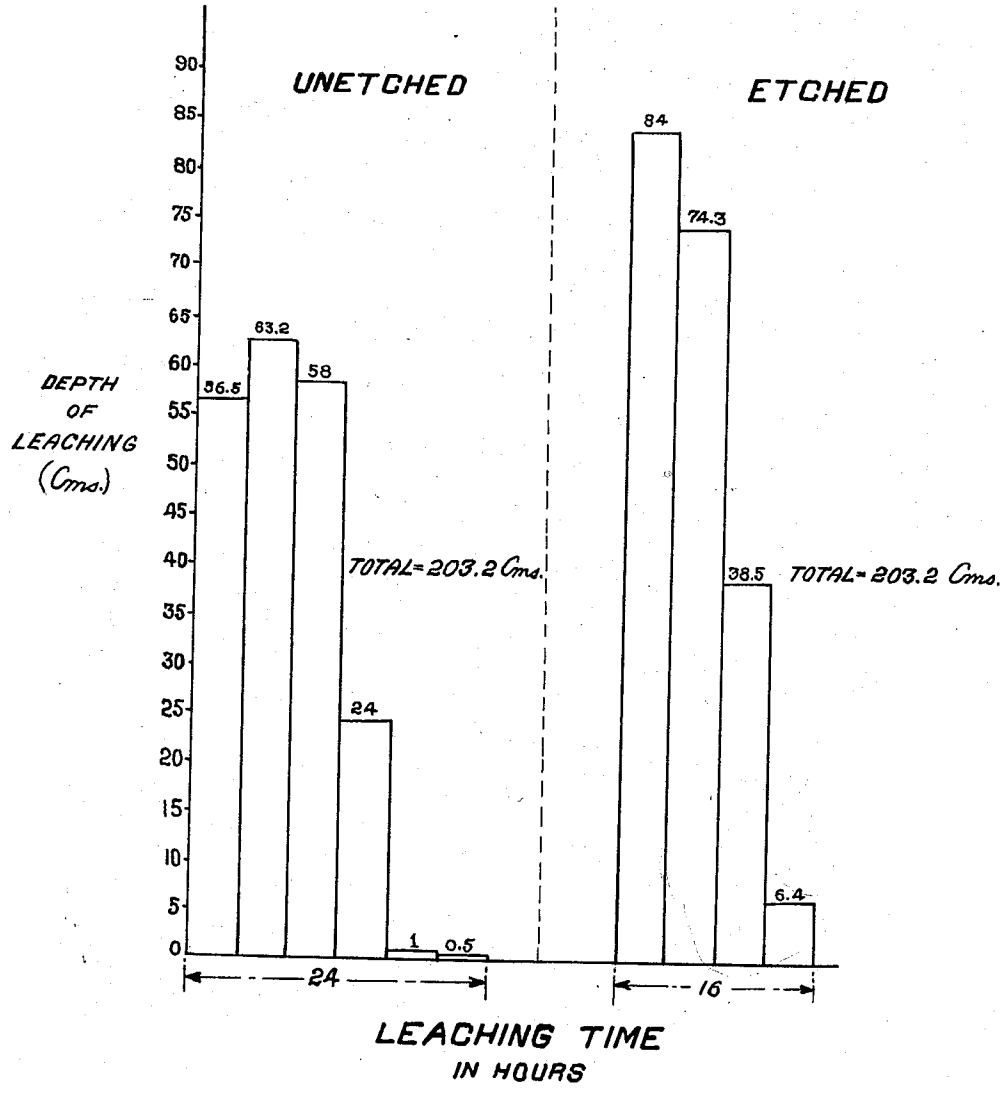
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PRODUCTION OF METAL ARTICLES WITH HOLES IN THEM

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PRODUCTION OF METAL ARTICLES WITH HOLES IN THEM

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The present invention relates to an improvement in the process of leaching filler material from hot-worked, heat-resistant metal articles having at least one internal filled passage and, more particularly, to the leaching of ferrous filler materials from said articles.

It is well known that one method of producing metal articles with holes or internal passages in them is first to produce a billet or the like with one or more holes in it; insert a filler in each hole; then to shape the billet or the like by extrusion or otherwise, the filler being simultaneously distorted; and finally to remove the filler. Usually the filler, and therefore the hole containing it, is considerably elongated and reduced in cross-sectional area during the shaping step. This method can be applied to the production of hollow turbine blades from nickel-chromium heat-resisting alloys, a billet of the alloy being drilled to form circular holes into which a ferrous filler is inserted; thereafter the billet is extruded to airfoil shape.

The usual method of removing the filler is to leach it out of the holes by an acid solution which attacks the filler but not the metal of which the article is made, or at least attacks the filler preferentially. Particularly advantageous types of ferrous fillers which may be used in conjunction with hot-workable heat-resistant alloys are described and claimed in U. S. patent applications Serial Nos. 509,380 and 472,755. These ferrous fillers may be leached by means of dilute solutions of common mineral acids which do not substantially attack the heat-resistant metal. Ferritic alloys of iron, manganese and titanium containing about 5% to about 20% manganese, about 1% to about 10% titanium with the balance essentially iron and iron-ceramic mixtures, for example, iron and magnesia mixtures containing from about 5% to about 25% magnesia with the balance essentially a continuous phase of iron, are particularly suitable.

As was mentioned hereinbefore, these ferrous fillers may be leached with dilute aqueous solution of common mineral acids. However, the leaching operation, even at elevated temperatures close to the boiling point of the acid solution, proceeds very slowly.

Although many attempts were made to overcome the foregoing difficulties and other disadvantages, none, as far as I am aware, was entirely successful when carried into practice commercially on an industrial scale.

It has now been discovered that the leaching of ferrous fillers from filled metal articles made from heat-resistant hot-workable alloys may be substantially accelerated by means of a special pretreatment prior to the leaching operation.

It is an object of the present invention to provide an improved process for leaching ferrous filler from filled heat-resistant hot-workable metal articles.

Another object of the present invention is to provide an improved process whereby the leaching of ferrous filler from filled metal objects made of hot-workable heat-resistant metal objects may be accelerated.

Other objects and advantages will become apparent

from the following description taken in conjunction with the accompanying drawing in which:

Figure 1 is a histogram depicting the relationship between the depth of filler leached and time, as measured on similar articles, leached in a similar manner and in the same reagent, one of which has been subjected to the novel pretreatment of the present invention and the other of which has been treated according to prior practice.

Generally speaking, the present invention contemplates the use of a conditioning pretreatment step comprising the chemical removal in aqueous media of the surface layer of the heat-resistant filled metal article prior to leaching with the conventional leaching reagents. According to this invention, the oxide layer is removed before the leaching by subjecting the articles to an acid-etching treatment in an aqueous acidic solution which attacks both the filler and the metal of which the article is made. The filler can then be leached by a solution which only, or preferentially (or selectively), attacks the filler. The acid-etching treatment may be carried out merely by immersion of the article in an acidic solution or by immersion of the article in said acidic solution coupled with anodic electrolytic action. Satisfactory etching solutions or reagents include aqueous solutions of hydrochloric acid, sulphuric acid and nitric acid which contain between about 50% to about 60% free concentrated acid. The etching solution should be maintained between about 95° C. to about 102° C. when no electrolytic action is involved. On the other hand, when electro-etching is used the temperature should be maintained between about 20° C. and about 25° C. As a general rule, the article should remain in the bath for between about 10 and 20 minutes. However, the etching should be carried on only for sufficient time for the oxide layer to be removed, or the article may be damaged.

The preferred etching solution for an article made of a nickel-chromium heat-resisting alloy is one consisting of equal parts of water and commercial concentrated hydrochloric acid; this solution should be used at its boiling point, when the etching is carried out by immersion only, but can be used at room temperature when the etching is electrolytic. Electrolytic treatment in a 6 volt circuit is satisfactory, the article forming the anode. It has been found that treatment of articles in this solution in either manner for 15 minutes is, in most cases, sufficient to remove the oxide layers but insufficient to do appreciable damage to the article. Preferably, the filler should be leached from the articles as soon as possible after the surface layer has been removed and in any event before the oxide layer has had time to reform. Suitable leaching solutions are described in the aforementioned patent applications. Aqueous nitric acid solutions and mixtures thereof with other mineral acids or salts are especially suitable.

Referring now to the drawing, wherein the width of the bars represents four-hour increments in time, and the length of the bars represents increments in depth of filler leached, it is to be observed that the histograms show the dramatic improvement in leaching action when the process of the present invention is used. In the histogram illustrating leaching after the etching treatment of the present invention, it is to be observed that a total of 16 hours was required to leach a total of 203.2 centimeters (cms.) of filler from turbine blade blanks whereas to leach the same depth of filler in an identical turbine blade blank a total of 24 hours was required.

For the purpose of giving those skilled in the art a better understanding of the invention and/or a better appreciation of the advantages of the invention, the following illustrative example is given:

EXAMPLE I

A series of simliar turbine blades, made from heat-resistant nickel-chromium alloy containing 18–21% chromium, 1.8–3% titanium, 0.8–2% aluminum, with the balance nickel, having small internal passages filled with a ferrous filler having a composition of 10% manganese, 2% titanium, balance iron, were produced. All samples of these blades were grit-blasted. One set of blades was etched for 15 minutes in 50% commercial concentrated hydrochloric acid maintained at the boiling point. The other set of blades was given no pretreatment. Two different leaching solutions were used for both sets. Leaching solution number 1 comprised an aqueous solution of 25% commercial concentrated nitric acid and 1% commercial concentrated hydrochloric acid by volume. Aqueous leaching solution number 2 contained 25% commercial concentrated nitric acid. The advantages provided by the present invention are illustrated by the following table in which leaching time indicates the time to remove all the filler material:

Table I

Surface Condition	Leaching Time, Hours	
	25% HNO_3, 1% HCl	25% HNO_3
Grit-blasted only	44	56
Grit-blasted and etched according to present invention	20	44

In a further series of tests it was found that without the etching treatment according to this invention the filler was removed from holes to a depth of 55 cms. in 4 hours when leached with nitric-hydrochloric acid solution, whereas after treatment according to the invention the filler was removed to a depth of 85 cms. in the same time.

In yet another set of experiments using similar turbine blades having holes 13.2 cms. deep it took 16 hours to remove the filler after the acid etching treatment of this invention but 24 hours without it. With the etching pretreatment at the fourth hour 5.2 cms. were leached and at the eighth hour 9.8 cms. were leached. Without the etching pretreatment of the present invention at the fourth hour 3.6 cms. were leached and at the eighth hour 7.6 cms. were leached.

With respect to the manufacture of turbine blades using the novel leaching process of the present invention, it should be understood that the term "heat-resistant metal" is used to include austenitic nickel-chromium, nickel-chromium-iron, cobalt-nickel-chromium, cobalt-chromium and cobalt-chromium-iron alloys which contain at least about 25% nickel plus chromium, cobalt plus chromium or nickel plus chromium plus cobalt in addition to small amounts of aluminum, titanium, molybdenum, tungsten, niobium, tantalum, silicon, manganese, zirconium and boron which may optionally be present in the alloys.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

I claim:

1. A process for producing hollow metal articles from heat-resistant metal which comprises in combination the steps of hot working a billet of heat-resistant metal filled with a ferrous filler, pretreating the formed heat-resistant metal containing said ferrous filler by subjecting it to a chemical etching treatment in an aqueous acidic medium to remove the surface layer therefrom, and thereafter removing said ferrous filler from said formed heat-resistant metal by selectively leaching said ferrous filler in an acidic medium.

2. A process for producing hollow metal articles from heat-resistant metal which comprises in combination the steps of hot working a billet of heat-resistant metal filled with a ferrous filler, pretreating the formed heat-resistant metal containing said ferrous filler by subjecting it to a chemical etching treatment in an aqueous solution of acid selected from the group consisting of sulphuric acid, hydrochloric acid and nitric acid, which contains between about 50% to about 60% free concentrated acid, to remove the surface layer from said formed heat-resistant metal and thereafter removing said ferrous filler from said formed heat-resistant metal by selectively leaching said ferrous filler in an acidic medium.

3. A process as set forth and described in claim 2 wherein the aqueous acidic solution is maintained at a temperature between about 95° C. and about 102° C., and the formed heat-resistant metal is treated therein for a time between about 10 and 20 minutes.

4. A process for producing hollow metal articles from heat-resistant metal which comprises in combination the steps of hot working a billet of heat-resistant metal filled with a ferrous filler, pretreating the formed heat-resistant metal containing said ferrous filler by subjecting it to a chemical etching treatment for about 15 minutes in an aqueous solution containing between about 50% to about 60% free concentrated hydrochloric acid to remove the surface layer therefrom, and thereafter removing said ferrous filler from said formed heat-resistant metal by selectively leaching said ferrous filler in an acidic medium.

5. A process for producing hollow metal articles from heat-resistant metal which comprises in combination the steps of hot working a billet of heat-resistant metal filled with a ferrous filler, pretreating the formed heat-resistant metal containing said ferrous filler by subjecting it to an electrochemical etching treatment in an aqueous solution of acid selected from the group consisting of sulphuric acid, hydrochloric acid and nitric acid, which contains between about 50% to about 60% free concentrated acid and which is maintained at a temperature between about 20° C. to about 25° C., to remove the surface from said heat-resistant metal, and thereafter removing said ferrous filler from said formed heat-resistant metal by selectively leaching said ferrous filler in an acidic medium.

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