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DISSIMILAR METAL WELDED JOINT WITH PROTECTIVE OVERLAY

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FIG. 1

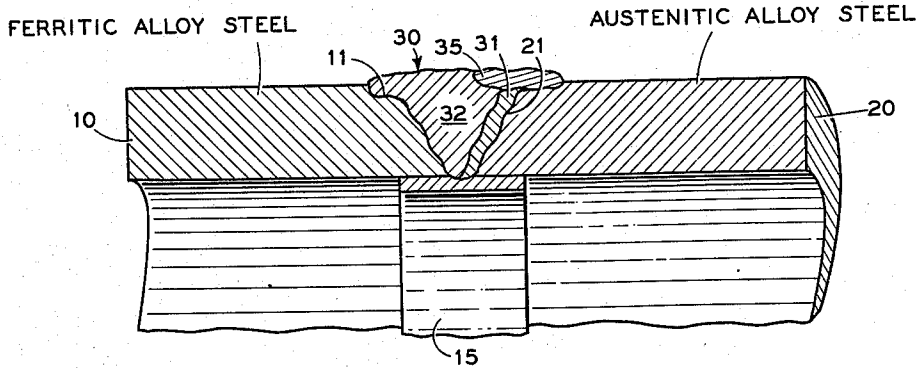


FIG. 2

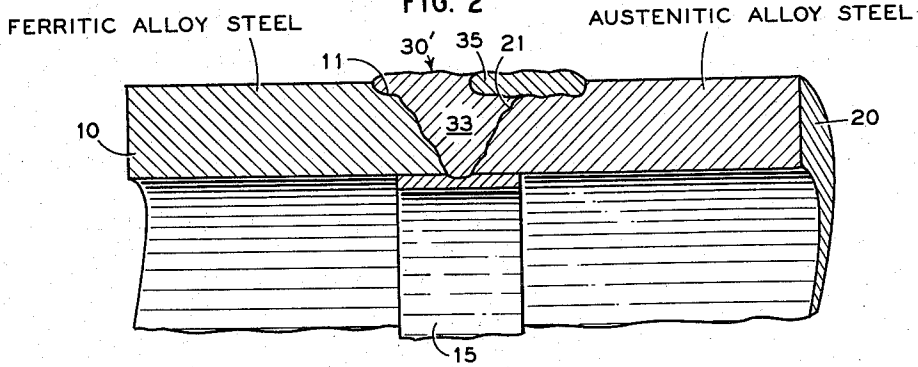
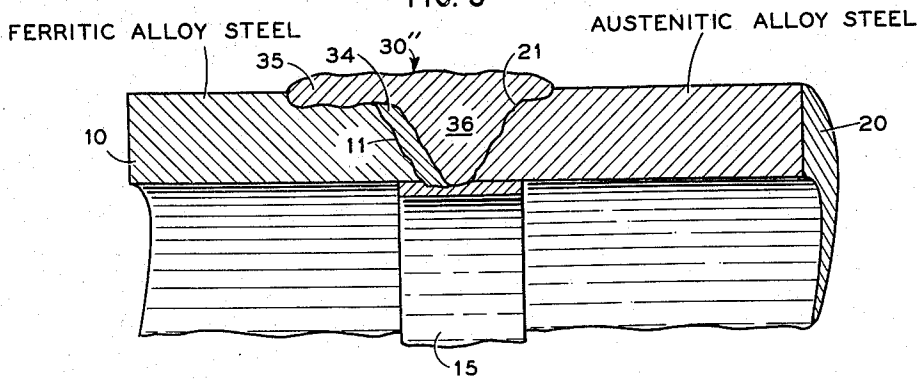


FIG. 3



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DISSIMILAR METAL WELDED JOINT WITH PROTECTIVE OVERLAY

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7 Claims. (Cl. 189—36)

This invention relates to the production of a welded joint between austenitic and ferritic materials suitable for high temperatures, high pressure service under conditions involving thermal shock and cyclic temperature and load applications.

Such conditions are encountered in high temperature process plants such as, for example, oil refineries, in vapor or steam generators, and in heat exchangers of various types. The particular problems in any one type of installation may differ in one or more aspects from those in another type. Thus, refineries involve high temperatures but only moderate pressures, in conjunction with alternating oxidation and reducing conditions, corrosive environments and the like. In steam generators a more complex stress condition exists due to the combined actions of high operating pressures and high operating temperatures, which are further aggravated by cyclic variations in these factors. While the invention is of general application under high temperature, high stress conditions in any type of installation, particular reference will be made, by way of example only, to the high temperature and high stress conditions encountered in steam generators.

In order to obtain higher efficiencies, the outlet steam temperatures and the operating pressures of central station steam generators have been constantly increasing, and presently some central station steam generating units have outlet temperatures of 1050° F. and operating pressures of over 2000 p.s.i. The increasing use of such high temperatures and pressures has brought with it problems of providing materials and joints between such materials which will successfully withstand the stresses encountered thereat.

The long time load carrying characteristics of metals at high temperatures, together with the economics involved, have led steam generator designers to use both austenitic and ferritic materials for the outlet components of the steam generators. For example, both types of material may be used in the superheater and its supports, and in the main steam line from the generator to the turbine. Use of both types of materials in the same component requires that particular attention be given to the junctions between these materials, which junctions must operate under the particular temperature and stress conditions encountered in producing steam at relatively high temperatures. In a superheater, for example, the external surface and the superheater support lugs are at a higher temperature than the internal surface of the superheater tubes, due to the higher temperatures of the heating gases as compared to the temperature of the steam flowing through the superheater. The reverse is true with respect to the steam line leading to the turbine.

Operation under stress at such high temperatures introduces many problems due to the differential expansion and contraction of the dissimilar materials on either side of the joint, their relative surface and structural stability, etc. Aside from mechanical stresses, such as, for example, those due to differential thermal expansion and con-

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traction, the factors influencing the service life of welded joints between ferritic and austenitic materials have been basically of a metallurgical nature, such as carbon depletion in the heat affected zone of the ferritic material, notching due to oxide penetration occurring therein, micro-fissuring in the weld junction, and accelerated creep due to these conditions. Examples of joints between ferritic and austenitic materials, with which these problems are encountered, are the joining of a ferritic alloy having substantially 2¼% chromium to an austenitic alloy of the "18-8" or "25-20" type.

The present invention is particularly directed to the production of a welded joint, between austenitic and ferritic materials, which has the requisite strength, ductility, and oxidation resistance to assure satisfactory performance under conditions of high stresses occasioned by thermal shock, cyclic temperature and load application, and differential thermal expansion. It has been found that these objectives can be obtained by weld uniting a low alloy ferritic member to an austenitic member by a weld deposit which is carbide-stabilized, has an oxidation resistance which is higher than that of the ferritic member, and a coefficient of thermal expansion intermediate the coefficients of thermal expansion of the two members, the weld deposit including an overlying heat resistant oxygen barrier. The welded joint is a composite deposit of two or more metals, at least one of which is a carbide-stabilized and oxidation-resistant ferritic metal and at least one more of which is an austenitic, heat-and-oxidation-resistant metal.

In one embodiment of the invention, the weld groove forming surface of the austenitic member is "battered" with a carbide-stabilized, ferritic metal having an oxidation resistance higher than that of the ferritic member. The remainder of the weld groove is then filled with a ferritic metal of substantially the same composition as that of the ferritic member, and which may be carbide-stabilized. At least the ferritic-austenitic junction of the welded joint is then covered with a weld deposit overlay of an austenitic heat-resisting metal having a heat expansion coefficient which is intermediate the heat expansion coefficients of the two base members.

In another embodiment, the weld groove between the ferritic and austenitic base members is filled with a carbide-stabilized, ferritic metal having a higher oxidation resistance than that of the ferritic base member. At least the ferritic-austenitic junction of the welded point is then provided with substantially the same overlay as in the first embodiment.

In a further embodiment, the weld groove forming surface of the ferritic member is "battered" with a carbide-stabilized, ferritic metal having an oxidation resistance higher than that of the ferritic member. The remainder of the weld groove is then filled with an austenitic, heat-resisting metal having a coefficient of thermal expansion intermediate those of the base members, the weld deposition of this latter metal being continued to form an overlay thereof across the ferritic-austenitic junction.

For a more complete understanding of the invention principles, reference is made to the following description of a typical embodiment thereof as illustrated in the accompanying drawings.

In the drawings:

Figs. 1, 2 and 3 are partial transverse sectional views of welded points, each weld uniting a low alloy ferritic base member to an austenitic base member, and embodying the invention.

In the following description of the invention, the term "ferritic alloy" is used to designate alloys having compositions such as carbon—0.5% molybdenum, 2% Cr—0.5% Mo, 2¼% Cr—1% Mo, 5% Cr—0.5% Mo, or

similar predominantly ferritic alloy steels. Similarly, the term "austenitic alloy" refers to alloys known to those skilled in the art as "18-8" (18 Cr-8 Ni), "18-8 Cb," "18-8 Ti," "25-12," "25-20," or any other alloy steel which is predominantly austenitic in structure.

Referring to Fig. 1 of the drawing, a predominantly ferritic alloy steel workpiece 10, such as a pressure tube or pipe, is illustrated as weld united to a predominantly austenitic alloy steel workpiece 20, such as a pressure tube or pipe, by a fusion deposited, carbide-stabilized, welded joint 30 having an oxidation resistance which is higher than that of member 10 and a coefficient of thermal expansion intermediate the corresponding coefficients of members 10 and 20, joint 30 including an overlying heat-resistant oxidation barrier 35. By way of example only, ferritic member 10 may be an alloy steel containing 2¼% chromium and 1% molybdenum, this steel being known commercially as "Croloy 2¼," and austenitic member 20 may be an 18-8-Ti alloy steel. The facing end surfaces of members 10 and 20 are suitably bevelled, as at 11 and 21, respectively, to form a weld groove, a backing member 15 being arranged to bridge the open lower end of the welding groove.

In this embodiment of the invention, the weld groove forming surface 21 of austenitic alloy steel member 20 is first "battered" with a fusion deposit 31 of carbide-stabilized ferritic metal having an oxidation resistance higher than that of ferritic alloy steel member 10. This deposit or layer 31 resists carbon migration, due to its being carbide-stabilized, and also resists oxidation at the relatively high and cyclically varying working temperatures to which joint 30 is exposed in practice. If, by way of example, member 10 is a low alloy steel containing 2¼% Cr and 1% Mo or 3% Cr and 1% Mo, the metal deposited to form buttering layer 31 may be a 5% Cr-0.5% Mo alloy steel stabilized with Cb (a 5 Cr-5 MoCb steel).

The remainder of the weld groove between surface 11 of member 10 and layer 31 is then filled with a fusion deposit 32 of ferritic alloy steel having about the composition of member 10. In the specific example given, deposit 32 may be a 2¼% Cr-1% Mo ferritic alloy steel. Deposit 32 may also be of carbide-stabilized ferritic alloy steel such as 2¼% Cr-1% Mo-Cb alloy steel, for example.

As the final step in forming the welded joint or weld deposit 30, the protective overlay 35 is fusion deposited at least across the ferritic-austenitic junction, which latter is the junction of battered layer 31 and surface 21 of member 20. This weld overlay is deposited of an austenitic heat resisting steel alloy having a coefficient of thermal expansion intermediate the corresponding coefficients of members 10 and 20.

A suitable austenitic steel alloy for overlay 35 is a 25 Cr-20 Ni steel, for example, or a 77 Ni-15 Cr steel known as "Inconel." Another suitable austenitic steel is an 80 Ni-20 Cr steel. In the specific welded joint given by way of example, the coefficients of thermal expansion, from room temperature to 1200 F., are 7.69×10^{-6} , for the "Croloy 2¼" member 10, and 10.41×10^{-6} for the 18-8-Ti member 20. The corresponding coefficient for a 25 Cr-20 Ni overlay is 9.20×10^{-6} , which is intermediate the coefficients of the base members 10 and 20.

The heat resistant overlay 35 protects the relatively vulnerable ferritic-austenitic junction (21-31) from the extreme effects of cyclically varying elevated temperatures during service. As the expansion of the overlay, with change in temperature, is intermediate the expansions of members 10 and 20, the tendency of the joint to fail due to differential thermal expansion of the base members is substantially eliminated. Welded joints between dissimilar metal members, including overlay 35, have a life as much as five times the life of corresponding joints without the overlay, when subjected to cyclically varying elevated temperatures.

In the embodiment of Fig. 2, the entire welding groove is filled with a fusion deposit 33 of carbide stabilized ferritic metal having an oxidation resistance higher than that of ferritic alloy steel member 10. By way of example, deposit 33 may be the 5 Cr-5 Mo-Cb ferritic steel useful for the buttering layer 31 of Fig. 1. Deposit 33 resists carbon migration, due to its carbide stabilization by the Cb, and resists oxidation at the relatively high and cyclically varying temperatures to which the joint is subjected in service.

At least the ferritic-austenitic junction (21-33) is then covered with the fusion deposited overlay 35 in the same manner as in the embodiment of Fig. 1. Overlay 35 may be one of the same heat resistant austenitic alloys as used in forming the overlay 35 of Fig. 1.

In the embodiment of Fig. 3, the weld groove forming surface 11 of ferritic member 10 is first battered with a fusion deposit 34 of a carbide-stabilized ferritic alloy, such as the 5 Cr-5 Mo-Cb steel previously mentioned. The remainder of the weld groove is then filled with a fusion deposit of an austenitic, heat resisting, steel alloy having a coefficient of thermal expansion intermediate those of members 10 and 20. For example, this may be the 25 Cr-20 Ni austenitic steel alloy, or the "Inconel" alloy, previously mentioned. The deposit 36 is continued to form the overlay deposit 35 so that the austenitic-ferritic junction 34-36 is covered by such heat resistant austenitic steel alloy.

The carbide-stabilized ferritic alloy steel deposit having higher oxidation resistance than that of the ferritic alloy steel member 10—such as deposits 31, 33 and 34—may, in general, have a higher chromium or silicon content than those of member 10, and may also have a slightly lower coefficient of thermal expansion. While this is less favorable than would be the case with a coefficient of thermal expansion somewhat higher than that of member 10, the slight decrease is insignificant and is out-balanced by the higher oxidation resistance. The combination of the carbide-stabilized and higher oxidation resistance deposit with the oxygen barrier over the dissimilar junction provides an effective safeguard against stress-oxidation or stress-oxidation-fatigue cracking.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the invention principles, it should be understood that the invention may be otherwise embodied without departing from such principles.

What is claimed is:

1. A composite welded assembly having an extended service life when subjected to cyclically varying elevated temperatures of the order of 1100 F. and higher, said assembly comprising, in combination, a ferritic alloy steel member having a weld groove forming surface; an austenitic alloy steel member having a weld groove forming surface; and a fusion welded joint uniting said members comprising a fusion weld deposit fused to both of said surfaces and including a fusion weld section of a carbide stabilized ferritic alloy steel having an oxidation resistance higher than that of said ferritic steel member, and a fusion weld section of a heat and oxidation resistant austenitic alloy steel; said ferritic alloy steel section of said deposit being fused to at least one of said surfaces and said austenitic alloy steel section of said deposit being fused to said ferritic alloy steel section of said deposit and overlying and overlapping the ferritic-austenitic junction of said assembly.

2. A composite welded assembly having an extended service life when subjected to cyclically varying elevated temperatures of the order of 1100 F. and higher, said assembly comprising, in combination, a ferritic alloy steel member having a weld groove forming surface; an austenitic alloy steel member having a weld groove forming surface; and a fusion welded joint uniting said members comprising a fusion weld deposit fused to both of said surfaces and including a fusion weld section of a carbide

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stabilized ferritic alloy steel having an oxidation resistance higher than that of said ferritic alloy steel member, and a fusion weld section of a heat and oxidation resistant austenitic alloy steel having a coefficient of thermal expansion intermediate those of said members; said ferritic alloy steel section of said deposit being fused to at least one of said surfaces and said austenitic alloy steel section of said deposit being fused to said ferritic alloy steel section of said deposit and overlying and overlapping the ferritic-austenitic junction of said assembly.

3. A composite welded assembly having an extended service life when subjected to cyclically varying elevated temperatures of the order of 1100 F. and higher, said assembly comprising, in combination, a ferritic alloy steel member having a weld groove forming surface; an austenitic alloy steel member having a weld groove forming surface; and a fusion welded joint uniting said members comprising a fusion weld deposit fused to both of said surfaces and including a fusion weld section of a carbide stabilized ferritic alloy steel having an oxidation resistance higher than that of said ferritic alloy steel member, and a fusion weld section of a heat and oxidation resistant austenitic alloy steel having a coefficient of thermal expansion intermediate those of said members; said ferritic alloy steel section of said deposit being fused to said austenitic alloy steel member surface and said austenitic alloy steel section of said deposit being also fused to said austenitic alloy steel member surface and overlying and overlapping the ferritic-austenitic junction of said assembly.

4. A composite welded assembly as claimed in claim 1

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in which said ferritic alloy steel section of said deposit is deposited against the groove forming surface of said austenitic member; and including a fusion deposit of a ferritic alloy steel, of substantially the same composition as the ferritic alloy member, deposited between said first deposit and the groove forming surface of said ferritic member.

5. A composite welded assembly as claimed in claim 1 in which said ferritic alloy steel section of said deposit is deposited against the groove forming surfaces of both of said members.

6. A composite welded assembly as claimed in claim 2 in which the fusion weld deposit further includes a fusion weld section of a ferritic alloy steel having substantially the same composition as said ferritic member.

7. A composite welded assembly as claimed in claim 3 in which said weld deposit further includes a fusion weld section of a ferritic alloy steel having substantially the same composition as said ferritic member.

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