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3,151,049

ELECTROLYTIC METHOD OF AND BATH FOR STRIPPING COATINGS FROM BASES

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This invention relates to an electrolytic method of and bath for stripping coatings from bases, and more particularly to stripping a substantially oxide-free, metal-containing refractory coating from a base material.

Many types of articles are provided with refractory coatings by for example, high temperature, high velocity coating processes such as detonation gun plating, jet-plating and arc torch methods. After these coated parts have been in service sufficiently long to wear to a point where replacement is necessary, it is desirable to have a method for quickly and economically removing the worn coating so that the base part can be coated again and placed back in service. In many instances the base part involves considerable expense in its original manufacture, so that reclaiming such parts can be of great importance. Also, in the course of applying refractory wear resistant coatings it may occasionally be necessary to remove coatings that do not meet specifications, in which case reclaiming the base part is again desirable.

The prior art has devised several methods of removing refractory coatings, including mechanical removal by grinding. On cylindrical parts, for example, the coating may be ground off down to the base metal with removal of a small amount of the base metal below the original dimension to insure complete removal of the old coating and permit recoating. It has been found, however, that such procedure is time consuming, expensive, and not always advisable since grinding away a portion of the base metal to insure complete coating removal prevents the reclaimed base material from conforming to the original dimensions as specified by its user. Also, parts which are not cylindrical often may not be ground. Improper coating of such parts may necessitate their replacement and scrapping of the original part with its attendant expense and time delay.

A known stripping method uses electrolytic solutions such as aqueous sodium hydroxide or sodium carbonate. The coated part is immersed in the bath and connected as the anode of an electrical circuit while the steel tank containing the bath is connected as the cathode. This method has been found satisfactory for removal of some coatings but is not suitable for stripping certain mixed refractory coatings such as tungsten carbide-chromium, carbide-nickel and chromium carbide-nickel-chromium. Also, the aforementioned sodium hydroxide or sodium carbonate electrolytic baths do not conveniently remove refractory coatings applied by the detonation plating process using inert gas dilution, as more fully described and claimed in copending U.S. Serial No. 738,283 filed May 28, 1958, in the name of J. F. Pelton, now U.S. Patent 2,972,550. Furthermore, no other known electrolytic baths have been found suitable for stripping these mixed refractory coatings, that is, the prior art solutions either completely fail to strip the coatings or only provide uneconomically low coating removal rates.

It is therefore a principal object of the present invention to provide an improved method of removing refractory coatings from all shapes of base materials in a rapid and economical manner without necessitating removal of any of the base material.

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A further object is to provide an electrolytic method of and bath for stripping difficultly removable metal-containing refractory coatings from base materials in a rapid and economical manner.

These and other objects and advantages of the invention will become apparent from the following description.

In accordance with one embodiment of the present invention, a method of electrolytically stripping a substantially oxide-free, metal-containing refractory coating from a base material is provided in which the coated base part is immersed as an anode in an electrolyte bath container, for example, in a steel tank serving as the cathode. Alternatively, a plate formed from steel or other suitable material such as carbon may be immersed in the bath and connected as the cathode. The bath consists essentially of about 0.02 to 2.0 mole percent of a soluble salt of an hydroxy organic acid, about 2.5 to 5.5 mole percent of an alkali metal carbonate and the remainder water. The aforementioned acid may either be monohydroxy or polyhydroxy and any soluble salt thereof is suitable, but the sodium, potassium and ammonium salts of tartaric and citric acid have been found especially appropriate. In particular, sodium tartrate is preferred since it provides the desired concentration with the smallest amount of raw material due to its lower molecular weight. Soluble salts of glycolic and tartronic acid might also be useful. Concentrations of the soluble salt below the lower limit of about 0.02 mole percent do not result in satisfactory stripping while concentrations above the upper limit of about 2.0 mole percent do not appreciably improve the stripping rate. A narrower range of about 0.2 to 0.9 mole percent of a soluble salt of a hydroxy organic acid is preferred.

Although sodium carbonate is preferred as the means of providing the stripping bath with the desired current carrying capacity, other alkali metal carbonates such as potassium carbonate would be suitable. Also, the expression "alkali metal" is to be understood as including the ammonium radical as a functional equivalent thereof. Concentrations below the lower limit of about 2.5 mole percent of the alkali metal carbonate result in prohibitively low current carrying capacity of the electrolytic bath, while concentrations above the upper limit of about 5.5 mole percent do not appreciably increase the current characteristics of such bath. A narrower range of about 3.0 to 4.6 mole percent of the alkali metal carbonate is preferred. Mutual solubility of the latter and the salt of a hydroxy organic acid in a common solution also has a moderating effect which helps to set the aforementioned composition limits.

The following tables indicate the effect of soluble salt of hydroxy organic acid and alkali metal carbonate concentration on electrolytic stripping rates.

TABLE I.—EFFECT OF HYDROXY ORGANIC ACID SALT CONCENTRATION

Salt (Mole Percent)	Approx. Stripping Rate (Inches Thickness/hr.)	Remarks
0	0.0006	Incomplete stripping and base metal stained.
0.04	-----	Complete stripping.
0.2	0.018	Complete stripping with base metal clean and bright.
0.5	0.022	Do.
1.0	0.010	Do.

TABLE II.—EFFECT OF ALKALI METAL CARBONATE CONCENTRATION

Carbonate (Mole Percent)	Approx. Stripping Rate (Inches Thickness/ hr.)	Remarks
0	-----	Low conductivity; slow removal.
1.1	-----	Do.
4.1	0.010	Complete removal, sur- face clean and bright.

The electrolytic bath of the present invention is the only solution which has been found suitable for removal of tungsten carbide-chromium carbide-nickel coatings on base materials, and in particular the preferred coating composition of about 70 weight percent of tungsten carbide, 24 weight percent of chromium carbide, and 6 weight percent of nickel. As more fully described and claimed in copending U.S. Serial No. 738,300 filed May 28, 1958, in the name of J. F. Pelton and J. M. Koffskey, Jr., now U.S. Patent 3,071,489, this preferred coating composition has improved oxidation resistance above about 1,000° F. and good resistance to attack by mild alkaline solutions. The present electrolytic bath is also the only solution which has been found suitable for removal of chromium carbide-nickel-chromium coatings on base materials, and in particular the preferred coating composition of about 85 weight percent of chromium carbide, 12 weight percent of nickel, and 3 weight percent of chromium. As more fully described and claimed in copending U.S. Serial No. 738,299 filed May 28, 1958, in the name of J. F. Pelton and J. M. Koffskey, Jr., now abandoned, this improved coating composition has desirable properties of high wear and oxidation resistance under severe conditions of high temperature and high load. It is especially useful for coating jet engine turbine blade spacers. It is to be understood that the aforescribed compositions refer to that of a powder mixture prior to high-temperature application, and that the actual composition of the resulting coating will be somewhat different from the starting compositions due to changes brought about by heating during the coating process.

The electrolytic stripping method and bath of the present invention may also be advantageously employed for removal of refractory coatings which can also be removed by known methods. For example, a tungsten carbide coating can be removed more rapidly by the present invention than by the prior art sodium carbonate electrolytic bath. Also, the base metal on parts stripped by the present method and electrolytic bath is clean and bright in contrast to black deposits present on the base metal using prior electrolytic methods.

While the invention is not to be limited thereto, the following theory is believed to provide an explanation of the improved operation of this invention. Many of the particular coatings that are conveniently stripped by this method and bath alone have an increased binder content as compared to other materials which can be stripped by the prior art methods. The available hydroxy groups of the soluble salts of hydroxy and polyhydroxy organic acids are believed to form ionized complexes with the binder material such as cobalt or nickel. These ionized complexes are then carried by the electrical current from the anode base part and deposited on the cathode. In contrast to non-ionized organic hydroxy compounds such as glycerine, the present salts are quite highly ionized and therefore provide high conductance and the necessary negative complexing ions to permit the metals to combine with the negative radical. The use of such salts in conjunction with an alkali metal carbonate also permits the high current densities required for rapid electrolytic stripping.

The temperature of the electrolytic bath may be maintained in a broad range of about 120° F. to 200° F. during the stripping operation. Also, when coatings are being stripped from steel base parts, the electrolyte temperature should preferably be maintained in the range of about 160° F. to 180° F. for best results. When coatings are being stripped from aluminum base parts, the bath temperature should be in the range of about 120° F. to 150° F. and preferably about 130° F. At this temperature a uniform polished appearance of the aluminum is obtained. At temperatures substantially below this value the stripping rate is decreased while at higher temperatures the aluminum begins to be attacked.

The current density preferred in the practice of the electrolytic stripping method of the present invention varies for different base materials, coating compositions, coating thickness and shape of part. Although current densities of 3 to 6 amperes per sq. in. have been used, the current could be increased up to the level at which the base material becomes severely attacked, and on the other hand could be reduced to a value at which the stripping time becomes impractically long. In practice, the current density is preferably adjusted to a workable value of about 3 to 4 amperes per sq. in. and the parts are then immersed in the bath. Depending on the coating and its thickness, some parts may be stripped in 30 minutes while other parts may take 8 hours or longer. Most of the base materials, and in particular the steels, appear to form a very thin oxide layer on the cleaned stripped base surface which prevents attack by the electrolytic bath. Thus, the finished parts can remain in the bath without damage after stripping is complete.

The present electrolytic bath is quite stable at operating temperatures against atmospheric oxidation and other destructive forces. It has been found that its useful life can be calculated on the basis that one pound of coating may be stripped by each 0.0036 lb.-moles of a soluble salt of a hydroxy organic acid in the bath.

During the stripping operation the base parts being stripped should be kept completely submerged at all times. Partial emergence of the coated part from the electrolytic bath can in some cases produce a serious corrosive effect on the base metal at the point of emergence. Care must also be taken to suspend the coated parts so that contact does not take place with the cathode tank to produce short circuiting and possible damage to the part.

The operation of the present invention is further illustrated by the following examples.

EXAMPLE I

Stripping of Chromium Carbide-Nickel-Chromium Coating

A steel round of about ½-inch diameter and having a 0.005 inch thick coating prepared from raw material having a composition of 85 weight percent chromium carbide-12 weight percent nickel-3 weight percent chromium was immersed as an anode in an aqueous electrolyte containing 1.02 mole percent (10 weight percent) dibasic ammonium citrate and 3.26 mole percent (15 weight percent) sodium carbonate. A steel container for the electrolyte was connected as the cathode. The electrolyte temperature was 150° to 180° F. The stripping operation was carried out at 6 volts D.C. and 11 amperes for a current density at the coating of about 4 amperes per sq. in. After 30 minutes the coating was completely removed and the base part remained clean and bright.

EXAMPLE II

Stripping of Tungsten Carbide-Chromium Carbide-Nickel Coating

A steel round of about ½-inch diameter having a 0.0015 inch thick coating prepared from raw material having a composition of 70 weight percent tungsten carbide-24 weight percent chromium carbide-6 weight percent

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nickel was immersed as an anode in an aqueous electrolyte containing 0.47 mole percent (5.0 weight percent) sodium tartrate hydrate and 3.08 mole percent (15 weight percent) sodium carbonate. A steel container for the electrolyte was connected as the cathode. The stripping operation was continued at 5.5 volts D.C. and 15 amperes for a current density at the coating of about 3 amperes per sq. in. After 10 minutes the coating was completely removed and the base metal was clean and bright. The electrolytic bath temperature was 170° to 172° F.

EXAMPLE III

Stripping of Tungsten Carbide-Cobalt Coating

A steel angle having a 0.027-inch thick coating prepared from raw material having composition of 91 weight percent tungsten carbide-9 weight percent cobalt and applied by the previously mentioned nitrogen diluted detonation plating process was immersed as an anode in an aqueous electrolyte containing 0.38 mole percent (5 weight percent) potassium sodium tartrate hydrate and 3.08 mole percent (15 weight percent) sodium carbonate. A steel container for the electrolyte was connected as the cathode. The electrolyte temperature was 150° to 185° F. The stripping operation was carried out at 5.0-5.5 volts D.C. and 21-22 amperes. After 50 minutes the coating was completely removed and the base metal was clean and bright.

EXAMPLE IV

Stripping of Tungsten Carbide-Cobalt Coating

An aluminum strip 4-inch long, 1-inch wide and 1/4-inch thick was coated on one side with a 0.030-inch thick coating prepared from raw material having composition of 91 weight percent tungsten carbide-9 weight percent cobalt and applied by the nitrogen diluted detonation plating process. This coated part was then immersed as an anode in an aqueous electrolyte containing 0.39 mole percent (3.5 weight percent) sodium tartrate and 3.38 mole percent (16.5 weight percent) sodium carbonate. A steel container for the electrolyte was connected as the cathode. The stripping operation was carried out at 5 volts D.C. and 15-20 amperes for a current density at the coating of about 4-5 amperes per sq. in. After 2 hours the coating was completely removed, and the base material was clean and bright. The base metal was only slightly attacked. The electrolyte temperature was 130° F.

EXAMPLE V

Stripping of Tungsten Coating

A brass cut about 1-inch diameter and 3-inch long having a 0.010-inch thick coating of tungsten was immersed as an anode in an aqueous electrolyte containing 0.39 mole percent (3.5 weight percent) sodium tartrate and 3.38 mole percent (16.5 weight percent) sodium carbonate. The electrolyte temperature was 140-155° F., and a steel container for the electrolyte was connected as the cathode. The stripping operation was carried out at 4.5 volts D.C. and 25 amperes. After 50 minutes substantially all the coating was removed and only slight attack to the brass resulted.

It is to be understood that certain modifications can be made to the specific forms of the invention as disclosed herein, without departing from the scope of such invention.

This application is a continuation of my co-pending application Serial No. 763,808, filed September 29, 1958, and now abandoned.

What is claimed is:

1. A method for electrolytically stripping a coating taken from the class of coatings consisting of pure refractory metals, and a mixture of at least 85 weight percent of a metal carbide and a metal; from a base metal taken from the class consisting of steel, aluminum and brass which comprises passing electric current at a current

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density sufficient to cause stripping from the coated base as an anode through a stripping solution in a temperature range of about 120° F. to 200° F., said stripping solution consisting essentially of about 0.02 to 2.0 mole percent of a soluble salt of a hydroxy organic acid, about 2.5 to 5.5 mole percent of an alkali metal carbonate and the remainder water.

2. A method for electrolytically stripping a coating comprising about 70 weight percent of tungsten carbide, 24 weight percent of chromium carbide and 6 percent nickel from a steel base material which comprises passing electric current at a current density sufficient to cause stripping from the coated base as an anode through a stripping solution in a temperature range of about 160° F. to 180° F., said stripping solution consisting essentially of about 0.02 to 2.0 mole percent of a soluble salt of a hydroxy organic acid, about 2.5 to 5.5 mole percent of an alkali metal carbonate and the remainder water.

3. A method for electrolytically stripping a coating comprising about 85 weight percent of chromium carbide, 12 percent by weight of nickel and 3 percent by weight of chromium from a steel base material which comprises passing electric current at a current density sufficient to cause stripping from the coated base as an anode through a stripping solution in a temperature range of about 160° F. to 180° F., said stripping solution consisting essentially of about 0.02 to 2.0 mole percent of a soluble salt of a hydroxy organic acid, about 2.5 to 5.5 mole percent of an alkali metal carbonate and the remainder water.

4. A method for electrolytically stripping a coating comprising about 91 weight percent tungsten carbide, 9 percent cobalt from a steel base material which comprises passing electric current at a current density sufficient to cause stripping from the coated base as an anode through a stripping solution in the temperature range of about 160° F. to 180° F., said stripping solution consisting essentially of about 0.02 to 2.0 mole percent of a soluble salt of a hydroxy organic acid, about 2.5 to 5.5 mole percent of an alkali metal carbonate and the remainder water.

5. A method for electrolytically stripping a coating comprising about 91 weight percent tungsten carbide, 9 percent cobalt from an aluminum base material which comprises passing electric current at a current density sufficient to cause stripping from the coated base as an anode through a stripping solution in the temperature range of about 120° F. to 150° F., said stripping solution consisting essentially of about 0.02 to 2.0 mole percent of a soluble salt of a hydroxy organic acid, about 2.5 to 5.5 mole percent of an alkali metal carbonate and the remainder water.

6. A method for electrolytically stripping a tungsten coating from brass base material which comprises passing electric current at a current density sufficient to cause stripping from the coated base as an anode to a stripping solution in the temperature range of about 140-155° F., said stripping solution consisting essentially of about 0.02 to 2.0 mole percent of a soluble salt of a hydroxy organic acid, about 2.5 to 5.5 mole percent of an alkali metal carbonate and the remainder water.

7. A method for electrolytically stripping a coating comprising about 70 weight percent of tungsten carbide, 24 weight percent of chromium carbide and 6 percent nickel from an aluminum base material which comprises passing electric current at a current density sufficient to cause stripping from the coated base as an anode through a stripping solution in a temperature range of about 120° F. to 150° F., said stripping solution consisting essentially of about 0.02 to 2.0 mole percent of a soluble salt of a hydroxy organic acid, about 2.5 to 5.5 mole percent of an alkali metal carbonate and the remainder water.

8. A method for electrolytically stripping a coating comprising about 85 weight percent of chromium carbide, 12 percent by weight of nickel and 3 percent by weight of chromium from an aluminum base material which com-

prises passing electric current at a current density sufficient to cause stripping from the coated base as an anode through a stripping solution in a temperature range of about 120° F. to 150° F., said stripping solution consisting essentially of about 0.02 to 2.0 mole percent of a soluble salt of a hydroxy organic acid, about 2.5 to 5.5 mole percent of an alkali metal carbonate and the remainder water.

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