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COMPOSITION AND METHOD FOR PREPARING METAL FOR COLD-WORKING

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10 Claims

ABSTRACT OF THE DISCLOSURE

Metal is prepared for cold working by coating it with an aqueous, soap-base lubricant comprising a meltable, water-soluble inorganic pigment, preferably borax and sodium nitrite, preferably a high molecular weight ester of a phosphoric acid, and at least one of the group consisting of water-swellaible organic polymers, and hydrophilic colloids or hydrophilic carbohydrates to increase viscosity. Said coating is applied under conditions wherein the metal is heated above 150° F., preferably 170 to 210° F., excess water is vaporized, and a molten soap base film is produced. The film is then rapidly and artificially cooled, as with air jets, to convert the film to the solid state to prevent growth of precipitated pigment crystals.

This invention relates to methods for and compositions suitable for the drawing and working of metal. It particularly relates to compositions which form non-tacky, dry films so that coated metal articles such as sheets or strips do not adhere together when they are stacked or coiled.

In the drawing of metal, the most satisfactory process of lubrication heretofore has been a process such as described in the Henricks Reissue Patent 24,017, wherein the metal is first coated with an integral layer of an iron salt, such as a zinc-iron phosphate, iron oxalate or sulfide and then a fixed film, comprising an organic binder, such as dried soap, and a fusible pigment, such as borax, is superimposed thereover. A hot, aqueous solution is applied over the surface of the phosphate or integral iron salt and the fixed film is formed either by heating the coated metal or a simple drying procedure.

While the aforementioned process has been markedly successful in the past, it has involved the application of a phosphate coating of the metal as well as the application of the lubricant. Treatment of the metal by a dual coating process is not desirable and has added to the cost. In addition, the application of phosphate coatings has contributed substantially to pollution problems because of the sludge that is necessarily formed in the various phosphate treatments. This sludge must be removed periodically or entire coating baths must be dumped.

It is an object of the present invention to provide a method of preparing metal for drawing which does not require the formation of an integral layer of phosphate or other iron salt and which forms a protective lubricating coating on the surface of the metal both before and after a metal-working operation is performed.

Another object of the present invention is to provide a method of working metal, particularly ferrous metal, wherein marked economies, such as improved die life, superior surface finish and other advantages result.

A still further object of the present invention is to provide compositions suitable for application to clean metal and which form a solid non-tacky layer on the metal that permits metal working for long periods after the coating has been applied to the metal and which permits stacking of coated metal without causing sticking together of the adjacent coated surfaces.

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Other objects will be apparent from the following more detailed description of the invention.

I have found that with certain pigmented soap-base compositions that a substantial improvement in lubricity of the type required for metal working or drawing occurs if the composition applied from the hot, aqueous solution to the surface of the metal is rapidly cooled on the metal surface from the liquid state by suitable means such as a stream of cooled air or the like. This is particularly the case when a hydrophilic colloid, such as, a highly water swellaible organic polymer or a hydrophilic carbohydrate base colloid is used to increase soap viscosity and increase film thickness. It appears, by rapid cooling of the molten coating on the surface of the article to be thereafter cold-worked, that the ingredients are maintained in a more finely dispersed condition, or in a condition analogous to a solid solution where they are more effective lubricants.

The compositions which I have found to provide this unique result comprise essentially (1) a water-soluble binder which is principally a water-soluble soap and which preferably contains a small proportion of (2) one or more hydrophilic colloids such as a water-soluble or water-soluble waxy polymeric material, such as carbowax (a high molecular weight, polyethylene glycol), polyvinyl alcohol and hydrophilic carbohydrate-base colloids, such as the amylose fraction of corn starch, methyl cellulose, carboxyethylcellulose and the like (3) at least one fusible, water-soluble pigment, such as borax, that normally contains water of hydration or preferably a mixture of borax and alkali metal nitrite and (4) preferably a finely divided water insoluble solid, thermoplastic, organic polymer such as PVC (5) preferably a small amount of a high molecular wt. organo-phosphate ester and (6) preferably some dispersed water insoluble soap. The water-soluble binder usually amounts from about 5 to about 45 or 50% of the weight of the composition and preferably is from 11 to 35% of the weight of the composition. The binder provides a triple function of (a) maintaining the other ingredients, including pigments in proper place on the surface of the metal (b) in providing a great portion of the lubrication at lower portions of the temperature range during the drawing process and (c) protecting the metal. The binder is primarily a high titer tallow soap, preferably a high titer sodium tallow soap. It preferably also comprises a small amount (i.e. always less than 1/2 the weight of the water soluble soap) of and preferably about 1 to 5% of the weight of the dry composition of a hydrophilic colloid such as a solid water-soluble to water-swellaible polymer having a plurality of ether or ester linkages, polyvinyl alcohol, and the hydrophilic carbohydrates above mentioned.

The water-soluble, fusible, inorganic pigment in the composition constitute in their hydrated state (i.e. with water of hydration present) the major portion of the dry weight of the total dry ingredients of the composition and preferably constitute 60 to 75 or 80% of weight. At least a major portion of the preferred fusible and water-soluble pigment is borax which is preferably 55 to 75% of the composition. When the water-soluble pigment present comprises an alkali metal nitrite, such as sodium nitrite, potassium nitrite or lithium nitrite, improved results are obtained for some unknown reason. It may be that the nitrite has a catalytic effect or assists in forming a eutectic with the borax to decrease melting temperatures. The alkali metal nitrite is preferably about 1 to 5% of the weight of the dry ingredients (including $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$). A water-insoluble soap (i.e. a polyvalent metal salt of a fatty acid) such as calcium, aluminum, barium and magnesium stearates, in a finely divided, dispersible form also adds to the efficiency of the composition for extreme cold work, such as, drawing or cold working of steel. Such water insoluble soaps act as pig-

ments in the fixed film formed in accordance with the present invention.

Finely divided thermoplastic high polymers, particularly those of high polarity, such as polymers and copolymers of one or more of vinyl chloride, acrylonitrile, acrylic acid, maleic and fumaric acids and anhydrides also are found to further substantially enhance the lubricating aspects of the dry or fixed films formed on the metal. The polar copolymers may be formed by copolymerizing a polar monomer, such as one of the above with another vinyl monomer, such as vinyl acetate, acrylic and/or methacrylic esters, styrene etc.

Phosphate esters of mono or polyhydric alcohols, particularly those having relatively high molecular weight, are also found to have a dual function. They improve both lubrication at elevated temperatures and also improve rust or corrosion resistance of the coated metal both before and after drawing. The phosphate esters should have a molecular weight of at least 400 and molecular weights of 600 and higher are preferred. Those phosphate esters of long chain aliphatic alcohols are preferred over those of equivalent weight having substantial aromaticity.

In the application of the lubricants the metal which is preferably in a clean state, as obtained immediately after roll reduction or after a pickling operation, is coated in any suitable way, as by dipping, spraying or roller coating it with a hot aqueous solution of the above described lubricant. The concentration of the above mixture of solid materials in the hot aqueous solution may be varied widely and determines in large measure the thickness of the film on the metal workpiece. Heavier films are usually desired for the more extensive draws or when successive cold working steps are provided. Usually the concentration of above solids is about 2 to 24 oz. per gallon of water, but concentrations of 12 to 16 oz. per gallon is ideal for most applications and is preferred. The metal and lubricant should be above 150° F. and below boiling temperature of the aqueous liquid when the film is first permitted to dry. It should preferably be between about 170° F. and 200° F. Such temperature is best obtained by passing the metal workpiece through a bath of hot aqueous liquid heated to almost boiling temperature or at about 170°–200° F. for a sufficient time to permit temperature of the metal to reach the desired range. Upon withdrawing the workpiece from the bath, the heat retained therein is usually sufficient to vaporize excess water and leave a melted layer or film comprising the solids of the composition.

I have found that a rapid cooling of the molten film thus produced greatly improves the lubricating and protective properties thereof. The cooling is preferably accomplished by blowing a strong stream of air or other gas over the molten film. The gas is preferably cooled well below room temperature either by normal expansion from the precompressed state or by being previously passed through a suitable refrigeration zone. The temperature of the gas as emitted from jets directed against the molten surface of the lubricant on the work piece should usually be less than 20° C. and should preferably be less than 15° C. The rapidity of cooling is also a function of velocity at the film surface and velocity should be sufficient to rapidly solidify the melted film.

The following examples in which parts are by weight illustrate the invention.

EXAMPLE I

	Parts by wt.
High titre tallow soap	10 to 30
Carbowax 4000 (polyethylene glycol 4000 M.W.)	1 to 5
Dispersible calcium stearate	1 to 5
Sodium nitrite	1 to 5
Borax ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$)	65 to 75
Polyvinylchloride powder	1 to 5

The above materials are mixed together dry and slowly added with stirring to water heated to 170° to 212° F. in the ratio of 12 to 16 oz. of the above solids to each gallon of water.

A ten-gauge steel strip which was previously cleaned is passed slowly through a bath of the solution or dispersion of the above that is maintained at 170° to 200° F. The strip is withdrawn substantially vertically from the bath permitting excess liquid to drain off. The film remaining rapidly loses moisture because of the heat retained in the metal and a film appearing wet because of its molten condition is formed. The metal strip with molten film on opposite sides is then passed between a series of high velocity air jets (not shown) which are directed against and impinge relatively uniformly against all faces of the metal, whereupon the molten film rapidly solidifies. The rapid solidification prevents or decreases separation or agglomeration of precipitated solids and liquids and retains materials in a more finely dispersed condition.

The metal thus coated is allowed to stand in coil form at room temperature and thereafter it is deep drawn into cup-shaped articles having excellent surface characteristics. The die-life of the drawing dies between honing operations is also greatly extended.

EXAMPLE II

One to five parts of a finely divided solid polyvinyl-methylether is added to the composition of Example I, other conditions and quantities remaining the same. Substantially equivalent results were obtained.

EXAMPLE III

One to five parts of fatty alcohol-phosphate ester having a molecular weight of about 700 and known as Antara L.P. 700 are added to the composition of Example I, other quantities remaining the same. The lubricity and corrosion resistance of the coated article is considerably improved without impairment of the non-tacky surface properties.

EXAMPLE IV

To the composition of Example III is added 1 to 5 parts of a finely divided water-swellaable to water-soluble polymer starch obtained under the trademark Amisol 1988, other ingredients remaining the same. The results were substantially identical with those of Example III.

EXAMPLE V

	Parts
Carbowax 4000	1 to 5
Poly vinyl chloride (powder)	1 to 5
High titre tallow soap	10 to 30
Borax	65 to 75
Sodium nitrite	1 to 5

The above ingredients were substituted for an equal weight of the mixture of Example I—other conditions and procedures remaining the same. About equivalent results were obtained.

EXAMPLE VI

	Parts
High titre tallow soap	25.5
Sodium nitrite	3.5
Antara L.P.—700 (high M.W. organic alcohol esters of phosphoric acid)	3.5
Amisol 1988 (polymeric starch)	5.5
Borax (5 mole.) $\text{Na}_2\text{B}_4\text{O}_7 \cdot 5\text{H}_2\text{O}$	62

The above ingredients were substituted for those of Example I using same detectors with water. Results obtained were substantially the same as those of Example III.

In the above example the high titre tallow soap may be substituted in whole or in part by other high titre soaps with about equivalent results. High titre soaps are pre-

ferred because the film is harder and the coated material may be stacked without adhesion of coatings. In cases where stackability is not a strong consideration, low titre soaps or soap mixtures may be substituted.

While the above compositions are especially suited for cold working of ferrous metal, such as steel, they may also be used on other metals such as aluminum, copper, magnesium etc.

It is also apparent that in accordance with the provisions of the patent statutes, modifications of invention may be made without changing the spirit thereof.

In the accompanying claims the term polymer is used in the generic sense to include copolymer.

Having described my invention I claim:

1. A process for preparing metal for cold working which comprises applying on surface portions of said metal while it is at a temperature above 150° F., an aqueous solution comprising about 2 to 24 ounces per gallon of dissolved solids which consist essentially of (a) about 5% to 45% by weight of a water-soluble high titre alkali metal fatty acid soap and from 1% up to 50% of the weight of said soap of a hydrophilic protective colloid and (b) from at least 50% to about 80% by weight of a water-soluble fusible inorganic pigment at least 50% of which is an alkali metal borate, said percentage being based on the hydrated formula $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$, permitting excess water to vaporize while leaving on said metal a dried molten film formed from the composition and then rapidly cooling said film from the molten state to the solid state by applying thereon a jet of gaseous fluid having a temperature below the fusion point of the water-soluble soap.

2. The process of claim 1 wherein said water-soluble soap is a high titre tallow soap, and is principally a sodium soap, said pigment comprises borax and sodium nitrite.

3. The process of claim 2 wherein the weight of the water-soluble pigments in said composition is 60% to 75% of the dry weight of the solids of said composition.

4. The process according to claim 2 wherein said coating composition on a dry basis comprises 10 to 30 parts of a water-soluble high titre fatty acid soap, 1 to 5 parts of an alkali metal nitrite, 1 to 5 parts of a hydrophilic colloid selected from the group consisting of solid polyethylene glycol, the amylose fraction of starch, polyvinyl alcohol, methyl cellulose, and carboxy ethyl cellulose, 1 to 5 parts of a finely divided thermoplastic polymer selected from the group consisting of polymers of vinyl chloride, acrylonitrile, acrylic acid and maleic and fumaric acids and anhydrides and 60 to 75 parts of borax.

5. The process of claim 4 wherein the composition also comprises 1 to 5 parts of a fatty alcohol ester of phosphoric acid, said ester having a molecular weight of at least 400 and 1 to 5 parts of a water-insoluble, fatty acid soap of a polyvalent metal selected from the group consisting of calcium, barium, aluminum, and magnesium.

6. A process for drawing metal which comprises forming a solid coating on surface portions of the metal according to claim 1 and thereafter drawing the metal.

7. A lubricating and protective film on metal that may be subject to cold work, said film being of a composition comprising about 10 to 30 parts of a high titre alkali metal fatty acid soap, 60 to 80 parts by weight of a meltable, water-soluble inorganic pigment of which a major portion is an alkali metal borate, 1 to 5 parts of a high molecular weight solid, water-insoluble thermoplastic polymer of an olefinic compound selected from the group consisting of vinyl chloride, acrylonitrile, acrylic acids and maleic and fumaric acids and anhydrides, 1 to 5 parts of a fatty alcohol ester of phosphoric acid having a molecular weight of at least 600 and 1 to 5 parts by weight of an alkali metal nitrite, and 1 to 5 parts of at least one hydrophilic colloid selected from the groups consisting of solid polyethylene glycol, the amylose fraction of starch, polyvinyl alcohol, methyl cellulose, and carboxy ethyl cellulose, said film being produced by the procedure of claim 1.

8. A process according to claim 1 wherein the lubricant film is increased in thickness by incorporating into the said coating composition a dispersion of a hydrophilic carbohydrate colloid.

9. The process of claim 8 wherein said colloid comprises the amylose fraction of starch.

10. The process of claim 6 wherein said coating composition on a dry basis comprises 10 to 30 parts of a high titre sodium soap, 1 to 5 parts of an alkali metal nitrite, 1 to 5 parts of a solid polyethylene glycol, 1 to 5 parts of a finely divided water-insoluble thermoplastic polymer of a monomer selected from the group consisting of vinyl chloride, acrylonitrile, acrylic acid, maleic and fumaric acids and anhydrides, and 60 to 75 parts of borax.

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