

Description

The present invention concerns a method for attaching a fibrous ceramic body to a metal substrate.

Superalloys are widely used for high temperature applications especially in the field of gas turbine engines. Such materials have exceptionally good properties at elevated temperatures up to very near their melting point. However the increasing demands for high temperature operation have raised operating temperatures to the point where superalloys are marginal for some required applications.

Ceramic materials are also used in gas turbine engines though only to a limited extent. Ceramics have very high temperature capabilities, but suffer from lack of ductility and lack of toughness in bulk form. This renders them subject to catastrophic brittle failure.

There are problems in joining bulk ceramic parts to metal parts because of the difference in their coefficients of thermal expansion. The coefficient of expansion of metals is much greater than that of ceramics and thus it is difficult to join ceramics to metal without encountering cracking and failure of the ceramic during heating.

Thin ceramic fibers have significant flexibility and it is known to form ceramic fibers into arrays, either random arrays such as a felt or complex woven arrays. Woven arrays may be of a two-dimensional nature such as a cloth, or may be true three-dimensional arrays formed by weaving fibers in three or more directions. Such structures are very interesting and have potentially great value for high temperature applications because of their flexibility and resistance to brittle failure. Woven and nonwoven ceramic fibers arrays find wide application from exotic aerospace applications to mundane applications such as oven gaskets.

The US-A-4338380 discloses a method of making a composite material wherein a solid ceramic member is attached to an alloy plate by means of an intermediate web interface layer.

The DE-A-3622781 discloses a process for joining titanium components by soldering method to a ceramic fibrous material wherein a knitted fabric made of a filament of ceramic material and a titanium wire are used.

Recently a superalloy component in a gas turbine engine, produced by the present assignee, required thermal insulation and it was decided that a woven fiber ceramic structure would be an ideal solution if it could be securely attached to the metallic substrate. To the best of the knowledge of the inventors a durable attachment of a woven ceramic structure to a superalloy substrate, has not previously been accomplished.

Accordingly, it is an object of the invention to teach a method for attaching ceramic fiber arrays, both woven and nonwoven, to metallic substrates.

It is another object of the invention to disclose a metallic substrate having a protective ceramic fiber array affixed firmly thereto.

The method of the present invention is defined according to the characterizing portions of claims 1 and 5 respectively

According to the present invention a ceramic fiber array is modified by adding metallic wires or metallic fibers to one face thereof. By suitably weaving or otherwise mechanically interlocking the wires or fibers to one face of the fiber ceramic array, the fiber ceramic array may be firmly attached to a metallic substrate by brazing the metallic fibers or wires to the array substrate.

The foregoing and other features and advantages of the present invention will become more apparent from the following description and accompanying drawings.

Figure 1 shows a woven fiber ceramic array containing thin metal wires woven into one face thereof.

Figure 2 shows a cross-section through the structure of Figure 1.

Figure 3 shows an alternate structure to that shown in Figure 2.

Figure 4 shows a nonwoven ceramic fiber felt containing thin metal wires woven into one interface thereof.

Figure 5 shows a cross-section through the structure shown in Figure 4.

Figure 6 shows an alternate structure to that shown in Figure 2.

Ceramic fiber arrays are a known article of commerce and may be comprised of a variety of ceramic fibers including for example, alumina, silica, mullite, silicon carbide, boron nitride and the like and mixtures thereof with exemplary fiber diameters of 1-30 microns. One preferred fiber is that sold by 3M Corporation under the name Nextel™ which comprises (by weight) 62% Al_2O_3 , 24% SiO_2 and 14% B_2O_3 and having a fiber diameter of 7-13 microns. These fibers may be woven using conventional weaving technology. Such woven structures are commonly termed two dimensional when they form a cloth type structure and three dimensional when significant amounts of fibers are woven through the thickness of the material. Ceramic fibers are also available in the form of felt which is a nonwoven structure wherein the fibers are randomly arrayed and are sufficiently interlocked and interwoven to provide structural integrity.

Such ceramic fiber arrays in both woven and nonwoven form will have particular utility in the invention in thicknesses from 0.50 to 25.4 mm (0.020 to 1.0 inch) and will usually be employed in

sheet form.

Ceramic fiber articles are used as insulating materials and are commonly adhered or bonded to substrates or to each other by ceramic bonding materials (i.e. cements) or by mechanical retention means. Ceramic fibers are generally not easily wet by metals so bonding techniques such as brazing are not generally successful.

According to the invention a plurality of metal fibers or wires are woven through the ceramic fiber structure with portions of the metal fibers or wires being exposed at one surface of the ceramic fiber structure. When done under proper conditions the fiber layer with exposed metal constituents can be brazed to a metallic substrate.

In one embodiment of the invention an existing ceramic fiber structure can have a plurality of fine wires woven into one surface thereof. This can be done by hand in small quantities or by machine. Metallic wires for example on the order of 10 mils in diameter of suitable materials such as Chromel™ (90% Ni, 10% Cr) a trademark of the Hoskins Mfg. Co. or Nichrome™ (80% Ni, 20% Cr) a trademark of the Driver-Harris Wire Co., can be woven through an existing fiber structure and can provide points of exposed wire on one surface ranging from about 3 to about 15 per linear inch. Once the wire weaving is complete the ceramic structure with the interwoven wires can be brazed to the desired metallic substrate using an appropriate braze material.

Since the ceramic fiber will usually be applied for thermal insulation it is generally important that the interwoven wires not penetrate or approach the surface of the ceramic which will be exposed to high service temperatures. Depending on the exact operating conditions and the brazing material used if the wires penetrate the surface which is to see the high temperatures sufficient heat can be conducted through the wires to the brazed substrate to weaken the braze joint and cause failure. Accordingly it is generally desired that the wires are maintained in the half of the thickness of the ceramic fiber array which will be adjacent to the substrate to which bonding is desired.

The fine wire can have long and continuous lengths wherein a single length of wire provides multiple points of exposure for brazing. Alternatively short sections of wire can be woven through the ceramic (for example resembling staples) so that each short section of wire comprises only a single or few contact points.

Another embodiment of the invention comprises weaving metallic fibers into the ceramic fiber array during array fabrication. In this case the metallic fibers will usually be smaller in diameter than the wires used in the previous embodiment and more numerous and will therefore provide from 4 to

40 contact points per cm (10 to 100 contact points per linear inch) for brazing. Again in this embodiment it is generally desirable to limit the metallic fibers to the half of the ceramic fiber array which is adjacent the metal substrate.

In the case of ceramic felt, the felt can be fabricated in a layered fashion with metallic fibers being present only adjacent one free surface. Alternately a plurality of separate felts can be fabricated with one of the felts having a concentration of metallic fibers and these felts can then be joined together by stitching or with ceramic fibers or other techniques known in the art.

Figure 1 shows an embodiment of the present invention. Shown in Figure 1 is a metallic substrate 10 having on one surface a layer of braze material 12 located on the braze material 12 is a woven structure 14 shown as a plurality of layers 16. Woven into the woven structure 14 are a plurality of fine wires shown as 18 where these wires project cut the expose surface in contact with the braze layer 12. Figure 2 is a sectional view through Figure 1 showing in greater detail the substrate layer 10, braze layer 12, the undulating wire 18 which projects from the surface of the woven ceramic structure 14 and makes contact with the braze layer 12. It can be seen in Figure 2 that the wire 18 is firmly attached to the substrate 10 by the layer of braze material 12 and that the rest of the ceramic fiber structure 14 is mechanically interlocked by the wire 18 and held firmly to the substrate-braze layer 10/12. Figure 3 is an alternate embodiment to that shown in Figure 2 wherein in place of a wire 18 as shown a plurality of fine metal fibers 19 which are interwoven with a portion 20 of the woven ceramic structure 14.

The teachings illustrated in Figures 4, 5 and 6 are analogous to those Figures 1, 2 and 3 except that instead of being a woven structure the structure in Figures 4, 5 and 6 is a ceramic felt.

We prefer to cut the ceramic fiber arrays using a high power laser, for example a CO₂ laser, since this fuses the fiber ends and reduces fraying and fiber loss during handling, fabrication, and in service.

The bonded metallic substrate-ceramic fiber arrays of the invention have primary application for thermal insulation.

Although this invention has been shown and described with respect to detailed embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail thereof may be made without departing from the scope of the claimed invention, as defined in the claims.

Claims

1. A method for attaching a fibrous ceramic body (14) to a metal substrate (10) characterized in that it comprises:
weaving a plurality of metal wires (18) through the fibrous body (14) with at least a portion of the woven metal wires (18) being exposed at one face of the fibrous body (14), and brazing the exposed wire portions to the metal substrate (10).
2. A method as in claim 1 characterized in that the ceramic fibrous body (14) is a woven structure.
3. A method as in claim 1 characterized in that the ceramic fibrous body (14) is a randomly oriented structure.
4. A method as in claim 1 characterized in that the woven metal wires (18) are located only in that portion of the ceramic fibrous body (14) which is adjacent the metal substrate (10).
5. A method for attaching a fibrous ceramic body (14) to a metallic substrate (10) characterized in that it comprises:
weaving a plurality of metal fibers (19) into the ceramic fibrous body (14) during its fabrication and brazing the multiple ceramic fibers to the metallic substrate (10).
6. A method as in claim 5 characterized in that the ceramic fibrous body (14) is a woven structure.
7. A method as in claim 5 characterized in that the ceramic fibrous body (14) is a randomly oriented ceramic felt.
8. A method as in claim 5 characterized in that the metal fibers (19) are located only in that portion of the ceramic fibrous body which is adjacent to metallic substrate.

Patentansprüche

1. Verfahren zum Befestigen eines Faserkeramikkörpers (14) an einem Metallsubstrat (10), dadurch gekennzeichnet, daß es umfaßt: Weben einer Vielzahl von Metalldrähten (18) durch den Faserkörper (14), wobei wenigstens ein Teil der gewebten Metalldrähte (18) an einer Seite des Faserkörpers (14) freiliegt, und Hartverlöten der freiliegenden Drahtteile mit dem Metallsubstrat (10).

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der Keramikfaserkörper (14) ein gewebtes Gebilde ist.
3. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der Keramikfaserkörper (14) ein willkürlich ausgerichtetes Gebilde ist.
4. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die gewebten Metalldrähte (18) nur in demjenigen Teil des Keramikfaserkörpers (14) angeordnet werden, der dem Metallsubstrat (10) benachbart ist.
5. Verfahren zum Befestigen eines Faserkeramikkörpers (14) an einem metallischen Substrat (10), dadurch gekennzeichnet, daß es umfaßt: Weben einer Vielzahl von Metalldrähten (19) in den Keramikfaserkörper (14) während dessen Fabrikation und Hartverlöten der mehreren Keramikfasern mit dem metallischen Substrat (10).
6. Verfahren nach Anspruch 5, dadurch gekennzeichnet, daß der Keramikfaserkörper (14) ein gewebtes Gebilde ist.
7. Verfahren nach Anspruch 5, dadurch gekennzeichnet, daß der Keramikfaserkörper (14) ein willkürlich ausgerichteter Keramikfilz ist.
8. Verfahren nach Anspruch 5, dadurch gekennzeichnet, daß die Metallfasern (19) nur in demjenigen Teil des Keramikfaserkörpers angeordnet werden, der dem metallischen Substrat benachbart ist.

Revendications

1. Procédé pour attacher un corps de céramique fibreux (14) à un substrat métallique (10) caractérisé en ce qu'il comprend:
tisser une pluralité de fils métalliques (18) au travers du corps fibreux (14) avec au moins une partie des fils métalliques tissés (18) étant exposés à une face du corps fibreux (14), et braser les parties des fils exposés au substrat métallique (10).
2. Procédé selon la revendication 1, caractérisé en ce que le corps de céramique fibreux (14) est une structure tissée.
3. Procédé selon la revendication 1, caractérisé en ce que le corps de céramique fibreux (14) a une structure orientée au hasard.



4. Procédé selon la revendication 1 caractérisé en ce que les fils métalliques tissés (18) sont positionnés seulement dans cette partie du corps de céramique fibreux (14) qui est adjacente au substrat métallique (10). 5
5. Procédé pour attacher un corps de céramique fibreux (14) à un substrat métallique (10) caractérisé en ce qu'il comprend:
tisser une pluralité de fibres métalliques (19) dans le corps de céramique fibreux (14) pendant sa fabrication et braser les fibres de céramique multiples au substrat métallique (10). 10 15
6. Procédé selon la revendication 5 caractérisé en ce que le corps de céramique fibreux (14) est une structure tissée.
7. Procédé selon la revendication 5 caractérisé en ce que le corps de céramique fibreux (14) est un feutre de céramique orienté au hasard. 20
8. Procédé selon la revendication 5 caractérisé en ce que les fibres métalliques (19) sont positionnées seulement dans cette partie du corps de céramique fibreux qui est adjacente au substrat métallique. 25

30

35

40

45

50

55

5

