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GOLD COATED STEEL ARTICLE

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1 Claim. (Cl. 29—183.5)

This invention relates to the prevention of hydrogen absorption by structural steel members. This application is a continuation-in-part of application Serial Number 68,607, filed November 14, 1960, now abandoned.

The presence of hydrogen in steel has a very serious deleterious effect on the metal. Thus, the presence of hydrogen in ultra high strength steel frequently results in static fatigue or delayed failures in equipment, machines, and various types of apparatus made therefrom. Ultra high strength steel is defined as one having a minimum room temperature yield strength of 175,000 p.s.i.

In many instances, the failure, with disastrous results, of vital pieces of equipment, such as aircraft landing gear, wing attachment fittings, and the like, has been found to be due to static failure caused by the presence of hydrogen in the ultra high strength steel components from which they were made.

It is extremely difficult to prevent hydrogen from entering steel since necessary conventional fabrication, processing and finishing treatments thereof frequently result in subjection to hydrogen. Even in the course of corrosion in the presence of water during fabrication or later use, hydrogen released by the oxidation of the metal surface may enter the basis metal. In another instance, the procedure of electroplating with cadmium, which is commonly adopted to prevent corrosion of ultra high strength steel components, results in the absorption of seriously damaging amounts of hydrogen by the steel being plated. This is well known, and to ensure that the deleterious effects of hydrogen may be reduced, it is common practice to bake the steel after electroplating with cadmium at temperatures between 350° F. and 375° F. for 20 hours or longer. This baking procedure drives some of the hydrogen out of the steel and some into it thus reducing and diluting the concentration at the surface where its embrittling effects might otherwise be manifested. Baking is not, however, completely satisfactory or reliable since it does not result in the complete removal of hydrogen, and requires furnaces, thermal energy and handling which add considerably to the cost of treatment.

It is an object of this invention to provide a structural component of ultra high strength steel having a non-deleterious hydrogen content and which has been rendered immune to the absorption of hydrogen during any subsequent processing or fabrication treatments or exposure to hydrogen-containing environments.

Another object is to provide a process of treating ultra high strength steel structural components which contain hydrogen in an amount which is not deleterious thereto whereby they are rendered immune to subsequent occlusion of hydrogen therein.

The process in accordance with the invention comprises selecting an ultra high strength steel structural component which, while susceptible to hydrogen embrittlement, does not contain hydrogen in an amount deleterious thereof. A substantially pore-free and substantially continuous coating of gold is applied to such structural member. Such a pore-free gold coating is impermeable to hydrogen and constitutes a completely effective barrier thereto. So long as the gold coating is pore-free and continuous, its thickness is not a factor in its effectiveness as a barrier.

A gold coating as described, on a structural object of ultra high strength steel, acts as an effective barrier to hydrogen as produced in subsequent plating of the object with other metals, such as cadmium.

A preferred manner of applying such coating is by immersion of the steel member in a bath comprising a gold salt solution whereby the coating is applied in an electroless manner, i.e., by chemical displacement from solution. While this method has practical and technical advantages, alternative methods such as vacuum deposition, dip coating, metal spray coating, electroplating, and the like, may also be used; however, it will be apparent that any method selected must provide a substantially continuous and pore-free coating on the metal.

The thickness of coating applied is only that necessary to ensure a substantially pore-free, continuous deposit which will serve as a fully effective impermeable barrier to the passage of hydrogen. While it has been found that a deposit in the order of approximately $9/1{,}000{,}000$ of an inch in thickness applied by the chemical displacement from solution method is satisfactory, a greater thickness would be equally effective but less economical. A thickness less than the above will suffice as long as an impermeable coating is provided. The method of application of the barrier coating will determine the minimum average thickness necessary to ensure that the coating as a whole is effective.

For example, if the electroplating process were used for deposition of the gold, it is anticipated that the thickness of the coating would need be at least 30% greater. When applied by the electroless, chemical displacement method, a thickness of approximately $9/1{,}000{,}000$ of an inch is demonstrably effective as is shown in the following table.

The following tests illustrate the effectiveness of the process described in which gold was applied by the preferred method, chemical displacement, as the barrier coating on specimens of high tensile AISI 4340 ultra high strength steel, prior to cadmium plating, tested under conditions of static fatigue in a range of loadings up to 230,000 pounds per square inch:

	Specimen (Steel)	Load p.s.i.	Time, Hours	Remarks
1	Cd plated only	150,000	2.9	Broke.
2	do	150,000	3.5	Do.
3	Cd plated+baked (400° F., 20 hrs.)	230,000	9.2	Do.
4	Gold coated*+Cd plating	180,000	138.0	Unbroken.
5	do	150,000	50.0	Do.
6	do	230,000	96.0	Do.
7	do	230,000	163.2	Do.
8	do	230,000	50.8	Do.

*Thickness of gold coating; approximately 9/1,000,000 of an inch.

The following is an example of treatment of specimens such as were subjected to the tests listed in the table. The specimens were of notched type because it has been found that a sharply notched object is most sensitive to hydrogen embrittlement.

Example

An ultra high strength steel notched object was carefully degreased in acetone using a brush to clean the notched area. The object was then placed in a proprietary immersion gold coating solution known under the trade name "Baker Atomex" and available from Engelhard Industries of Canada Limited. The solution was made up according to manufacturer's specifications, the concentration being diluted 19:1 with distilled water. The solution was heated to 90° C. (190° F.) and the object totally im-

mersed therein for 10 minutes, that is; sufficient time to deposit 2.9 mg. of gold per square inch, equivalent to a thickness of 9×10^{-6} inches.

The surface of the test object was masked except for the notched area using a proprietary electroplating stop-off adhesive tape in order to concentrate the effects of subsequent cadmium plating and hydrogen embrittlement in the sensitive notched area. The object was then electroplated with cadmium in a solution made up of distilled water and 3.5 oz./U.S. gal. cadmium oxide and 17 oz./U.S. gal. sodium cyanide. A cadmium anode was used and the object (being the cathode) was slowly rotated during the plating. A current of 60 ma. was applied for 20 minutes.

The resulting object was tested as Specimen No. 7 in the table with the results indicated.

The gold coated component in accordance with the invention may, as previously indicated, be subjected to a subsequent plating with cadmium. It will be apparent that any suitable, conventional surface treatment may be employed to apply, if necessary, a protective outer layer or layers of other materials on the gold-coated object.

We claim:

A structural component of ultra high strength steel having a minimum yield strength of 175,000 p.s.i. and having thereon a continuous, pore-free, hydrogen-impermeable gold coating of a minimum thickness of the order of $\frac{1}{1,000,000}$ of an inch, and a protective outer layer of cadmium overlying and coextensive with said gold coating.

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