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METHOD OF IMPROVING THE CORROSION RESISTANCE OF STAINLESS STEEL TO SODIUM

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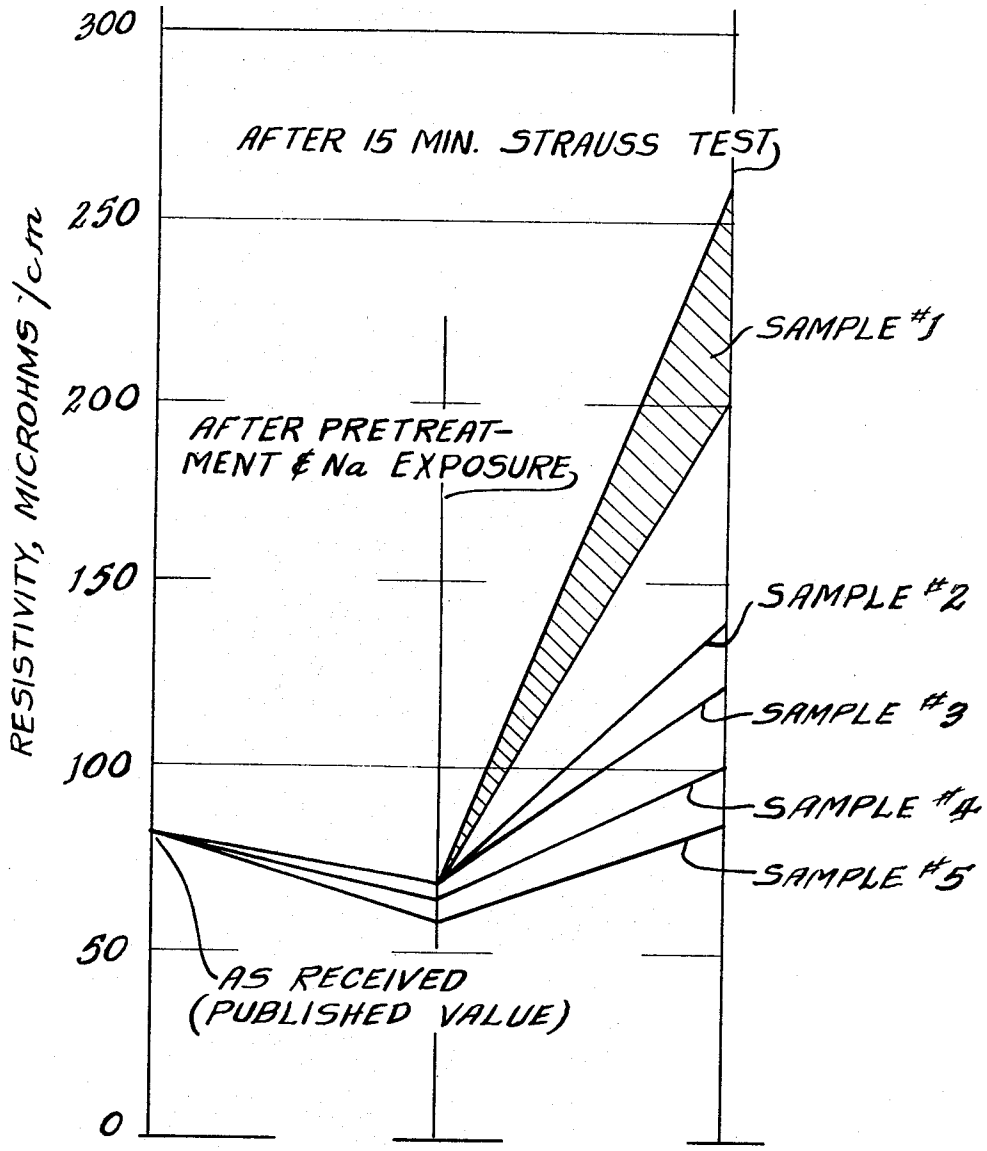

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METHOD OF IMPROVING THE CORROSION RESISTANCE OF STAINLESS STEEL TO SODIUM

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U.S. Cl. 148—15 1 Claim

ABSTRACT OF THE DISCLOSURE

A method of improving the corrosion resistance of nonstabilized type 304 austenitic stainless steel to sodium at about 1000 to 1200° F. comprising exposing the stainless steel to sodium at a temperature of over 1400° F. for a period of at least 4000 hours.

Contractual origin of the invention

The invention described herein was made in the course of, or under, a contract with the United States Atomic Energy Commission.

Background of the invention

This invention relates to a method of improving the corrosion resistance of stainless steel to hot sodium. In more detail, the invention relates to a method of improving the corrosion resistance of nonstabilized austenitic stainless steel to sodium at between about 1000° and 1200° F.

In view of the current interest in sodium-cooled nuclear reactors, materials of construction which will withstand the corrosive effect of hot sodium are of great importance. The cost of such materials of construction—provided other properties are satisfactory—is, of course, of importance because of the interest in obtaining economical power from such reactors. Due to its low cost and its reported properties, type 304 stainless steel—a nonstabilized austenitic stainless steel—appeared to be the indicated choice for such reactors. While stabilized stainless steels such as type 316, 321 and 347 could also be used, each has certain disadvantages in addition to a higher cost. We have found, however, that type 304 stainless steel is not satisfactory without a heat treatment but that with a heat treatment to be described hereinafter type 304 stainless steel is perfectly satisfactory.

Summary of the invention

According to the present invention a nonstabilized austenitic stainless steel is heat treated in sodium at a temperature between about 1400 and 1600° F. for at least about 4000 hours. This treatment makes it possible to use the stainless steel in contact with sodium at temperatures between 1000° F. and 1200° F., whereas the stainless steel could not be so used without the treatment.

Description of the drawing

The sole figure of the drawing is a graph showing the effect of various pretreatments on the resistivity of type 304 stainless steel. As will be explained hereinafter, the resistivity is a measure of the corrosion resistance of the stainless steel.

Description of a specific embodiment of the invention

Discovery that heat treatment in hot sodium increases the corrosion resistance of stainless steel came about accidentally. A loop formed of type 304 (18% chromium-8% nickel) stainless steel was placed into service at Argonne National Laboratory carrying sodium at a temperature of 1400 to 1600° F. and was operated for over 4000 hours while a series of tests was run. The temperature of the sodium was then reduced to between about 1000 and 1200° F. and operation of the loop was continued for several years without failure or replacement.

"As received" type 304 stainless steel specimens which had not received any heat treatment were introduced into the loop and maintained submerged in sodium at about 1200° F. for seven days. These specimens deteriorated rapidly as shown by a badly deteriorated microstructure and a high equivalent electrical resistivity. Thus, it has been shown that type 304 stainless steel is not satisfactory at temperatures between 1000 and 1200° F. when employed in the "as received" condition but is satisfactory at temperatures above about 1400° F. up to the boiling point of sodium and also that heat treatment at above 1400° F. for an extended period of time makes it possible to use the stainless steel at between 1000 and 1200° F.

The reason that nonstabilized austentic stainless steel can withstand a sodium environment at temperatures above about 1200° F. but cannot withstand such an environment at temperatures between about 1000° F. and 1200° F. is that sensitation occurs between these temperatures. By sensitation is meant the precipitation of chromium carbide at grain boundaries thereby rendering the boundaries susceptible to attack by sodium. Maximum sensitation for type 304 stainless steel containing a normal amount of carbon (.08 weight percent maximum) is at 1200° F. Above about 1200° F. chromium carbide does not precipitate at grain boundaries to a great extent but rather is retained in solid solution in the grains.

The sole figure of the drawing compares type 304 stainless steel which has had the heat treatment of this invention with type 304 stainless steel that has had no heat treatment as well as other types of heat treatment. Sample No. 1 is a control sample of "as received" type 304 stainless steel that was not heat treated. Sample No. 2 was heated in an air furnace at 2000° F. for one hour, then water quenched. Sample No. 3 was heated in vacuum for 15 hours at 1500° F., then furnace cooled. Sample No. 4 was heated in argon for one hour at 2150° F., then water quenched. And Sample No. 5 was treated for early 10,000 hours in a sodium loop at temperatures between 1200° F. and 1600° F. Results are given in terms of the resistivity of the sample before and after boiling the sample for 15 minutes in a modified Strauss reagent consisting of 30 grams $CuSO_4$, 55 ml. H_2SO_4 and 870 ml. distilled water. Electrical resistivity measurements provide a quantitative method of estimating intercrystalline corrosion in austenitic stainless steel as described in Rutherford, J. J. B. and Aborn, R. H., "A Quantitative Method for the Estimation of Intercrystalline Corrosion on Austenitic Stainless Steels," American Institute of Mining and Metallurgical Engineers, Vol. 100, 1932, pages 293–301. It will be noted that the measured resistivity of Sample No.

5 is the lowest of all the samples. This sample was taken from the high-temperature sodium loop previously described. In sharp contrast, Sample No. 1 of an "off the shelf" 304 stainless steel specimen and exposed only to 1200° F. sodium had the highest resistivity value measured. Since low resistance values are an indication of the integrity of the material, then pretreatment by the method of this invention shows greatly improved results over any other pretreatment known.

The embodiments of the invention in which an exclusive property or privileges is claimed are defined as follows:

1. A method of improving the corrosion resistance of type 304 stainless steel to sodium at a temperature of between 1000 and 1200° F. comprising heating said stainless steel in contact with sodium at a temperature of about 1400 to 1600° F. for at least 4000 hours.

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