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METHOD OF DETERMINING DEFECTS IN ALUMINUM AND ALUMINUM ALLOY ARTICLES

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This invention relates to a method of testing by which articles made of aluminum or aluminum alloy may be quickly and easily examined to determine whether the article is free of cracks and similar defects. The object of the invention is to provide a cheap and simple testing method employing a minimum of equipment and capable of being used at the place of manufacture without undue interruption of the manufacturing process.

The method of testing which is the subject of this invention has proven particularly useful in the inspection of forged aluminum alloy parts for cracks and laps and is positive and sensitive in the detection of such defects. However, its usefulness in the testing of any aluminum or aluminum alloy article will be apparent from the following description of the invention.

The invention contemplates the treating of an aluminum or aluminum alloy article to form in any cracks or defects which exist therein an aluminum compound which will serve to fix a dye and then applying a dye solution to the thus treated article. The result is that the dye penetrates the cracks or other defects, is fixed therein, and there remains when the article surface is treated to remove any dye and compounds superficially fixed or retained on the surface. The dye thus retained in the defects contrasts with the aluminum surface and indicates the location and extent of the defects into which it has penetrated. In the practice of the invention it may be desirable, as a preliminary step, to remove from the surface of the article any dirt or grease which would interfere with the essential treatments. This may be accomplished by the use of solvents or detergents. The first step of the invention is to form in the cracks and other defects an aluminum compound which will act as a mordant or similarly serve to fix the dye; for example, various aluminum salts are suitable for this purpose. The desired compound may be produced in the cracks and the like by chemical treatment of the surface of the article with a reagent which reacts with the aluminum to form the aluminum compound. As a practical matter, however, it is best to employ a reagent whose attack on the metal can be closely controlled so as to avoid injury to the surface of the article. For this purpose the mineral acids are particularly suited, and of these hydrofluoric acid is preferred since its reaction with the aluminum is quick and easily controlled. The concentration of the reagent used for this purpose is not critical or important so long as attack is not too severe within the minimum time of immersion. Since the minimum time of immersion is governed by outside mechanical factors, such as the weight and shape of the treated article and the means immediately available for handling the same, the proper concentration of any given reagent may be easily determined under the particular shop conditions encountered. When using hydrofluoric acid under circumstances where the articles to be tested can be easily and quickly moved into and out of the acid, I have employed an aqueous solution of about 2½ to 5 per cent by weight of this acid. With such a solution a light attack is quickly obtained and an immersion of one minute will usually suffice.

After this treatment the next step is to immerse the treated article in a dye solution or to otherwise bring the dye solution to the surface of the article. Preliminary to the dyeing treatment it is desirable, although not necessary, to first rinse the article, as with water, to remove from its surface residual reagent retained from the preceding step. This is desirable since the residual reagent, if not removed, will contaminate the dye solution and reduce its efficiency for future operations. This rinse likewise will remove at least some of the aluminum compound formed on the surface of the article by the previous reagent treatment without materially disturbing the aluminum compound formed in the cracks and other defects in the article. Either without this rinsing treatment or after such a rinse, the article is treated with the dye solution. The dye penetrates into the cracks and becomes fixed therein by the aluminum compound formed in the previous step. Any aluminum compound formed on the surface of the article will also fix dye on said surface and often, even if such compound has been removed by preliminary rinsing, dye will be superficially adsorbed on the metal surface. This superficial coloring of the surface of the article is thereafter removed, if desired, by further washing or by light abrasion to increase the contrast between the now colored cracks, laps or crevices and the surface of the article. This washing or rubbing does not materially disturb the dye which is fixed in the defects, and the defect areas remain colored and easily observable against the contrasting color of the metal surface.

Some organic dyes are better adapted to this method of testing than others. Selection of suitable dyes from the large number available is a matter of simple trial. A list of some of the commercial dyes which are satisfactory is as follows: Alizarine Red S, Neolan Red BRE, Aluminum Scarlet C, Aluminum Red B, Alizarine Cyanine Green 3G, Neolan Green BL conc., Alizarine

Sapphire SE, Aluminum Blue A, Aluminum Blue B and Helio Fast Rubine 6BL. The selection of a particular dye is, however, no part of this invention and many commercial dyes will prove satisfactory. The dye solution is best used hot. An organic dye, as is well known, colors most effectively in solution in limited pH ranges, and care should be taken that this range is maintained. The usual employment of buffers and of additions of acids and alkali to maintain and establish the proper pH range is recommended. A specific example of the practice of the invention is as follows:

An aluminum alloy forging in which craks were suspected was preliminarily cleaned to remove grease and other superficial material and then immersed for 30 to 60 seconds in an aqueous solution containing 2½ per cent by weight of hydrofluoric acid. The forging was rinsed in water and then immersed for 5 minutes in an aqueous solution containing 4 grams per liter of Helio Fast Rubine 6BL and held at a temperature of about 170° F. Thereafter the forging was rinsed thoroughly and dried. Very fine cracks in the forging retained the dye and were clearly outlined against the aluminum surface.

I claim:

1. The method of testing the surface of aluminum and aluminum alloy articles to discover cracks and similar physical defects therein which comprises forming in said cracks and defects an aluminum compound which is effective to fix an organic dye, and thereafter treating the surface with a solution of organic dye susceptible of being fixed by said aluminum compound.

2. The method of detecting cracks and similar defects in aluminum and aluminum alloy articles, which comprises subjecting the surface of said article to the action of a mineral acid, rinsing said surface, treating the rinsed surface with a solution of organic dye and finally treating the article surface to remove therefrom surface held dye.

3. The method of detecting cracks and physical defects in aluminum and aluminum alloy articles which comprises treating the article with a reagent to form in said cracks and defects an aluminum compound which is effective to fix an organic dye, removing from the treated surface residual reagent and thereafter penetrating a solution of organic dye into said cracks and defects, said dye being susceptible of being fixed by said aluminum compound.

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