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METHOD OF CLEANING FERROUS METAL OBJECTS

Graham L. Gulick, 33 Union Ave., Bala-Cynwyd, Pa.

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1 Claim. (Cl. 204—145)

This invention relates to a method of removing scale, rust or other corrosion products, also certain electroplated surface films and the like from surfaces of ferrous metal articles or alloys thereof.

It has heretofore been suggested that the surface of an iron or steel article can be cleaned by immersing the article in an aqueous solution of sodium hydroxide and sodium cyanide, and passing an alternating current through the article to be cleaned, the aqueous solution, to an electrode. However, the sodium cyanide bath is toxic and accordingly presents special problems both in the operation of the bath and in its ultimate disposal. Furthermore, the parent metal is subject to attack as iron reacts with alkali cyanide to form alkali ferrocyanide.

Other methods of cleaning iron and steel articles have been proposed, but it is an object of this invention to provide a method giving radically improved results.

More particularly, it is an object of this invention to provide an improved process which is of a substantially universal nature in removing rust, scale and corrosion products with equal ease. Still another object is to provide a method of cleaning a ferrous metal object wherein the underlying base metal is not attacked and wherein the cleaned metal, after removal from the bath, is so conditioned that it resists corrosion and that it can readily be silver soldered, soft soldered electroplated or that other surface coating operations can be performed once the cleaned object is removed from the bath and given a swill in cold water.

Still another object of this invention is to provide an electrolytic method of removing rust, scale and the like from the surface of a ferrous metal object, which method uses easily available and relatively inexpensive alternating current as distinguished from the direct current of either fixed polarity or periodic reverse polarity required by most processes of the prior art.

Other processes of the prior art have required the use of a separate chelating or complexing agent for preventing the staining of clean surfaces, and it is another object of this invention to provide an improved process of this kind having the advantage that no such separate chelating or complexing agent is required, this function being performed by the reaction products of the essential ingredients disclosed.

Still another object of this invention is to provide a method of this type, using a solution in which the compounds removed from the cleaned metal surface have limited solubility in the bath liquid and tend to settle to the bottom as sludge without interference with the operation of the process.

Still another object of this invention is to provide a process as referred to above wherein spent ingredients of the processing solution may inexpensively be regenerated. Other objects and advantages of this invention, including the simplicity and economy of the same, and the ease with which it may be applied to a variety of ferrous metal objects, will further become apparent hereinafter.

In accordance with the method of this invention, a ferrous metal object is immersed in an aqueous solution of sodium hydroxide and an amine, triethanolamine being a preferred example, and an alternating electric current is passed through the solution.

Although the composition of the bath in accordance with the process of this invention may be varied considerably, the bath must be an aqueous solution of an alkali metal hydroxide such as sodium, potassium or lithium hydroxide or the equivalent. Incorporated into this solution is a tertiary amino alcohol having nitrogen bonded directly to terminal carbon atoms of three saturated hydrocarbon chains which each have a single OH group bonded to a carbon atom other than that bonded to the nitrogen and where said chains contain from 2 to 4 carbon atoms.

When the amine is incorporated into the alkali metal hydroxide solution, the hydrogen atoms of the —OH groups are replaced by alkali metal until equilibrium is established between —OH and —ONa.

The preferred amine in accordance with this invention is triethanolamine, which is readily available and efficient. Triisopropanolamine is also effective and falls within the scope of this invention. Mixtures of various amines as defined above may also be used.

The relative proportions of ingredients of the bath may vary within wide limits, but it is preferred to employ a molar ratio of about three moles alkali metal hydroxide per mole amine.

The concentration of the solution may vary from as low as .3% alkali metal hydroxide and .5% triamine in the balance water up to about 30% alkali metal hydroxide and 47% amine in the balance water, all such percentages being calculated on a weight basis. The more dilute solutions are suitable for removal of light rust, particularly where time is not of the essence, while the more concentrated solutions provide very rapid cleaning and are particularly suitable for the removal of heavy coatings of mill scale, rust and the like.

The current applied to the bath is an alternating current, preferably sixty cycle current because of its ready availability. However, I have utilized four hundred cycle alternating current and the cleaning effect is greatly accelerated by using the higher frequency. Additionally, I have cleaned work in accordance with this process by using in induction field of a high frequency induction heat treating unit, and thus produced almost instant cleaning. I have also obtained excellent cleaning results using a low voltage secondary transformer having a maximum voltage of about seventeen volts R.M.S.

Although the work is cleaned with optimum economy and efficiency by connecting the work as an electrode, good cleaning results may be obtained by using a pair of spaced electrodes connected to opposite sides of an A.C. source and by simply placing the work in the bath between the electrodes, free of any electrical connection. Such an arrangement is desirable from a practical standpoint since the work can more easily be introduced into and removed from the bath.

The work may be placed in the bath in various ways without departing from the scope of this invention. I have obtained excellent results using carbon electrodes which are highly preferable to steel electrodes, and the shape of the electrode has considerable bearing upon the efficiency of cleaning. For example, flat electrodes produce the best results when the work is round, and round electrodes when the work is flat.

For optimum results, the work should be placed at a point substantially midway between the electrodes, and the electrodes should be placed as far away from the

work as is possible, to provide uniform cleaning over the entire surface of the work.

The current density may similarly be varied within wide limits. Using sixty cycle alternating current, and using two carbon electrodes each measuring 2" x 6", a current in excess of fifty amperes may be applied. The maximum current density may be over five thousand amperes per square foot of electrode. Using the work as one electrode, a maximum current density of about five thousand amperes per square foot may be employed. The current density may be reduced almost to zero, but cleaning is much slower.

A typical example of the practice of this invention follows:

Nine hundred ml. of tap water are placed into a one litre glass beaker. Thirty grams sodium hydroxide and seventy-five grams triethanolamine are stirred in until dissolved. Two carbon electrodes, each one measuring 2" x 6" x ¼", are placed in the beaker in such a way that opposed surfaces of maximum area lie parallel and spaced apart as far as the dimensions of the beaker allow. Electric conductors are connected from both electrodes to one side of an alternating current power supply having an adjustable output of from 10 to 17 volts. The other side of the power supply is connected to a cable fitted with a steel clamp at its terminus, which serves to support work to be cleaned and to establish electrical contact. The work to be cleaned is clamped firmly and placed in the bath between the two carbon electrodes, the power is turned on and work is kept immersed until clean.

The procedure outlined above was followed, using a variety of processing baths. The following table sets forth the compositions of the specific baths and also the character of the results obtained.

Table

Bath No.	Molar Ratio			Molar Wt. Equiv.				Percent		
	TEA, 80%	NaOH, C.P.	H.OH Dist.	TEA, 80%	NaOH, C.P.	H.OH Dist.	Total	TEA, 80%	NaOH, C.P.	H.OH Dist.
1	1	3	5	187.5	120	90	397.5	47	30	23
2	1	3	10	-------	-------	180	487.5	38	25	37
3	1	3	20	-------	-------	360	667.5	28	18	54
4	1	3	50	-------	-------	900	1,207.5	16	10	74
5	1	3	100	-------	-------	1,800	2,107.5	9	6	85
6	1	3	500	-------	-------	9,000	9,307.5	2	1	97
7	1	3	1,000	-------	-------	18,000	18,307.5	1.1	.6	98.3
8	1	3	2,000	187.5	120	36,000	36,307.5	.5	.3	99.2

Bath No. 1 had a melting point of approximately 220° F., and produced very rapid cleaning. Bath No. 2 had a melting point of approximately 170° F., and produced very rapid cleaning. The melting point of bath No. 3 was below room temperature and baths 3 and 4 gave excellent and rapid cleaning. Bath 5 was very satisfactory, while bath No. 6 was satisfactory for very light scale and for a medium weight coating of rust. Bath No. 7 was quite slow for removal of rust and for most scale. Bath No. 8 was suitable for light rust only and was very slow.

Operating temperatures for the bath, at which satisfactory cleaning takes place, from the standpoint of surface finish, range from 15–20 to 90–100 degrees centigrade. Excessive time is required at the lower temperatures, however, and the most satisfactory temperature range lies from about 60 degrees on up to boil.

One specific use for which this invention was developed was to clean ball and roller bearing components after heat treat, oil quench and anneal operations. This cleaning method is very rapid in its operation while at the same time being very thorough. All recesses, grooves, etc., are de-scaled almost as rapidly as the outer surfaces. A steel bearing race of ¾ inch O.D., ⅝ inch I.D., ¼ inch high; coated with scale, carbonized oil, etc., may be cleaned in less than one-half minute, at which time its appearance is that of a like object made of silver.

Typical objects that were cleaned with this bath were black steel pipe cut in short sections for convenient handling, bolts, nuts, and bearings that have been heat treated as well as bearings which have become rusted, tools such as micrometers and gauges and the like which have become rusted, steel strapping that is used in shipping bales and bundles and packages, metal which has been blackened by rust proofing processes and the like, black iron screws, and heat treated hack saw blades which have been painted.

In accordance with my invention, the work may be connected directly by external means to one side of the alternating current line, or the two electrodes may be connected one each to the two sides of the line and the work placed in the bath without external connection, depending upon the current induced in the work by the flow of current between the electrodes.

Faster results are to be had by connecting the work directly to one side of the alternating current line rather than depending upon the current induced by current flow between the electrodes for supplying the energy needed for cleaning. However, either arrangement gives satisfactory results if time and power consumption are not important factors.

The time required to clean a piece of one-eighth inch pipe over six inches long in the bath at the highest concentration which I have reported in the foregoing table is approximately fifteen seconds. The time increases as the concentration of triethanolamine-sodium hydroxide reaction compound decreases, but in other baths which I have considered satisfactory, the time to clean this ⅛ inch pipe six inches long has run approximately 1 to 1½ minutes.

There is apparently no destruction or dissolution of the parent metal by this process, as is the case when cyanide solutions are used. Pieces of steel left in the bath for a considerable length of time (up to fifteen hours or more), and then measured by a micrometer indicate no measurable difference in length or width, nor is there any weight change once the piece is cleaned and then replaced in the bath for a considerable length of time such as fifteen hours or more.

According to my process, the surface of the metal is so cleaned that it has a silver colored appearance and is considerably more resistant to corrosion than it would have been had the scale been cleaned off with emery cloth. It is my belief that there is a change in the surface charge in the metal which is at least partially responsible for this result although this theory has not been scientifically established. However, it has been established that perfectly clean metal produced by my process, immersed in tap water, rusts much less than metal which has been cleaned by mechanical abrasion and immersed in the same tap water.

Although various forms of this invention have been referred to in particular terms herein, it is to be ap-

preciated that various modifications may be resorted to without departing from the scope of this invention. For example, equivalent chemicals and currents may be utilized, and various features may be used independently of the use of others, all without departing from the spirit and scope of this invention as defined in the appended claim.

Having thus described my invention, I claim:

In a method of cleaning a ferrous metal object, the steps which comprise immersing said object in an aqueous solution consisting essentially of .3–30% alkali metal hydroxide and about .5–47% by weight of a tertiary amino alcohol having nitrogen bonded directly to terminal carbon atoms of three saturated hydrocarbon chains

which each have a single OH group bonded to a carbon atom other than that bonded to the nitrogen and where said chains contain from two to four carbon atoms, and subjecting said solution and the object immersed therein to a high frequency induction field by passing alternating current of at least 400 cycles per second through said solution and object.

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