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AUSTENITIC CHROMIUM NICKEL STEEL ALLOY

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Experience has shown that austenitic chromium nickel steel alloys thus far used for corrosion-resting material cease to be resistant against attack by chemical agents, lose their metallic ring, become brittle, and finally even crumble to metal powder when they are exposed to a heat treatment comparable to a drawing treatment of approximately between 500° to 900° C., as, for instance, in welding together of individual structural sections or in use, as for instance, in a process of hydrogenation. It has already been proposed with considerable success that for the purpose of making articles of austenitic chromium nickel steel alloys which either in their manufacture or use are exposed to a temperature comparable to a drawing treatment, austenitic chromium nickel steel alloys should be used whose carbon content is below 0.07% or which contain singly or together elements such as titanium or vanadium which form stable chemical combinations with carbon, the relation between titanium, respectively vanadium, to the carbon being preferably such that practically the entire carbon enters into the inter-combination with the added elements.

I have found that it is not only the type of chromium nickel steel alloys having a stable surface that is to say, austenitic chromium nickel steel alloys which either have a carbon content of less than about 0.07% or contain, for example, titanium, and/or vanadium which have the advantage that they do not lose their resistance to corrosive agents and do not become brittle when in manufacture or use they are exposed to temperatures comparable to drawing treatments of about 500° to 900° C., but that this advantage is also inherent in austenitic chromium nickel steel alloys which contain one or more of the elements columbium (niobium) and tantalum. These elements also, as has been proven, form such a stable chemical combination with the carbon in solution in the austenitic base mass that the chemical and mechanical stability of the alloy is not affected for practical purposes after a heat treatment of about 500° to 900° C. In these cases, as in the case of titanium and vanadium, it is also advantageous to establish such a relation of the stated alloy components with respect to the carbon that practically the entire amount of carbon is bound to the added alloy components. Tests with chromium nickel steel alloys having a stable surface and containing about 0.17% carbon, 8% nickel, 18% chromium, 1.3% tantalum plus columbium, show that such alloys still preserve their resistance to corrosive attack and do not become brittle when they have experienced heating to about 500° to 900° C.

It is especially advantageous to use as the added alloy component one or both of the elements columbium and tantalum, since these elements not only combine with the carbon in a manner which does not deleteriously affect the chemical and mechanical stability of the alloy but they furthermore result in particularly good welding conditions. The loss due to burning off of the elements columbium and tantalum during welding is only very small and in fact smaller than that of other elements such as zirconium, uranium, hafnium, cerium, thorium, lanthanum, yttrium, neodymium, samarium, or other rare earth metals, any one or more of which may be used with columbium or tantalum, or both, to effect the purpose of my invention, as the advantage of my invention is, at least to a certain extent, inherent also in the use of such other elements.

The iron content of the alloys forming the subject-matter of the invention may be as low as 50%, or even lower.

The chromium content of the alloy may be of the order of approximately 12% to 40%, the nickel content of the alloy may be of the order of approximately 7% to 25%, while the carbon content is preferably less than 1%. In the preferred embodiment of the invention, the alloy contains about 18% chromium, 8% nickel, between .07% and .2% carbon, and columbium or tantalum, or a mixture of these elements, about .3% to 2.5%. The added element or elements may be used up to 10%, and should be present in amounts at least sufficient to bind practically all the carbon contained in the alloy.

Austenitic chromium nickel steel alloys, of the type to which the present invention relates, are in themselves well known and, as ordinarily used, contain about 12%–30% chromium (preferably in the neighborhood of 18%), about 7% to 25% nickel (preferably in the neighborhood of 8%), carbon from about .07% to about .2%, and iron, constituting substantially the entire balance (with the exception of normal impurities), the iron being substantially all in the gamma form.

One of the principal uses of these alloys is in the production of chemical apparatus of various types, in which sheets or plates, made of the alloy, are united by fusion welding. These alloys, however, if exposed to elevated temperatures of the approximate range of 500° to 900° C., for instance by uniting individual parts thereof by fusion welding, and then exposed to corrosive conditions, become liable to intergranular corrosion. If they are exposed, for any appreciable length of time, to such temperature range, chromium carbides will precipitate therein, robbing the grain boundaries of their protective chromium, thus permitting intergranular corrosion to occur. The temperaure range specified may therefore be termed the "carbide precipitation range". The difficulty caused by the formation of these carbides, could be cured, as was known, by reheating the metal to a temperature of 1000° C. or higher, and then rapidly cooling it. Such a process is, however, impracticable, if not impossible, with larger articles, not only because it is difficult, or impossible to heat them to the necessary high temperature, and then to cool them rapidly, but also because of the liability of distortion of the article, by its own weight, while the metal is in a softened condition.

It should be kept in mind that my invention includes articles made of austenitic chromium nickel steel alloys, to which have been added columbium or tantalum, or both, as equivalent substances, for the purpose of combining with substantially all of the carbon present, so that the carbon will not be able to combine with the chromium, thus preventing intergranular corrosion when the alloy is subjected to the temperature range (carbide precipitation range) specified, without being thereafter necessarily further heat treated. By way of example, my alloys will thus, even on prolonged heating at a temperature such as 500° C., lessen materially loss of corrosion resistance.

The alloys, containing one or both of these addition materials, may therefore, as hereinabove stated, be used in the manufacture of metal articles, including fusion welded articles, which, in their normal use, are subjected to active corrosive influences, while the metal in at least a part thereof is in a condition resulting from heating, for instance, by fusion welding, at ranges within the carbide precipitation range, without the necessity of curing, that is, without subsequent heating at substantially higher temperatures (and then rapidly cooling); and such articles will nevertheless be resistant to corrosive influences, that is, will not be subject to intergranular corrosion.

Any departure from the proportions specified in my claims which may, however, result in an alloy which exhibits the advantages of my invention, even though in a less effective manner, would still be within the spirit of my invention, and of the scope of my claims.

Articles made of the alloy hereinabove described containing zirconium as the addition material. are claimed in my divisional application Ser. No. 227,689, issued May 2, 1939, as Patent No. 2,157,060.

I claim:

1. A corrosion-resisting steel alloy containing about 12% to 30% chromium, about 7% to 25% nickel, carbon in appreciable quantity but less than 1%, and an additional material acting to lessen materially loss of corrosion resistance on prolonged holding at 500° C., in an amount sufficient to combine with substantially all of the carbon but not in excess of 10%, the balance being substantially all iron, such additional material consisting substantially all of columbium.

2. A corrosion-resisting steel alloy containing about 12% to 30% chromium, about 7% to 25% nickel, about 0.07% to 0.2% carbon, and from 0.3% to 2.5% of an additional material acting to lessen materially loss of corrosion resistance on prolonged holding at 500° C., the balance substantially all iron, said additional material consisting substantially all of columbium.

3. A corrosion-resisting steel alloy containing about 18% chromium, about 8% nickel, .07% to .2% carbon and from .3% to 2.5% of an additional material acting to lessen materially loss of corrosion resistance on prolonged holding at 500° C., the balance substantially all iron, said additional material consisting substantially all of columbium.

4. A fusion welded article composed of an austenitic corrosion resisting steel alloy containing about 12% to 30% chromium, about 7% to 25% nickel, carbon in appreciable quantity but less than 1%, and an additional material in amount sufficient to combine with substantially all of the carbon but not in excess of 10%, said additional material being at least one of the elements of the group consisting of columbium and tantalum, the balance being substantially all iron.

5. A fusion welded article composed of an austenitic corrosion resisting steel alloy containing about 12% to 30% chromium, about 7% to 25% nickel, about .07% to .2% carbon, and about .3% to 2.5% of an additional material acting to lessen materially loss of corrosion resistance, the balance being substantially all iron, said additional material being at least one of the elements of the group consisting of columbium and tantalum.

6. A fusion welded article composed of an austenitic corrosion resisting steel alloy containing about 18% chromium, about 8% nickel, about .07% to .2% carbon, and about .3% to 2.5% of an additional material acting to lessen materially loss of corrosion resistance, the balance being substantially all iron, said additional material being at least one of the elements of the group consisting of columbium and tantalum.

7. A fusion-welded article composed of an austenitic corrosion-resisting steel alloy containing about 12% to 30% chromium, about 7% to 25% nickel, carbon in appreciable quantity but less than 1%, and an additional material in an amount sufficient to combine with substantially all of the carbon but not in excess of 10%, the balance being substantially all iron, said additional material consisting substantially all of columbium.

8. A fusion-welded article composed of an austenitic corrosion-resisting steel alloy containing about 12% to 30% chromium, about 7% to 25% nickel, about 0.07% to 0.2% carbon, and from 0.3% to 2.5% of an additional material acting to lessen materially loss of corrosion resistance, the balance substantially all iron, said additional material consisting substantially all of columbium.

9. A fusion-welded article composed of an austenitic corrosion-resisting steel alloy containing about 18% chromium, about 8% nickel, 0.07% to 0.2% carbon, and from 0.3% to 2.5% of an additional material acting to lessen materially loss of corrosion resistance, the balance substantially all iron, said additional material consisting substantially all of columbium.

10. A fusion-welded article composed of an austenitic corrosion-resisting steel alloy containing about 12% to 30% chromium, about 7% to 25% nickel, carbon in appreciable quantity but less than 1%, and an additional material in an amount sufficient to combine with substantially all of the carbon but not in excess of 10%, the

balance being substantially all iron, said additional material consisting substantially all of tantalum.

11. A fusion-welded article composed of an austenitic corrosion-resisting steel alloy containing about 12% to 30% chromium, about 7% to 25% nickel, about 0.07% to 0.2% carbon, and from 0.3% to 2.5% of an additional material acting to lessen materially loss of corrosion resistance, the balance substantially all iron, said additional material consisting substantially all of tantalum.

12. A fusion-welded article composed of an austenitic corrosion-resisting steel alloy containing about 18% chromium, about 8% nickel, 0.07% to 0.2% carbon, and from 0.3% to 2.5% of an additional material acting to lessen materially loss of corrosion resistance, the balance substantially all iron, said additional material consisting substantially all of tantalum.

13. A fusion-welded article composed of an austenitic corrosion-resisting steel alloy containing about 12% to 30% chromium, about 7% to 25% nickel, carbon in appreciable quantity but less than 1%, and an additional material in an amount sufficient to combine with substantially all of the carbon but not in excess of 10%, the balance being substantially all iron, said additional material consisting substantially all of columbium and tantalum.

14. A fusion-welded article composed of an austenitic corrosion-resisting steel alloy containing about 12% to 30% chromium, about 7% to 25% nickel, about 0.07% to 0.2% carbon and from 0.3% to 2.5% of an additional material acting to lessen materially loss of corrosion resistance, the balance substantially all iron, said additional material consisting substantially all of columbium and tantalum.

15. A fusion-welded article composed of an austenitic corrosion-resisting steel alloy containing about 18% chromium, about 8% nickel, 0.07% to 0.2% carbon, and from 0.3% to 2.5% of an additional material acting to lessen materially loss of corrosion resistance, the balance substantially all iron, said additional material consisting substantially all of columbium and tantalum.

16. A metal article which, in its normal use, is subjected to active corrosive influences while the metal in at least part of the article is in a condition resulting from heating at ranges within the carbide precipitation range (approximately 500° to 900° C.) without subsequent heating at substantially higher temperatures, said article being resistant to said corrosive influences and composed of a corrosion-resisting austenitic steel alloy, the iron of which is substantially all in the gamma form, containing about 12% to 30% chromium, about 7% to 25% nickel, carbon in appreciable quantity but less than 1%, and columbium in an amount sufficient to combine with substantially all of the carbon but not in excess of 10%, the balance being substantially all iron.

17. A metal article which in its normal use is subjected to active corrosive influences while the metal in at least part of the article is in a condition resulting from heating at ranges within the carbide precipitation range (approximately 500° to 900° C.) without subsequent heating at substantially higher temperatures, said article being resistant to said corrosive influences and composed of a corrosion resisting austenitic steel alloy, the iron of which is substantially all in the gamma form, containing about 12% to 30% chromium, about 7% to 25% nickel, about .07% to .2% carbon, and from .3% to 2.5% of an additional material consisting substantially all of columbium, the balance being substantially all iron.

18. A metal article which, in its normal use, is subjected to active corrosive influences while the metal in at least part of the article is in a condition resulting from heating at ranges within the carbide precipitation range (approximately 500° to 900° C.) without subsequent heating at substantially higher temperatures, said article being resistant to said corrosive influences and composed of a corrosion-resisting austenitic steel alloy, the iron of which is substantially all in the gamma form, containing about 18% chromium, about 8% nickel, about .07% to .2% carbon and about .3% to 2.5% columbium, the balance being substantially all iron.

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