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STABILIZATION OF AUSTENITIC CHROMIUM NICKEL STEELS

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My present invention relates to the stabilization of austenitic chromium nickel steels and more specifically to the prevention of intercrystalline corrosion in such steels by a special heat treatment at relatively low temperature.

Austenitic chromium nickel steels, such as those which contain about 18% chromium, about 8% nickel and low carbon up to about 0.2%, the balance being principally iron, are considered the most corrosion resistant steels known. It is, however, realized that when these steels are heated and/or slowly cooled through the temperature range of approximately 800 to 1500° F. they undergo a structural change and a constituent which is known as carbide is precipitated at the grain boundaries. Such conditions are usually met or caused to arise in hot forming and welding operations as in the fabrication of articles from such steels.

When these steels are in this condition, that is, when carbide is precipitated at the grain boundaries at 800–1500° F., they are rapidly attacked by many active corroding agents. The attack is chiefly at the grain boundaries, where the carbide has precipitated. After the attack has proceeded sufficiently far these steels lose their metallic ring and eventually disintegrate. After the attack has proceeded far enough to seriously affect the grain boundaries the steels become very brittle and failure from cracking usually occurs even before disintegration has actually set in because the attack upon the grain boundaries so weakens the steel that it is unable to resist the stresses and strains to which it is subjected. This type of failure is commonly known as intercrystalline corrosion or embrittlement and is also known as intergranular disintegration. The term intercrystalline corrosion will be used herein with the understanding that it is used broadly to indicate corrosion, disintegration or deterioration at the grain boundaries where the carbide is precipitated.

In such austenitic chromium nickel steels failure from intercrystalline corrosion invariably occurs when the sheet has been heated in the temperature range which precipitates carbide at the grain boundaries and is then subjected to an active corroding agent as occurs in many types of use. Insofar as I am aware all austenitic chromium nickel steels are susceptible to this type of failure when they are treated as above described.

An accelerated test has been developed the results of which have been generally accepted as indicative of the susceptibility of the (austenitic) steels to intercrystalline corrosion. This test consists in subjecting the steel to what is known as a sulphuric acid-copper sulphate reagent. The reagent contains a 10% solution of 66° Baumé sulphuric acid by volume in which 100 grams of copper sulphate per liter has been dissolved. The reagent is used at its boiling temperature. The percentage of sulphuric acid and copper sulphate may be varied within certain recognized limits without materially affecting the results. It has been found that steels which have been heated in and/or slowly cooled through the above mentioned range of 800 to 1500° F. and in which carbide has been precipitated at the grain boundaries will eventually fail when subjected to the above mentioned reagent.

It is known further that steels in the above condition can be again restored to their original condition by heating the same above the carbide precipitation range and rapidly cooling the same from this annealing temperature. The temperatures usually employed in commercial practice range from 1800 to 2000° F. At this temperature the carbides which have been precipitated at the grain boundaries again go into solid solution and when the steels are in this latter condition they are not susceptible to intercrystalline corrosion as indicated either by the boiling sulphuric acid-copper sulphate reagent mentioned above or in service where active corroding agents are present. Apparently, solution of the precipitated carbides may be effected at temperatures as low as 1600° F., but at the lower temperatures a considerably longer time is required to recondition the steels and as above stated the usually used temperatures range from 1800 to 2000° F.

Such treatment, however, is frequently impractical or impossible. Many fabricated chromium nickel steel articles are too large for annealing since the existing annealing furnaces are not able to accommodate them. Again, annealing at 1800 to 2000° F., results in serious warping and distortion of the articles because they do not possess the strength to withstand the same, thus either ruining them or necessitating further treatment to restore them to their original configurations. Such in addition measurably increases the cost of the articles.

One of the objects of my present invention is to obviate the above noted defects and disadvantages while at the same time providing a treatment which will make the indicated types of steels stable and immune to intercrystalline corrosion.

Another object of my invention is to give the steel or the articles fabricated therefrom a final heat treatment at 1400 to 1600° F., 1550° F. being the preferred temperature.

A further object of my invention is to render the steels and articles made therefrom stable and immune to intercrystalline corrosion by altering the nature of the carbide precipitated at the grain boundaries.

A still further object resides in the various details to be hereinafter set forth or which will be apparent as the description proceeds and still

other objects and advantages will be understood by those skilled in this art.

I have discovered that when austenitic chromium nickel steels, such as those low in sonims and containing about 18% chromium, about 8% nickel, and low carbon, with the balance principally iron, and which may or may not contain other alloying additions such as vanadium, tungsten, molybdenum, manganese, copper, titanium, praseodymium, aluminum, columbium, selenium, tellurium, silicon, tantalum, etc. are heated in the range of from approximately 1400 to 1600° F., I in some way alter the nature of the precipitated carbide so that such carbide is different than the carbide which is precipitated at lower temperatures. Such altered carbide may, for example, be different, in distribution, hardness, fineness of subdivision, chemical composition, etc., but steels which have been treated within this temperature range and which show, upon microscopic examination, precipitated carbide at the grain boundaries, when subjected to the boiling sulphuric acid-copper sulphate reagent, show no tendency toward intercrystalline corrosion or embrittlement even after they have been subjected to the above mentioned reagent for periods of time upwards of 500 hours. While I have stated that the temperature range is approximately from 1400 to 1600° F., I find that about 1550° F. is preferable for most of these steels, but with steels of lower carbon content temperatures of 1400° F. or slightly lower may be employed.

In the tabulations given below the results show that the carbide which is precipitated within the temperature range of the present invention must be of a different nature than that which is precipitated at lower temperatures, e. g., the common temperatures of 1000 to 1200° F. The results are indicative of results which have been obtained on many of the austenitic chromium nickel steels over a long period of time.

Heat treatment	Composition	
	.20 C 18.41 Cr 8.14 Ni	.06 C 17.60 Cr 8.79 Ni
	Time for failure in sulphuric acid-copper sulphate solution	
1 hr. at 1200° F.—air cooled	½ hr	384 hrs.
500 hrs. at 1200° F.—air cooled		12.
1 hr. at 1400° F.—air cooled	1 hr	800 hrs. (O. K.).*
1 hr. at 1500° F.—air cooled	3 hrs	800 hrs. (O. K.).*
500 hrs. at 1550° F.—air cooled	8000 (O. K.)	8000 hrs. (O. K.).

*Tests discontinued after 800 hrs.

	Composition			
	.07 C 18.38 Cr 8.90 Ni	.08 C 20.40 Cr 10.12 Ni	.11 C 18.05 Cr 8.95 Ni	.10 C 18.33 Cr 7.95 Ni
500 hrs. at 1000° F	9 hrs	2½ hrs	18 hrs	
500 hrs. at 1200° F	15 hrs	250 hrs	5½ hrs	
500 hrs. at 1550° F	1000 hrs. (O. K.)	1000 hrs. (O. K.)	1000 hrs. (O. K.)	200 hrs. (O. K.).*
3 hrs. at 1550° F				

*Test discontinued.

It is apparent from the foregoing figures, which have been compiled after extensive research and test, that treatment of the chromium nickel steels or articles fabricated therefrom within the temperature range of about 1400 to 1600° F., as a final treatment, completely stabilizes such austenitic chromium nickel steels and renders them immune to intercrystalline corrosion or embrittlement.

My invention, therefore, has a double aspect. From one point of view it contemplates a final heat treatment of the austenitic chromium nickel steels or articles fabricated therefrom in the temperature range of about 1400 to 1600° F. From another point of view my invention contemplates the fabrication of the austenitic chromium nickel steels and articles or products made therefrom by welding operations and the subsequent treatment of the so welded and fabricated materials by subjecting them to a final heat treatment at 1400 to 1600° F.

It is clear that the above description is intended in an illustrative rather than in a limitative manner and that I may make suitable modifications, variations, substitutions and omissions depending upon the precise steel being treated and the results desired without departing from the spirit and scope of the present invention. It is apparently of great advantage to be able to anneal at lower temperature and to thus greatly extend the use of these steels to many cases where they could not be heretofore used. In addition these steels and articles made therefrom are homogeneous throughout.

What I claim as new and desire to secure by Letters Patent is:

1. A process of permanently stabilizing austenitic chromium nickel steels and articles of manufacture fabricated therefrom which comprises subjecting the same to a final heat treatment at a temperature between about 1400° F. and 1600° F. and converting the carbide precipitation deposited at the grain boundaries by the fabricating operations into a form in which it is not subject to intercrystalline corrosion.

2. A process of permanently stabilizing austenitic chromium nickel steels and articles of manufacture fabricated therefrom which comprises subjecting the same to a final heat treatment at a temperature between about 1400° F. and 1600° F. and converting the carbide precipitation deposited at the grain boundaries by the fabricating operations into a form in which it is not subject to intercrystalline corrosion, the precise temperature between the limits aforesaid being so cor-

related to the carbon content of the particular steels and articles of manufacture that the lower the carbon content the lower the temperature that may be employed in the heat treatment.

3. A process of permanently stabilizing austenitic chromium nickel steels and articles of manufacture fabricated therefrom which comprises subjecting the same to a final heat treatment at a temperature between about 1400° F. and 1600° F. and converting the carbide precipitation deposited at the grain boundaries by the fabricating operations into a form in which it is not subject to intercrystalline corrosion, said process being characterized by the capacity of producing permanent stabilization in a relatively few hours.

4. A process of permanently stabilizing austenitic chromium nickel steels and articles of manufacture fabricated therefrom which comprises subjecting the same to a final heat treatment at a temperature between about 1400° F. and 1600° F. and converting the carbide precipitation deposited at the grain boundaries by the fabricating operations into a form in which it is not subject to intercrystalline corrosion, said process being characterized by the capacity of producing permanent stabilization in 1–10 hours.

5. A process of permanently stabilizing austenitic chromium nickel steels and articles of manufacture fabricated therefrom which comprises subjecting the same to a final heat treatment at a temperature between about 1400° F. and 1600° F. and converting the carbide precipitation deposited at the grain boundaries by the fabricating operations into a form in which it is not subject to intercrystalline corrosion, said process being characterized by being carried out irrespective of the factor of ductility but which tends to increase brittleness rather than decrease it without imparting the disadvantages of embrittlement.

6. The method of preventing intergranular corrosion of austenitic chromium nickel steels containing chromium in excess of nickel and also containing a small amount of a strong carbide forming element which comprises heating the steels at a temperature of approximately 1550 degrees F. for a length of time sufficient to cause a precipitation of stable carbide compounds and thus render the steels resistant to such corrosive attack.

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