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[54] METHOD OF DETECTING AND LOCATING CORROSION SITES

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[57] ABSTRACT

Method of detecting and locating areas responsible for incipient galvanic corrosion on a metallic surface. Localized electrochemical cells which occur on metallic surfaces as a result of anodic and cathodic sites in contact with an electrolytic solution and which results in corrosion at such locations are detected by immersing the surface in an aqueous electrolytic solution containing a suspension of particles bearing an electrical charge of opposite polarity to the charge carried by the localized site. Particles in the suspension are attracted by the opposite polarity of the localized sites, if any, on the metallic surfaces, causing such particles to accumulate at the locations of the sites. These accumulations of particles remain on the metallic surface following withdrawal from the aqueous solution.

Coated metallic surfaces can be examined for the existence of pinholes, cracks, and other penetrating surface discontinuities by subjecting the metallic surface to an electrical charge of polarity opposite that of the particles suspended in solution.

8 Claims, No Drawings

METHOD OF DETECTING AND LOCATING CORROSION SITES

This invention relates in general to corrosion and in particular to a method of detecting and locating sites of actual or incipient corrosion on metallic surfaces.

The problems constantly presented by the susceptibility of metals to corrosion are notorious and need little elaboration here. It is well-known that large amounts of money and effort are devoted to preventing the occurrence of corrosion on metallic products of many kinds. Not only does unwanted corrosion result in reduction of the metallic surface, leading to weakening of the metal and possible structural failure, but the actual corrosion products, which frequently occupy a volume greater than the volume of the corroded metal, can also exert a damaging effect on a structural assembly.

Because of the importance attached to the prevention of unwanted corrosion of metal, it is desirable to be able to detect and locate metallic surface sites which are responsible for the galvanic corrosion of a metal which is susceptible of corrosion, even though no evidence of actual corrosion may be apparent from a visual inspection of such sites. These sites, which may be identified as locations of incipient corrosion, are generally considered to occur as a result of the formation of localized electrochemical cells involving the detectable galvanic locations on a metallic surface. It is believed in the art that these cells are formed between different phases in the metal, between impurities and inhomogeneities and the bulk of the metal, between precipitates at grain boundaries and the grains themselves, or by other similar conditions wherein electrically connected surface areas having different electromotive potentials are available to come in contact with a corrosive environment. It will be understood that the term "corrosive environment" broadly includes any environment which permits an oxidation-reduction reaction to occur, and that mere exposure to normal atmospheric conditions is a corrosive environment of a degree.

The localized electrochemical cells which constitute areas of incipient corrosion are considered to consist of anodic areas where solution of the metallic surface occurs, causing formation of corrosion pits, and cathodic areas where there is a corresponding chemical reduction. Prior art techniques have been proposed for locating cathodic and anodic corrosion sites on metallic surfaces. One example of the prior art is found in Corrosion, Volume 18, pages 239*t* –246*t*, June 1962. This technique involves the use of complex and expensive equipment, including an oscilloscope, to synthesize a map of the distribution and intensity of corrosion potential on a metallic surface. It is apparent that the need exists for a technique which will rapidly and inexpensively enable locations of corrosion and incipient corrosion on metallic surfaces to be detected and located.

Accordingly, it is an object of the present invention to provide an improved method for detecting incipient galvanic corrosion.

It is another object of the present invention to provide an improved method of detecting and locating sites which lead to the formation of galvanic corrosion cells.

It is still another object of the present invention to provide an improved method for detecting the existence and the location of penetrating discontinuities in coatings on a metallic surface.

Other objects and many of the attendant advantages of the present invention will become more apparent from the following description of the preferred embodiment disclosed herein.

Stated in general terms, the method of the present invention comprises subjecting a metallic surface to an aqueous electrolytic solution containing a suspension of particles which bear an electrical charge of polarity opposite to the polarity of the corrosion-forming localized electrochemical sites on the metal surface. The charged particles are electrically attracted to such localized areas because of opposite polarities of charges, and the localized electrochemical sites are thus identifiable by the accumulations of particles remaining on the metallic surface when withdrawn from the aqueous solution. Similarly, a metallic surface coated with a dielectric coating can be examined for pinholes or other discontinuities in the surface by first charging the metallic surface at a polarity which is the opposite of the particles in the aqueous suspension, and then subjecting the coated surface to the suspension of charged particles.

The nature and practice of the present invention will be more apparent with reference to the following description of a specific disclosed embodiment thereof. An aqueous solution prepared containing a suspension of fused SiO_2 (silica) particles in water. The average particle size is about six microns in diameter, and the suspension contains approximately 82 percent by weight of the silica particles. The pH of the suspension is generally between 4.0 and 5.0, as a result of the formation of silicic acid during its composition, although the pH can be adjusted to any desired value within the range of about 2.0–7.0 with acid or base additions. The viscosity of the exemplary suspension is about 100 centipoise.

Samples of metal such as iron, steel, brass, aluminum, and the like were cleaned to remove grease and surface film and were then immersed in the foregoing aqueous electrolytic suspension. The metal samples acquired a thin coating of the suspension by simple wetting, but after immersion is maintained for a few minutes, a number of depositions of the silica particles became visibly apparent at various sites on the surface of the metal. These depositions appear as small mounds or bumps of the silica particles and are readily observable after an immersion time of only a few minutes. When the metallic sample is removed from the suspension, the nonadherent suspension wetting the entire sample is briskly shaken off or very carefully rinsed off with water. The adherent depositions can be conveniently scraped away, if desired, while the sample is being viewed through a microscope or other suitable apparatus. Microscopic examination of the metal surface sometimes reveals that the depositions have formed on pre-existing corrosion pits or sometimes on what appear to be inclusions or areas of inhomogeneity in the metal.

The method of the present invention can be used for analytical and investigative purposes apart from mere detection of incipient corrosion sites. As an example, the ionic content of the aqueous solution can be adjusted to simulate various types of actual corrosive environments and the effect of such adjustment can be evaluated by noting the corresponding effect on the deposition of particles suspended in the aqueous solution. Such adjustment of the ionic content could consist of

the addition of sea salts in an amount to simulate a sea water environment, for example, or the addition of ions known to increase or to inhibit the rate of corrosion.

As an experiment confirming the foregoing theoretical operation of the present invention, a pair of electrodes made of metal or graphite are connected to an external source of EMF and disposed in the suspension. A very rapid deposition of suspension particles occurs on the electrode connected to the positive potential source, and this deposition continues to the extent of removing most of the particles from the suspension within a few minutes. Accordingly, it appears that the suspension particles are negatively charged and, by inference, the deposition sites on metallic surfaces are, or include, anodic poles.

The method of the present invention is applicable to investigation of coated metallic surfaces to determine the existance and location of any pinholes, scratches, or other surface discontinuities which penetrate the thickness of the coating. The coated metal sample is made to be the positive electrode by appropriate connection to an external source of EMF, and the sample is then immersed in a suspension as described above. Any coating discontinuities which expose the underlying charged metallic surface to the suspension particles will become apparent by deposition of particles upon the discontinuities. Alternatively, if no discontinuities exist in the coating, this fact is made apparent by the absence of any localized deposition of particles on the coated surface.

Although the method of the present invention is practicable with any suspension of particles which bear the proper electrical charge with respect to the polarity of the corrosion sites being investigated, the use of aqueous suspensions of amorphous (fused) silica are found to provide superior results and are preferred. The particle size and particle concentration is not considered to be critical, provided that the particle size is such as to maintain the particles in suspension for the duration of a corrosion site test according to the invention.

Furthermore, it will be understood that the foregoing relates only to a preferred embodiment of the present invention, and that numerous alterations and modifications may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. Method of detecting sites of potential corrosion on a metallic workpiece, comprising the steps of subjecting a metallic surface to an aqueous electrolytic suspension containing electrically charged particles the charge of which are opposite to that of suspected sites of potential corrosion on the metallic surface, observing the locations on the surface of any accumlations of said particles adhering thereto, and determining from said locations where the sites of potential corrosion are located.

2. The method of claim **1**, wherein said metallic surface is subjected to an aqueous electrolytic suspension of particles of amorphous (fused) silica.

3. The method of claim **1**, wherein said step of subjecting comprises immersing the surface in said aqueous electrolytic suspension, subsequently removing the surface from the aqueous suspension, and observing the location on the surface of any accumulation of said particles adhering thereto.

4. The method of claim **3**, further comprising the step of removing the residual quantity of said suspension which remains on the surface after removal from the aqueous electrolytic suspension.

5. The method of claim **1**, for detecting penetrating discontinuities in the coating of a coated metallic surface, additionally comprising the steps of charging the metallic surface with an electromotive force of polarity opposite the polarity of said charged particles in suspension.

6. The method of claim **5**, wherein said step of subjecting comprises immersing the coated charged surface in said aqueous suspension, subsequently removing the coated charged surface from the aqueous suspension, and marking the location on the coated surface of any accumulation of said particles adhering thereto.

7. The method of claim **6**, further comprising the step of removing the residual quantity of said aqueous suspension which remains on the coated surface after removal from said solution.

8. The method of claim **1**, wherein the corrosion sites being detected have an electrically positive charge, and wherein said aqueous solution contains a suspension of particles having an electrically negative charge.

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