing by a first machining a reservoir or reservoirs in at least one of the surfaces to be joined, locating between the joining surfaces a ribbon or foil of brazing metal or alternatively providing a deposit of brazing metal on at least one of the surfaces to provide a layer between them, filling the reservoir or reservoirs with powdered brazing metal, clamping the parts together by at least one screw incorporated in the parts, placing the assembly of parts in an enclosure with a non-reactive atmosphere, heating the assembly of parts for a first period to cause distribution of the reservoir and layer brazing metal and for a second period to cause diffusion of the brazing metal into the surfaces to be joined and then a second machining to remove the at least one screw and the reservoir or reservoirs.

The invention will now be described by way of example, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a perspective section of one example of a joint to which the method in accordance with the invention is being applied;

Figure 2 shows the joint of Figure 1, again as a perspective section in its completed configuration after secondary machining;

Figure 3 is a section of another joint which can be made by the method in accordance with the invention; and

Figure 4 is a section of the joint of Figure 3 after secondary machining.

The preferred method in accordance with the invention comprises several phases; primary machining, preparation, diffusion brazing and secondary machining.

The primary machining of the parts to be joined consists in providing the necessary shapes for carrying out the method, namely reservoirs and passages for screws enabling the parts to be clamped together. The reservoirs may be provided in one only of the parts in the form of cylindrical or frusto-conical holes or in the form of grooves of rectangular or circular section. The provision of the reservoirs is intended to enable distribution of the brazing metal over the whole area of the surfaces to be joined, any lack of uniformity of the clearance between the surfaces being taken up during the distribution by flow of metal from the reservoir or reservoirs.

The clamping screws have similar coefficients of expansion to the parts to be joined or are of a material possessing a thermal coefficient of expansion lower than that of the parts. The clamping which they provide enables the clamping of the parts as well as good progress of the operation and they are disposed so as to distribute uniformly the pressure over at least a proportion of the surfaces to be joined.

The preparation phase consists in carrying out a deposition on the faces to be joined of one of the parts or, according to the case in question, to prepare a ribbon having the shape of the surfaces to be joined. This ribbon is generally over-dimensioned by from 0.5 to 1 mm, with respect to the surfaces to be joined and its thickness may be varied from several μm to 250μm. This composition may be varied similarly to the variation in the deposit which may be effected by successive layers.

The ribbon or the deposit serve essentially to facilitate the distribution of the joining metal from the reservoir(s). During the melting phase, the joining metal disposed in the reservoir(s) ensures that the joint will be completely filled.

The assembly of parts, held together by screws, is placed in an oven for the diffusion brazing phase. The diffusion brazing is carried out in the oven in a non-reactive atmosphere. The cycle comprises successively the melting phase and the diffusion phase; the temperatures of carrying out these two phases may be different.

After cooling, the joined parts are removed from the oven in order that they can be subjected to secondary machining. This machining enables the elimination of portions of the parts which have served to accommodate the screws and to eliminate, if possible, the reservoirs of joining metal.

The example of Figure 1 shows a joint after preparation and before introduction into the oven for treatment under vacuum.

The joint comprises a circular collar 1 on which there have been secured one or several bosses 2 or other inserts distributed around its periphery. This member of TA5E (collar with bosses) being difficult to manufacture by machining, it appears to be more economic and simpler to secure the bosses, by diffusion brazing, on a part which is readily machinable.

The collar 1 has a U-section. The hollow boss 2 of cylindrical form is shaped on its internal face so as to come into contact with the bottom of the U and comprises two flats 3 and 4 which come into contact with the flanks of the U. It also comprises reservoirs 5 and 6 produced during the primary machining.

The reservoirs 5 are cylindrical holes terminated by a frustrum of a cone of which the larger base has the same diameter as the cylindrical hole, the smaller base serving for the introduction of the powder.

The reservoirs 6 are straight-sided blind grooves formed across the flats of the boss. It is only necessary to provide one groove on condition that it is disposed uppermost when the parts to be joined are laid flat in the treatment oven, since gravity will assist the distribution of the brazing metal from the one groove.

Other types of reservoirs differently located may be provided. For example, it is possible to provide one or several grooves in the lower base of the boss or in the flanges of the collar opposite the flats of the boss.

The shaped ribbon 7 is disposed between the collar 1 and the boss 2 before the parts are engaged in one another. This ribbon has a thickness of 50 μm; it is composed of 70% titanium, 15% copper, 15% nickel with a solidification range of 900 to 940°C. In order to obtain a good filling of the parts to the limit of the mating surfaces, the ribbon is so prepared as to cover the whole of the surfaces to be joined with a peripheral excess of 0.5 to 1 mm.

The ribbon may be replaced by electrolytic deposits on the faces of the boss at which the joint is formed. The coating thus produced is composed of three successive layers of Ni, Cu, Ni respective thicknesses: 3, 6, 3 μm.

The clamping of the parts in position is effected by screws 8 and 9 of which the composition is identical to that of the parts to be assembled. These screws are therefore made of a titanium based alloy with 5% Al and 2.5% Sn designated herein by the code Ta5E.

All the parts are cleaned before engagement one in the other. The reservoirs are filled with atomized powdered metal (Ti 70%, Cu 15%, Ni 15%) before or after such engagement depending upon their accessibility after engagement and then assembly of parts is then introduced into the vacuum treatment oven.

The operation of brazing metal distribution is carried out in two phases comprising two temperature levels each maintained for 15 minutes. The first level is carried out at 870°C and the second at 980°C thus causing the transitory liquid phase to appear which ensures proper distribution of the joining metal over the surfaces. The operation of diffusion brazing is then carried out subsequently at 900°C for two hours.

Figure 2 shows the joined parts after the secondary machining. The latter has effected the removal of the cylindrical reservoirs 5 and the screws 8 and 9. In the embodiment shown by way of example in the Figure, the reservoirs 6 remain.

Figures 3 and 4 show another example for carrying out the invention with the parts likewise of TA5E.

Figure 3 shows a plate 10 on which a flanged sleeve 11 is mounted. A ribbon 12 of brazing metal is disposed between the parts 10 and 11. It has a thickness of 50 μm and a peripheral excess of 0.5 to 1 mm with respect of the surfaces to be assembled.

The foil or ribbon can be replaced by electrolytic deposits of Ni, Cu, Ni effected on the face of the sleeve to be assembled. The various layers have thicknesses respectively of about 3, 6, 3 μm.

A reservoir 13 is formed in the sleeve 11. It is in the form of a frustrum of a cone with the larger base opening into the surface which is to receive the brazing metal. The reservoir is filled with brazing metal in the form of atomized powder composed of Ti 70%, Cu 15%, Ni 15%.

A screw 14, likewise of TA5E, keeps the parts under the necessary pressure for diffusion brazing. As hereinbefore described, the method is carried out at 870°C for 15 minutes then at 980°C for 15 minutes in order to effect the distribution from the reservoir of the transitory connecting liquid phase. The operation of diffusion brazing is then carried out at 900°C for two hours.

The part is shown in Figure 4 after secondary machining. The screws and the reservoir have been removed.

The joining method according to the invention is applicable to simple plane parts as well. It is also possible, in the case of the collar of Figure 1 for example, to secure conforming rectangular bosses provided with the reservoirs in the base of the U of the collar while clamping them together with screws.

The invention is not limited to the developed examples; it is also applicable to the construction of joined part of materials other than titanium and alloys of titanium and applies in particular to steels and super alloys. The term "super alloys" covers austenitic high resistance alloys of which the base is nickel or cobalt.

WHAT WE CLAIM IS:—

1. A method of joining metallic parts by diffusion brazing comprising the steps of providing at least one reservoir containing powdered brazing metal in at least one of the surfaces to be joined, providing a layer of brazing metal distinct from the reservoir brazing metal on one of or between the surfaces to be joined, applying pressure to the two parts so that a pressure is also applied to at least a proportion of the surfaces to be joined, placing the assembly of parts in a chamber with a non-reactive atmosphere, heating the assembly within the chamber for a first period to cause the reservoir and layer brazing metal to melt and be distributed between the surfaces and for a second period to cause diffusion of the distributed brazing metal into the said surfaces of the parts, and removing the joined parts from the chamber.

2. A method according to claim 1, wherein the said pressure is applied by at least one screw incorporated in the parts to be joined.

3. A method according to claim 1, comprising the further step of machining the joined parts after removal from the chamber to remove the reservoir or reservoirs.

4. A method according to claim 2, comprising the further step of machining the joined parts after removal from the chamber to remove the reservoir or reservoirs and also the at least one screw.

5. A method according to claim 2 or claim 4, wherein the or each screw has the same coefficients of expansion as the parts to be joined.

6. A method according to claim 2 or claim 4, wherein the or each screw has an expansion coefficient less than that of the parts to be joined.

7. A method of joining metallic parts comprising the steps of providing by first

machining a reservoir or reservoirs in at least one of the surfaces to be joined, locating between the joining surfaces a ribbon or foil of brazing metal or alternatively providing a deposit of brazing metal on at least one of the surfaces to provide a layer between them, filling the reservoir or reservoirs with powdered brazing metal, clamping the parts together by at least one screw incorporated in the parts, placing the assembly of parts in an enclosure with a non-reactive atmosphere, heating the assembly of parts for a first period to cause distribution of the reservoir and layer brazing metal and for a second period to cause diffusion of the brazing metal into the surfaces to be joined and then a second machining to remove the at least one screw and the reservoir or reservoirs.

8. Joined metal parts when joined by a method according to any one of the preceding claims.

MATHISEN MACARA & CO.,
Chartered Patent Agents,
Lyon House,
Lyon Road,
Harrow,
Middlesex, HA1 2ET.
Agents for the Applicants.

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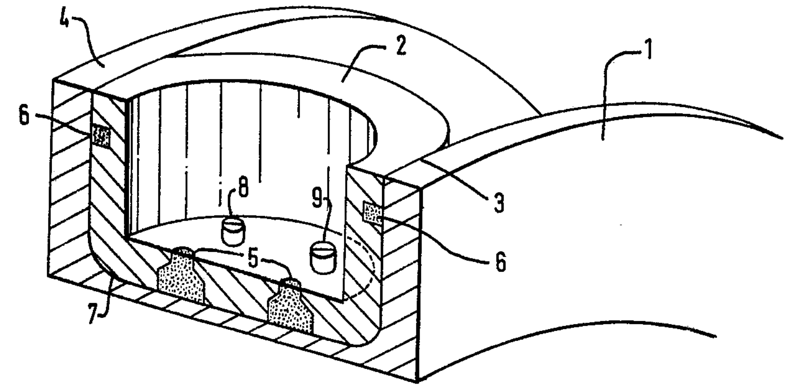

Fig. 1

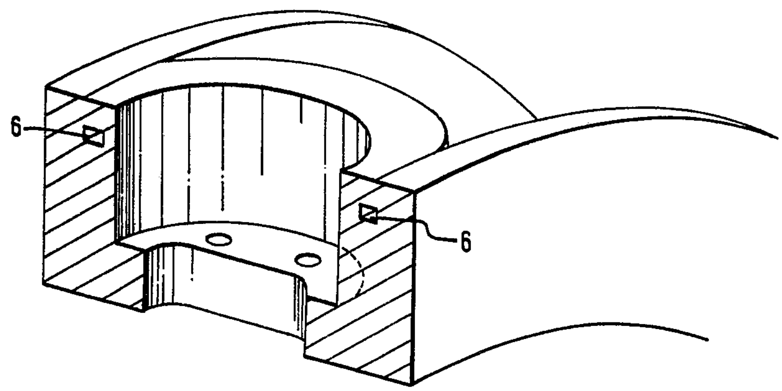

Fig. 2

Fig. 3

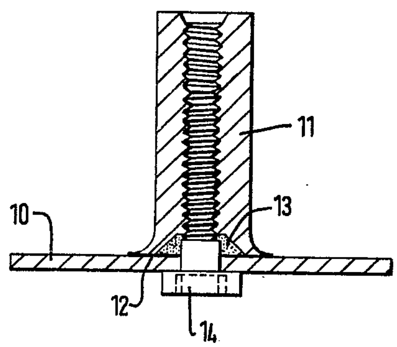

Fig. 4