

- [54] **METHOD OF IMPROVING THE CORROSION RESISTANCE OF NICKEL-COPPER ALLOYS**
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- [58] Field of Search **156/2, 3, 7, 18; 252/79.2, 252/387; 75/159; 148/20.6; 134/3, 41**

[56] **References Cited**
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[57] **ABSTRACT**

The corrosion resistance of nickel-copper alloys containing 63-70 wt. percent nickel to water is improved by immersing the alloy in concentrated hydrochloric acid for 24 hours at room temperature prior to exposure of the alloy to water.

2 Claims, No Drawings

METHOD OF IMPROVING THE CORROSION RESISTANCE OF NICKEL-COPPER ALLOYS

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 nickel-copper alloys to water. In more detail, the invention relates to a method of increasing the corrosion resistance of 63 to 70 wt. percent nickel-copper alloys to hot water.

High nickel-copper alloys containing 63 to 70 wt. percent nickel are extensively used where good corrosion and heat resistance are required. Varieties containing minor amounts of other constituents have other desirable properties. Unfortunately, experience has shown that bodies formed of these alloys begin pitting shortly after exposure to water at a high temperature — about 170° C — and extensive failures are known to have occurred after 2 years service.

SUMMARY OF THE INVENTION

According to the present invention, high nickel-copper alloys such as Monel alloy R-405 which contains 63-70 wt. percent nickel and a maximum of 0.30 wt. percent carbon, 2.0 wt. percent manganese, 2.5 wt. percent iron, 0.025-0.060 wt. percent sulfur and 0.50 wt. percent silicon, the balance being copper is immersed in concentrated hydrochloric acid at room temperature for about 24 hours to etch the surface thus increasing the resistance of the alloys to water. The invention is particularly useful when the alloy is expected to be in contact with hot water for a long period of time.

SPECIFIC EMBODIMENT OF THE INVENTION

Immersion-type resistance temperature detectors enclosed in Monel alloy R-405 have been used in reactor service at Hanford Engineer Works, Richland, Washington. The temperature of the water in which the temperature detectors were immersed ranged from 20° to 170°C.

According to a 1969 bulletin of the Huntington Alloy Products Division of The International Nickel Company, Inc., on Monel nickel-copper alloys, alloy R-405 (formerly known as "R" Monel) contains 63.0 to 70.0 wt. percent nickel (plus cobalt) and a maximum of 0.30 wt. percent carbon, 2.0 wt. percent manganese, 2.5 wt. percent iron, 0.025 to 0.060 wt. percent sulfur, and 0.50 wt. percent silicon, the balance being copper. The nominal composition of one specific Monel R-405 alloy is 66.7 wt. percent nickel, 30 wt. percent copper, 1.7 wt. percent iron, 1.1 wt. percent manganese, 0.1 wt. percent carbon, 0.05 wt. percent silicon and 0.035 wt. percent sulfur. In addition, I have determined that Monel contains a small quantity of magnesium present in the form of stringers. Approximately 90 percent of the detectors installed on one particular reactor began pitting shortly after installation. Failures due to pinholes in the Monel metal after two years service caused extensive effort to stop the pitting action on the alloy.

Metallurgical studies indicated that both Monel alloy R-405 — which was the alloy used — and Monel alloy

400 contain magnesium sulfide stringers, Monel alloy R-405 having more stringers intentionally introduced to improve machinability. Monel alloy 400 has the same composition as alloy R-405 except that the amount of sulfur present is lower. Since magnesium is employed as a deoxidizer when forming the alloy, it is believed that the magnesium in the stringers is residual from the forming process. The amount is very small, probably less than 0.5 wt. percent. It is believed highly probable that the magnesium is present in the stringers in the form of magnesium sulfide. Our belief is based on the fact that chemical analysis of the stringers established the presence of magnesium and sulfur and magnesium was found to be present in every sample of Monel tested. Since the stringers dissolve instantly in tap water and the only compound of magnesium and sulfur which is soluble in water is magnesium sulfide, the stringers must be composed of magnesium sulfide.

Immersing the Monel alloy R-405 in nominally 38 percent hydrochloric acid (reagent grade concentrated HCl) at room temperature results in the following. Magnesium sulfide stringers exposed to the surface are dissolved and removed from the metal. In addition, the difference in dissolving rates of copper and nickel coupled with their relative oxidation potentials causes the surface molecules of copper to go into solution and leaves the metal surface relatively high in nickel content. Thus, the surface of the treated metal is relatively high in nickel content and contains no magnesium sulfide stringers exposed to the surface.

A direct comparison has been made between resistance temperature detectors including a Monel alloy R-405 body which has been etched according to the present invention and detectors including Monel alloy R-405 bodies that have not been so etched. Photographs clearly show that detectors which have been etched in hydrochloric acid show very little pitting after 2 years in a reactor in a water environment, while non-etched detectors under the same conditions pitted heavily in 3 or 4 months.

It is, of course, evident that the hydrochloric acid concentration, time and temperature may be varied within rather wide limits.

While this invention was developed for the purpose of improving the corrosion resistance of Monel alloy exposed to high temperature water and it is here that the invention is most important, the invention should increase the useful life of the alloy in any temperature water.

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

1. A method of improving the corrosion resistance to hot water of a resistance temperature detector including a body formed of a nickel-copper alloy containing 63-70 wt. percent nickel and minor amounts of sulfur, said alloy further containing magnesium residual from the forming process wherein it had been used as a deoxidizer, comprising etching the detector body in concentrated hydrochloric acid prior to exposure of the detector to hot water.

2. A method according to claim 1 wherein the alloy contains 63-70 wt. percent nickel (plus cobalt) and a maximum of 0.30 wt. percent carbon, 2.0 wt. percent manganese, 2.5 wt. percent iron, 0.025 to 0.060 wt. percent sulfur and 0.50 wt. percent silicon, the balance being copper and wherein the detector body is etched in nominally 38 percent hydrochloric acid (reagent grade concentrated hydrochloric acid) for 24 hours at room temperature.

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