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DRAWING LUBRICANT COATING COMPOSITION

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6 Claims. (Cl. 252—34.7)

This invention relates to improved metal working lubricants. More particularly, the invention relates to compositions for producing so-called "dry lubricant coatings" on metal surfaces to provide lubrication during subsequent metal working operations.

This application is a division of application Serial No. 794,166, filed February 18, 1959, for Drawing Lubricant Coating Methods and Compositions, which was issued on December 27, 1960 as U.S. Patent No. 2,966,425.

The principal objects of the present invention are to provide an improved dry lubricant coating on metal surfaces through the use of cleaning and coating solutions which do not have to be held at an elevated temperature during application; to provide coating compositions which may be applied to the metal surface and dried quickly and with a minimum of equipment occupying a minimum of floor space; to provide coating compositions which can be so applied and dried using existing conventional equipment; to provide dry lubricant coatings on metal surfaces which will dry quickly and be effective throughout all stages of a multiple stage drawing operation; and to provide lubricant coatings which will not build-up in the draw dies to cause interference in the fabrication of the metal, such as imprint damage.

The advantages flowing from the invention are of particular importance in highly automated production lines in which metal sheets or continuous metal strips are moved substantially continuously at high speed from a supply point along a production line through cleaning, coating, drying, and single-stage or multiple-stage metal drawing machines.

Metal drawing lubricants are generally classified into two groups commonly referred to as "wet lubricants" and "dry lubricants." Both types are applied as liquids, the wet lubricant remaining liquid, but the dry lubricant being dried to form a solid film. The dry lubricant compositions are commonly applied as hot liquids, either as heated solutions or as hot melts depending upon the particular components therein.

The wet lubricants have been more widely used since a minimum amount of floor space and equipment is required for the application of the coating compositions. These lubricants usually are applied by spraying, manual swabbing, or with a roller. Spraying is not completely satisfactory since there is a great deal of waste due to over-spraying and loss of vapor to the surrounding atmosphere. As a rule, only about one-third of the sprayed material actually is retained on the surface of the metal. Manual swabbing or brushing requires the employment of additional manpower for the application of the coating composition and, therefore, is considered undesirable. Application of the coating composition by coating with a roller provides the most efficient utilization of the coating material. However, roller coating generally cannot be employed with wet lubricants in multiple-stage drawing operations since the wet lubricant must be reapplied after each drawing stage, and there is insufficient space to permit roller coating between stages, quite apart from the fact that the metal is no longer flat after the first draw and hence is difficult to roller coat. Reapplication of coatings after each draw, therefore, must generally be either by swabbing or spraying.

To permit roller coating in multiple-stage drawing operations, it has been proposed to employ dry lubricants. Generally, one application of a dry lubricant is sufficient for all of the drawing stages, and no lubricant need be added between stages. However, the use of dry lubricants creates a number of new problems.

The application of a dry lubricant to a metal surface requires, in addition to the coating step, a drying step and, in many cases, also a precleaning step. The precleaning step is necessary since dry lubricant coatings do not satisfactorily adhere to the metal surfaces unless the surfaces to be coated are substantially free of oil and other similar contaminants. This cleaning operation generally is accomplished by spraying a hot alkali solution onto the metal surface while brushing or otherwise scrubbing the surface. Although the hot alkali solution successfully removes the contaminants from the metal, any alkaline solution remaining on the metal surface after the treatment severely reduces the lubricity of the subsequently applied lubricant film. Thus, it is necessary to wash the metal surface with water to remove any traces of the alkaline cleaning solution before the coating composition is applied. The equipment necessary to perform the alkali precleaning operation occupies a substantial amount of floor space (for example, a space approximately 8 to 10 feet in length and wider than the metal sheets). The large amount of floor space required by the cleaning equipment and by the coating and drying equipment is a deterrent to the application of dry lubricant coatings in continuous metal drawing production lines.

Since the effectiveness of conventional dry lubricant films is dependent upon the degree of dehydration of the film, the lubricity of the film increasing as the amount of residual water decreases, it is necessary to remove substantially all of the water from the film. The removal of water from prior dry coatings, however, has been difficult since the coating compositions have a marked tendency to congeal as they cool from the elevated temperatures at which they are applied. In congealing, a substantial amount of water is trapped in the film and removal thereof requires drying at relatively high temperatures and/or for long periods of time. This same tendency of the dry coating solutions to congeal as they cool requires troublesome control of temperatures of the solutions while in use and draining and cleaning of the solutions from the applying machines prior to shutdowns at the end of a day or over holidays and week ends.

In high temperature drying of the applied dry coating solutions, the metal is necessarily also heated. However, if the metal becomes too hot, workmen are not able to handle it efficiently even with special protection against the heat. Moreover, before fabrication of the metal can be started, the metal should be allowed time to cool, since the fabrication of hot metal causes the build-up of excess heat in the metal working tools or dies, resulting in excessive wear. The necessity for a metal cooling step makes a continuous coating and drawing process impractical in many plant operations. Another difficulty arises if the metal has been passed through a roller-leveler machine to remove age-hardening prior to coating, since any long delay at elevated temperatures before fabrication, e.g., a period of the order of eight hours or so, will result in a loss in the beneficial effects of the roller leveling step. Thus, close supervision and control of the process must be maintained to insure sufficient cooling of the metal while making sure that fabrication is completed before age-hardening of the metal becomes significant.

From the above discussion, it will be apparent that, although satisfactory lubricant coatings for particular drawing operations could be obtained heretofore, the prior coating compositions were quite inflexible as regards the

conditions under which they could be used and the methods by which they could be applied, and as regards their adaptability to different kinds of metal fabricating operations. In particular, none of the prior coating systems has been easily adaptable for general use in continuous, high speed, highly automated production line operations.

By employing the compositions of the present invention, a number of specific important advantages are realized. The cleaning operation is simplified, the need for removing the cleaning solution is eliminated, and more thorough drying is rapidly accomplished. As a result, the compositions of the present invention enable the cleaning, coating, and drying operations to be completed within a much smaller floor space area than was previously required. This reduction in floor space facilitates incorporation of these steps into a continuous coating and drawing production line.

In addition, a number of unexpected advantages are realized from the present invention. The equipment preferably employed to accomplish the cleaning and coating steps is of a much lower cost, and much of the equipment used in prior processes and, therefore, available in many plants, may be used with little or no change. Since both the cleaning and coating compositions can be easily and simply applied to metal surfaces without the compositions having been previously heated to elevated temperatures, no preparation time is required to heat these compositions before starting operation; and since the solutions do no congeal upon standing, they may be left in the machine during a shutdown. Furthermore, the greater ease and speed of drying of the applied coating facilitate more complete water removal at lower temperatures and produce more effective lubricant films without causing any significant heating of the metal itself. As a result, the metal cooling step formerly required after the application and drying of dry lubricant compositions is completely eliminated. In addition, the lubricant-coated metal sheets of the present invention can be stored in stacks or rolls for extended periods of time, up to three months or so if desired, without deterioration of the coating or corrosion of the metal. Another advantage is the absence of coating build-up in the dies during fabrication, which build-up results in imprint damage on the surface of the metal.

In addition to all of the above advantages, the compositions of the present invention possess a high degree of flexibility as regards the processes and apparatus that may be used for the formation of the lubricant coatings on metal surfaces. This flexibility greatly facilitates adaptation of the invention to varying production line setups, even where there are severely limiting conditions as regards the space that is available, the kinds of existing cleaning, coating, and/or drying equipment that are available for use, the requirements of the subsequent metal forming operations, and the like.

The compositions of the present invention have particular value and special advantages when applied onto a surface of the sheet with pressure from a roller applicator surface at ambient temperatures so as to press a film of the composition into intimate contact with the surface of the sheet, and evaporating water from said film until the moisture content thereof is reduced to less than about 15% by weight, the temperature of the coating composition and the metal sheet at all times being maintained below about 150° F. Such a process is the subject of the claims of the above mentioned copending application Serial No. 794,166.

The coating compositions of the present invention are non-congealing, aqueous soap solutions comprising mixtures of an organic amine soap and an alkali metal soap, the soaps being formed with low titer fatty acids.

The soaps used in accordance with the present invention may be prepared using conventional soap-forming fatty acids having titers below about 30° C. These fatty acids may be mixtures of fatty acids derived from various oils, such as vegetable oils. For example, the acid mixtures derived from castor, coconut, palm kernel, linseed, olive, peanut, rape seed, corn, and soya bean oils are suitable. Also suitable are individual acids, such as oleic acid, ricinoleic acid, etc., which have been separated from fatty acid mixtures such as those mentioned above. In addition, fatty acids such as tall oil, which are formed as by-products of other reactions, also may be used.

The amines which are reacted with the low titer fatty acids to form the amine soaps may be any of the water-soluble organic amines having boiling points above about 100° C., for example, ethylene diamine, monoethanolamine, diethanolamine, triethanolamine, dimethyl ethanolamine, monoisopropanolamine, morpholine, and 2-amino-1-butanol. Particularly advantageous for use in high speed roller coating processes are coating compositions in which the amine soap is made with amines such as 2-amino-2-methyl-1-propanol; 2-amino-2-methyl-1,3-propanediol; and 2-amino-2-ethyl-1,3-propanediol.

The alkali metal soaps of the present invention may be any of the conventional sodium and/or potassium derivatives of the low titer acids.

The selection of a particular coating composition formulation is primarily dependent upon the fabricating operation which is subsequently to be performed on the metal, the deciding factor being the magnitude of the coefficient of friction between the work pieces and the tools. A method for evaluating this lubricant property is described in an article entitled "Sliding Friction Test for Metalworking Lubricants" by W. J. Wojtowicz, published in the May and June, 1955, issues of Lubrication Engineering.

As a general rule, in the cold drawing of heavy gauge metal, it is important that the lubricant coating provide maximum protection against scoring. In such cases, it is advantageous to employ a coating composition in which the proportion of alkali soap is relatively great. As the thickness of the metal decreases below about 0.060 inch (16 gauge), scoring becomes of secondary importance, and softer coatings such as those containing a high proportion of the amine soap may be utilized. Soft coatings are generally preferred where applicable because of their high degree of mobility and high film strength.

The following formulations, 1, 2, and 3 are examples of coating compositions which will produce films suitable for heavy gauge metal, whereas formulations 4, 5, 6, and 7 produce softer films suitable for lighter gauge metal:

		Percent
(1)	Triethanolamine	2.6
	Caustic potash	3.7
	Oleic acid	23.7
	Water	70.0
(2)	Monoisopropanolamine	1.5
	Caustic potash	3.7
	Oleic acid	24.8
	Water	70.0
(3)	2-amino-2-methyl-1-propanol	1.8
	Caustic potash	3.7
	Castor fataty acids	24.5
	Water	70.0
(4)	Triethanolamine	5.0
	Caustic soda	1.8
	Tall oil	23.2
	Water	70.0
(5)	Monoethanolamine	2.8
	Caustic potash	2.5
	Coconut fatty acids	24.7
	Water	70.0
(6)	Monoisopropanolamine	4.7
	Caustic soda	0.9
	Corn fatty acids	24.4
	Water	70.0

	Percent
(7) 2-amino-2-methyl-1-propanol	5.3
Caustic soda	0.9
Soya bean fatty acids	23.8
Water	70.0

The proportion of the alkali metal soap to the amine soap may be varied over a considerable range from approximately one part of the alkali metal soap to three of the amine soap up to approximately three parts of the alkali soap to one of the amine soap. In other words, the alkali metal soap may comprise between about 25% and 75% by weight of the total soap with the amine soap comprising the remaining 75% to 25%.

Although the above formulations each contain 70% water, the water content may be varied in actual operations over a wide range with amounts between about 50% and 95% by weight being generally employed, and amounts between about 70% and 90 or 95% being preferred. Changes in the proportion of water provide a simple and convenient means for controlling the film thickness in cases where film thickness is important. To facilitate shipping and storage of the coating compositions of the invention, more concentrated solutions containing less than about 50% water may be prepared and subsequently diluted before use. Surprisingly, even when the percentage of water is reduced to as low as 30% or so, there is generally no tendency for the composition disclosed herein to congeal. This characteristic permits greater flexibility in the selection of the specific formulation and coating method to be employed.

The proportion of water may be important when certain amine soaps are used. For example, when triethanolamine soaps are employed in the coating composition, there is an intermediate range of concentrations around 50% at which the composition becomes stiff, though it does not form a gel and thins out again at lower concentrations.

The coatings of the invention also may be modified by the incorporation of other materials in the coating compositions. For example, softer films may be produced by the incorporation of about 5% up to 10 or 15% of a suitable plasticizer. Among the suitable plasticizers are the water-soluble glycols and polyoxyethylene derivatives as well as the sulfonated or sulfated fatty oils.

Where the coated sheets are to be stacked for a period of time prior to fabrication, it may be desirable, in some cases, to incorporate an anti-blocking agent in the composition to minimize the sticking of one sheet to another. Suitable anti-blocking agents are those which are compatible with the coating compositions but which migrate to the surface of the coating to form a tack-free superficial film upon removal of moisture. For example, methyl cellulose and/or polyvinyl alcohol, when used in amounts by weight of from 5 to 15% (anhydrous basis), minimize the blocking of coated metal.

The coating compositions of the present invention also may be modified, if desired, with small amounts of other materials which are known to improve the drawing qualities of lubricants, for example, water-insoluble materials such as chlorinated oils, flowers of sulfur, colloidal graphite, etc.

Although the coating compositions of the invention are particularly adapted for use in the roller coating process briefly described above, the coating compositions provide certain advantages when employed in other methods of coating, such as spraying or dipping. The viscosity of the coating composition will vary depending upon the particular coating method employed. For example, the coating compositions used in the roller coating process may have viscosities in the range of about 20 to 200 centipoises at 70° F., while for dip coating the viscosity may be as high as about 1000 centipoises at 70° F., and for spray coating might approach 5000 centipoises at 70° F.

The dry lubricant coatings produced on metal sheets by the employment of the coating compositions of the present invention are water-soluble, thermoplastic films having a wax-like texture. In addition, the coatings are substantially free of inorganic salts which permit the coated metal to be welded without removal of the lubricant, whereas in the case of soap-borax dry lubricant coatings employed heretofore, it is necessary to remove the coating before welding. The lubricant films of the present invention have melting points in the range of about 150–300° F. as determined using the Dropping Point of Lubricating Grease Test Method, ASTM D566–42. They have hardnesses in the range of about 40 to 140 as determined by the Test for Needle Penetration of Petroleum Waxes, ASTM D1321–55T.

One of the advantages of employing the roller coating process to apply the coating composition of the invention is the fact that the metal sheets do not have to be thoroughly clean when the coating composition is applied thereto. This is in direct contrast to the dry lubricant coating processes employed heretofore, in which it was necessary not only to thoroughly clean the sheets prior to coating, but also to make sure that any cleaning agent on the sheets was removed.

If the surface of the metal contains large amounts of oil and/or other contaminants, the metal sheet should be cleaned to remove at least the excess of the oil and other contaminants before the application of the coating composition. However, it has been found that when only a relatively thin film of oil is present or is left on the metal surface, the application of a coating composition of the invention by roller coating without removing the oil film provides an adherent lubricant film on the metal. As the rolls apply the coating composition to the metal surface, the rolls break through the oil film and mix the oil into the coating composition. The coating composition, in turn, takes up the oil and makes it an integral part of the coating so that the oil will not interfere with the adhesion of the coating to the sheet.

The cleaning solution employed may be any one of the common metal cleaners, such as the aqueous or emulsion type cleaners. The cleaning solution, for example, may be an aqueous solution of one or more inorganic salts, such as the alkali carbonates or phosphates. Advantageously, a cleaning solution is selected which may be used without being heated so as to minimize any tendency toward reformation of age-hardening characteristics in the metal.

One of the important factors in selecting a cleaning solution is its ability to take up oils without emulsification of the oils in the solution. This characteristic permits easy separation of the oils from the cleaning solution so that the cleaning solution may be reused without purification merely by the addition of small quantities of water to replace any lost by evaporation. Generally, the oils and light dirt particles collected by the cleaning solution form a layer on the surface of the solution in the tank or reservoir in which the solution is stored. This permits the oils and light particles to be separated readily, e.g., by centrifuging, decanting, etc. Any heavy dirt particles settle to the bottom of the tank and may be removed periodically as needed.

The cleaning of the surface of metal sheets can be easily accomplished in conventional equipment already generally employed in connection with drawing operations. For example, the cleaning operation may be performed on a roller-leveler machine which is used to remove age-hardening characteristics by flexing metal sheets as they pass through the machine. This machine contains a pair of offset scrubbing brushes mounted one above and one below the path of the metal sheet near the entrance end of the machine, and a spray of the cleaning solution may be applied to both the top and bottom surfaces of the metal sheet at the point of contact between each brush and the sheet. In place of a roller-leveler machine, any apparatus containing similar scrubbing

brushes and at least one pair of driving rollers may be employed.

To insure that the lubricant coating on the metal sheet is uniform and adherent, it is important that any non-uniform accumulations of cleaning solution on the sheet, such as puddles, be removed prior to the coating step. This may be accomplished by the use of rubber squeegee rolls at the exit of the scrubbing machine, by blowing a blast of air against the surface of the sheet as it emerges from the scrubber, or by a combination of these steps. It is not necessary to remove all of the cleaning solution from the sheet, but it is important that the solution be uniformly distributed over the sheet.

As stated above, the coating composition is preferably applied to the surface of the metal sheet with suitable roller coating apparatus. Advantageously, the roller coater may be of a design similar to that described in U.S. Patent 2,774,684, to Fucinari. In this apparatus, a doctor roll is associated with each coating roll, and the coating composition is distributed on the coating roll by applying the composition at the juncture of the doctor and coating rolls. The pressure between the doctor and coating rolls determines the thickness of film applied to the metal sheet, and the thickness can be controlled by changing the pressure.

The thickness of the film applied to the metal sheet may be varied over a considerable range, depending upon the particular drawing operations to be performed. For example, satisfactory thicknesses for most fabricating operations will vary from about 0.00004 to about 0.0003 inch thickness corresponding to coating weights of between about 100 and 700 milligrams per square foot of surface.

One of the unexpected advantages in the employment of the coating compositions of the present invention is the complete flexibility in the starting-up and shutting-down of equipment. In the dry lubricant coating processes employed heretofore, it was necessary to drain the coating machines or else keep the machines heated even during relatively short shut-down periods to prevent the coating compositions from congealing in the apparatus. Moreover, if the coating machine was accidentally or intentionally permitted to cool and the lubricant coating composition congealed, it was then necessary to begin reheating the machine well before resumption of the coating operation. In contrast, the coating compositions of the present invention may be applied at ambient temperatures, e.g., in the range of about 50° to 110° F., and, since they are non-congealing in character, the process may be closed down for any length of time and started again with no expenditure of time or expense to prepare for shutting down the process or to prepare for resumption of operations.

After the film is applied to the metal sheet, the excess water therein is evaporated from the coating. The water may be removed merely by air-drying at room temperature or with moderate heat in a variety of ways, depending upon space limitations, speed of travel of the metal sheet, and the importance of limiting the temperature of the metal. Since the coating compositions of the present invention are non-congealing, the excess moisture in the applied coating can be removed relatively quickly merely by circulating air over the surface of the coated metal sheet at room temperature or at moderately elevated temperatures. By contrast, the dry lubricants employed heretofore quickly congealed and formed an impervious skin on the surface of the coating, making the removal of additional quantities of water difficult and the employment of relatively high temperatures and/or a long drying time essential.

Another unexpected advantage of the lubricant coatings of the present invention is that they possess a high degree of lubricity even when as much as about 10% to 15% by weight of water remains in the coating. As a result, the removal of water from the coatings is, advantageously, only continued until the moisture content of the coating is reduced to about 5 to 10%. This is in direct contrast to the previously known dry lubricants, which required substantially complete dehydration of the coating. This was because the lubricity of the coatings was reduced severely even when amounts of moisture as low as 5% by weight remained in the coatings. The retention of about 5 to 10% moisture in the coatings produced in accordance with the present invention, however, helps in maintaining the lubricity characteristics of the film at a high level and assists in the prevention of lubricant build-up on the draw dies.

When heat is employed to assist in the drying of the film, it is important that the amount of heat be controlled so that the temperature of the metal sheet will not exceed about 150° F. Advantageously, the temperature of the metal is kept below about 120° F. Since the metal is not permitted to absorb any significant amount of heat, the drawing operation can be performed as soon as the excess water has been removed without causing the draw dies to overheat. Overheating may cause press control problems and may lead to scoring, and even breakage, of the draw parts. In addition, difficulties in the handling by workers of metal which is too hot are not encountered, and reformation of age-hardening characteristics in the metal is minimized.

From the above description, it will be apparent to one skilled in the art that many modifications of the invention may be made while accomplishing some or all of the various objects and advantages of the invention described herein. Therefore, the invention as defined by the appended claims is intended to cover all such modifications and equivalents of the illustrative details described herein.

What is claimed is:

1. A coating composition for the formation of metal working lubricant films consisting essentially of a non-congealing aqueous solution of an amine soap and an alkali metal soap which have been formed from fatty acids having a titer below about 30° C., said amine soap being formed from a water-soluble aliphatic amine having a boiling point above about 100° C., said amine soap comprising between about 25% and 75% by weight of the total soap, the proportion of water in said solution being sufficient to prevent gelation of the solution at ambient temperatures and sufficient to maintain the viscosity of the solution between about 20 and 5000 centipoises at 70° F.

2. A coating composition according to claim 1 in which the water-soluble aliphatic amine is 2-amino-2-methyl-1-propanol.

3. A coating composition according to claim 1 in which the water-soluble aliphatic amine is 2-amino-2-methyl-1,3-propanediol.

4. A coating composition according to claim 1 in which the water-soluble aliphatic amine is 2-amino-2-ethyl-1,3-propanediol.

5. A coating composition for the formation of metal working lubricant films consisting essentially of a non-congealing, liquid, aqueous solution of an amine soap and an alkali metal soap which have been formed from fatty acids having a titer below about 30° C., the proportion of water in said solution being between about 50% and 95% by weight, said amine soap being formed from a water-soluble aliphatic amine having a boiling point above about 100° C., and said amine soap comprising between about 25% and 75% by weight of the total soap.

6. A coating composition for the formation of metal working lubricant films consisting essentially of a non-congealing, liquid, aqueous solution of an amine soap and an alkali metal soap which have been formed from fatty acids having a titer below about 30° C., the proportion of

water in said solution being between about 70% and 90% by weight, said amine soap comprising between about 25% and 75% by weight of the total soap, and said amine soap being formed from a water-soluble aliphatic amine selected from the group consisting of 2-amino-2-methyl-1-propanol, 2-amino-2-methyl-1,3-propanediol, and 2-amino-2-ethyl-1,3-propanediol.

References Cited in the file of this patent

UNITED STATES PATENTS

1,833,899	Hoyt	Dec. 1, 1931
2,238,478	Ott	Apr. 15, 1941
2,345,199	Hodson	Mar. 28, 1944
2,474,325	Rodger	June 28, 1949
2,625,509	Lang	Jan. 13, 1953