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COLD FORMING LUBRICANT AND METHOD OF APPLYING SAME

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This invention relates to lubricants to be used on metals during the cold forming thereof, and particularly to such lubricants used in the cold extrusion of metals.

Since the development of the cold extrusion process for relatively malleable metals such as, for example, aluminum, magnesium, copper and their alloys, efforts have been made to increase the reduction and surface ratios of the extruded article. By reduction and surface ratios I mean the ratio of the cross-sectional areas and the ratio of the surfaces of the metal article after extrusion to the original metal billet. Ratios of 2 to 1, or 3 to 1, may be achieved with many standard lubricants such as petroleum oils and greases, particularly when the cross-sectional area of the metal billet, i.e., the metal article prior to extrusion, is small. When these ratios approach or exceed 5 to 1, and the cross-sectional area of the metal billet is increased, standard lubricants are unsatisfactory. In such cases, phosphate base lubricants have been used. The complex and dynamic or metastable nature of the phosphate lubricants makes control difficult and the lubricant is frequently marginal if not unsatisfactory. Further, the use of such phosphate lubricants in the cold extrusion process adversely affects the surface finish of the extruded metal, probably because of an undesirable chemical reaction which takes place under the pressures and heat generated between the billet and the die. For example, in the case of the cold extrusion of aluminum tubing the resulting product has a dull, cloudy, streaked surface finish. As the reduction and surface ratios are increased above approximately 7 to 1, and the cross-sectional area of the metal billet is increased, the efficiency of the phosphate lubricant decreases. As a result of lubricant failure, the extruded metal welds itself to the die or tooling, causes excessive wear on the die, or tends to cause "stick-slip" extrusion, giving the resulting extruded product a nonuniform cross-section.

Accordingly, one of the principal objects of the present invention is to provide a lubricant suitable for use in the cold forming of metals which overcomes the above disadvantages.

A further object of the present invention is to provide a lubricant which will allow metals to be extruded at low temperatures and at high reduction and high surface ratios.

A further object of this invention is to provide a lubricant suitable for use at high pressures and high surface temperatures.

A further object is to provide a lubricant which may be applied to a metal billet in a uniform and controllable manner.

A further object of this invention is to provide a method for applying a cold extrusion lubricant to a metal billet.

Still another object of this invention is to provide a metal billet suitably lubricated for use in the cold extrusion process.

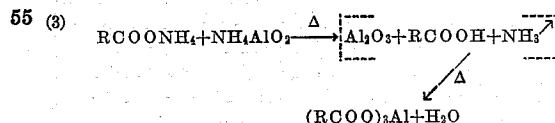
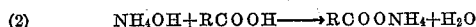
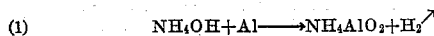
Other objects and advantages of this invention will be apparent, it is believed, from the following detailed description of a preferred embodiment thereof.

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Generally, the lubricant which is the subject of the present invention is in the form of an emulsion and comprises a mixture of a fatty acid or a soap or ester thereof and an ammoniacal compound in a selected solvent. For the purpose of this specification, the term "lubricating agent" will refer to the fatty acid or derivative thereof indicated above and the term "reactant" will refer to the ammoniacal compound.

In order to achieve satisfactory lubrication at high reduction and surface expansion ratios, i.e., 5:1 or more, it is essential that the lubricant adheres firmly to the metal billet, that it maintains its presence on the expanding surface under the conditions found in the cold extrusion process and that it does not adversely affect the surface finish of the extruded article. For the purposes of this specification the terms "cold forming" and "cold extrusion" refer to the working of a metal at temperatures below its recrystallization temperature and include such processes as cold rolling, deep drawing and wire drawing in addition to extrusion. Fatty acids and their esters and metallic soaps, are well known lubricants. However, under the conditions of cold extrusion such compounds are not sufficient by themselves to give satisfactory lubrication. I have determined that by the use of a reactant, a chemical bond is formed between the surface of the metal billet and the lubricant. The exact nature of this bond is not completely understood. However, it may be hypothesized that under the conditions of the process of applying the lubricant to be discussed below, the following reactions occur:

The ammoniacal compound reacts with the metal billet to form an ammonium metal salt and with the lubricating agent to form an ammonium salt of a fatty acid. These ammonium salts, upon heating, lose ammonia and are converted, respectively, into the metal oxide and the fatty acid. The metal oxide in turn reacts with the fatty acid to form a fatty acid metal salt. The surface of the metal billet may then be defined as one having a multilayer composition, the first layer being the pure metal, the intermediate layer being the metal salt of the fatty acid used, and the top layer being the lubricating agent. It will be understood that these layers are closely interrelated and theoretically, through what might be termed ion interaction, are chemically bonded to one another. The following equations are illustrative of the nature of the reactions which theoretically take place to form the intermediate layer. For the purpose of this illustration, ammonium hydroxide is chosen as the reactant, RCOOH, a fatty acid, is the lubricating agent and the metal billet is formed from aluminum.



The reaction illustrated by Equation No. 1 above is slow at room temperature and very rapid at 120° F., the evolution of hydrogen being very apparent at this higher temperature. By testing the pH of the resulting coated billet, it has been determined that substantially all ammonia is removed since the coating is substantially neutral. While the reactions may not occur in the precise way indicated, it is apparent from an examination of the coating and the efficiency of the lubricant in the cold extrusion process that some form of chemical bond exists between the surface of the metal billet and the lubricant itself.

Because of the chemical as distinguished from the

physical nature of the bonding of the lubricant to the billet, reduction and surface expansion ratios as high as 33 to 1 have been attained without lubricant failure. It has further been observed that wear on the die has been considerably reduced and that the use of a lubricant in accordance with this invention results in an extruded metal product characterized by excellent surface characteristics.

The lubricating agent used in the cold extrusion lubricant may consist of one or more compounds selected from the group of organic compounds normally considered as fatty acids or the derivatives thereof having the general formula $(R_1COO)_nR_2$ where n is 1, 2, or 3. R_1 may be a nonpolar monovalent organic radical containing 7 or more carbon atoms which may include a hydroxyl constituent or which may include a branch carbon chain or a carbon chain interrupted by an ether linkage. R_2 may be a hydrogen ion, a metal ion, or a saturated straight chain hydrocarbon. Generally speaking, depending on the solvent, any metallic salt may be used as the lubricating agent. However, the sodium and potassium salts of fatty acids are considered unsatisfactory when water is used as the solvent. It has been observed that while the lithium salt is substantially insoluble in water and, therefore, satisfactory, the sodium and potassium salts ionize and preferentially attack the metal billet to form the alkali metal salt rather than the ammoniacal metal salt. The presence of the caustic salt considerably reduces the efficiency of the lubricant and I therefore, prefer to use only solvent insoluble metal salts in the lubricant.

At high reduction and surface expansion ratios the lubricating agent must be saturated to prevent "stick-slip" phenomena. Compounds wherein the total number of carbon atoms in the R_1 group in the above illustration is less than 7, are normally inoperative because of their volatility under the conditions of cold extrusion, the lack of an adequate soapy quality, and their general inability to act as a lubricant. As the reduction and surface expansion ratios are increased, the length of the chain in the lubricating agent must be increased, there being a direct relation between the length of the chain and its ability to act as a lubricant at increasing reduction ratios. While there is theoretically no upper limit to the number of carbon atoms suitable for use in the lubricating agent, practically speaking, compounds wherein R_1 has more than 22 carbon atoms are difficult to obtain and the increased chain length above that point does not appreciably increase the lubricating ability of the compound. While the methyl, ethyl, propyl and butyl esters of the fatty acids are satisfactory as a lubricating agent, compounds wherein R_2 is a saturated straight chain hydrocarbon having between approximately 6 and 14 carbon atoms are not considered satisfactory at high reduction and surface ratios since one of the reaction products between the reactant and the lubricating agent may be a liquid having a high boiling point. For example, if ammonium hydroxide were to be used as the reactant and R_2 in the lubricating agent were a hydrocarbon having 7 carbon atoms, the reaction product between this lubricating agent and reactant as shown in Equation 2 above would be the alcohol heptanol having a boiling point of approximately 350° F. As a result, since in the curing or glazing of the billet not all of this alcohol would be driven off, the resulting coating would be diluted by the remaining liquid. While at low reduction and surface ratios this dilution would not seriously limit the efficiency of the lubricant, as the ratios are increased the diluting effect of the relatively nonvolatile reaction product softens the coat to a point where it may not firmly adhere to the billet. It is, therefore, advisable that the lubricating agent be selected such that the R_2 reaction product is either driven off in the glazing operation, has lubricating qualities of its own, or does not affect the lubricant. Examples of compounds suitable for use as a lubricating agent are: caprylic, pelargonic, capric, lauric, myristic, palmitic, phenylstearic, arachidic, behenic and stearic

acids, the corresponding esters and the metallic salts thereof, hydroxystearic acid and similar hydroxy homologs of the acids, esters and salts named, 2-ethyl caprylic acid and similar branch-chain fatty acids, lanolin, beeswax and hydrogenated jojoba oil. Lanolin is a complex mixture of sterols and sterol esters, beeswax is a mixture of esters of long chain fatty acids and alcohols, and jojoba oil consists mainly of esters composed of C_{18} to C_{22} acids and alcohols.

The reactant is a basic nitrogenous compound selected from the group consisting of ammonia and substituted ammonia compounds. Inorganic and organic substituted ammonia compounds including primary, secondary and tertiary amines and amides are effective in permitting the reactions illustrated in the equations above to occur. While ammonia and ammonium hydroxide are the preferred reactants, other ammoniacal compounds which may be used as the reactant are hydrazine, hydroxylamine, methylamine, ethylamine, isopropylamine, allylamine, benzylamine, monoethanolamine, diethanolamine, triethanolamine, morpholine, pyridine, aniline, acetamide and propionamide.

In addition to the lubricating agent and reactant, additional ingredients may be used advantageously to effect specific purposes. Typically, the lubricating agent is suspended in a solvent. When an aqueous solution is used, wetting agents may be advantageously incorporated to disperse the insoluble lubricating agent in water. The viscosity of the composition may be controlled by the addition of suitable binders. To observe the thickness and completeness of the lubricant as applied to the metal billets a dye may be advantageously used. Further, parting compounds may be included to prevent metal-to-metal contact. Finally, since the lubricant is either sprayed or painted onto the metal billet in relatively uneven amounts, a leveling compound may be used to cause the formation of a uniform level coat around the billet.

The wetting agents which may be incorporated in order to disperse the insoluble soaps, esters and fatty acids in water may be selected from a wide group of commercial compounds and such choice is determined by their chemical stability, their ability to keep the emulsion dispersed and to keep the tacky point above the operating temperature. Examples of such wetting agents are: a polyoxyalkylene derivative of sorbitan monostearate having a molecular weight of about 1300 (Tween 60, manufactured by Atlas Powder Co.), polyoxyethylene sorbitan monooleate (Tween 80, manufactured by Atlas Powder Co.), sorbitan monostearate (Span 60, manufactured by Atlas Powder Co.), sorbitan monooleate (Span 80, manufactured by Atlas Powder Co.), oxyethylene nonylphenol (Tergitol NPX, manufactured by Union Carbide Co.—composition approximately one mole of oxyethylene per mole of nonylphenol), polyoxyethylene nonylphenol (Tergitol NP14, manufactured by Union Carbide Co.—composition approximately 14 moles of oxyethylene per mole of nonylphenol), polyoxyethylene nonylphenol (Tergitol NP35, manufactured by Union Carbide Co.—composition approximately 35 moles of oxyethylene per mole of nonylphenol), sulfated castor oil (manufactured by Baker Castor Oil Co.), alkyl aryl sulfonate (Duponol G, manufactured by Du Pont de Nemours & Co.), alkyl aryl sulfonate (Textilana MW, manufactured by Textilana Corp.), polyoxypropylene glycol (Pluronic L62, manufactured by Wyandotte Chemicals Corp.), and fatty alkanolamides (Emcol 5100T, manufactured by Witco Chemical Co.). Other similar wetting agents may be used.

Binders suitable for use to control the viscosity of the lubricant are materials such as gum tragacanth, starch, dextrine, casein, and glue. Other similar thixotropic materials may be used. While the use of a dye is not essential to the lubricant, it may be used advantageously for at least two purposes, first, the final glazed lubricant

in the thickness used is transparent and the inclusion of a dye provides a visible film, the relative thickness of which can be judged by the intensity of the color; secondly, if the dye chosen acts as a pH indicator, the evolution of ammonia during the curing operation can be readily followed by the change in color. Oil soluble dyes and other dyes which do not participate in the reaction may be used.

Parting compounds well known in the extrusion art to prevent metal-to-metal contact may also be included. Examples of such compounds are talc, mica, graphite, chalk, borax, lithopone, zinc oxide, white lead and polyhydric alcohol esters of bentonite ("Bentones," manufactured by National Lead Company).

As indicated above, in order to achieve a uniform thickness, leveling compounds may be added to the cold extrusion lubricant to eliminate brush strokes and to provide a smooth and level surface. I have determined that ammonium hydroxide makes the lubricant self-leveling. However, if other ammoniacal compounds are used as the reactant, such compounds as carboxymethylcellulose, tricresyl phosphate, glycerine, lecithin, ethylene glycol and sorbitan borate tend to make the lubricant self-leveling.

I have determined that the pH of the lubricant may be varied over a wide range and that suitable coatings may be achieved with both acid and basic solutions. It will be apparent, however, that strongly acid solutions would have a deleterious effect on the surface of the metal billet. Accordingly, I have determined that a satisfactory pH range is from 6.2 to 12 and I prefer to adjust the pH of the lubricant so that it lies above 9.

Although water is satisfactory as a solvent in forming the emulsion, other volatile solvents which do not react with the metal billet or enter into unfavorable side reactions with the other constituents may be used. Examples of such solvents are acetone, methylethyl-ketone, methyl, ethyl, and isopropyl alcohols and kerosene.

The relative proportions of the various constituents included in the cold extrusion lubricant may be varied over a wide range and depend, to a large extent, on the reactivity of the particular metal to be extruded, the pH of the lubricant, the reduction and surface expansion ratio desired and the lubricating qualities of the fatty acids or derivatives thereof used. The effective by weight ratio of lubricating agent to reactant may vary from 100:15 to 100:1. The use of increased amounts of reactant, particularly if the reactant is volatile, does not substantially affect the efficiency of the lubricant. Such excess reactant adds nothing to the lubricant and cannot increase the efficiency thereof. If less than the indicated minimum of reactant is used, the intermediate layer will be incomplete and the resulting lubricant will be physically rather than chemically bonded to the metal billet. Based on 100 parts by weight lubricating agent, the following indicates satisfactory by weight ranges for the additional constituents which may be advantageously used in the composition:

	Maximum, parts	Minimum, parts
Wetting agent.....	5	$\frac{1}{2}$
Blinder.....	5	$\frac{1}{2}$
Parting compound.....	30	$\frac{1}{10}$
Leveling compound.....	5	$\frac{1}{10}$

The amount of solvent to be used in the compound should be sufficient to have a thin, regularly dispersed solution, preferably in the range of from 400 to 2000 parts solvent to 100 parts lubricating agent. If dye is used, a sufficient quantity should be present to adequately color the emulsion.

The metals to which the cold extrusion lubricant may be applied include any metal to which the cold extrusion process is commercially practicable, provided the indicated

reactions can occur. Examples of such metals are aluminum, iron, copper, lead, silver, magnesium and the alloys thereof. By the use of this lubricant, reduction and surface expanding ratios from 5 to 1, to 33 to 1, have been readily achieved.

The process by which the lubricant is applied to the metal billet consists essentially of four steps: cleaning, application, glazing and cooling.

In order to achieve the chemical bond indicated above, it is necessary that the metal billet be chemically clean. The cleaning can be accomplished by etching, the use of suitable solvents or sandblasting. The chemically clean surface is essential for application of the lubricant to the billets where the surface expansion is large. In cases of relatively small surface expansion, sufficient reaction takes place to maintain the adhesion of the lubricant even though the billets are not clean.

The lubricant may be applied by any of the standard methods of paint application. It is desirable to obtain a uniform coat of controlled thickness. The coating weight will vary according to the material and type of extrusion and may be in the range of from 100 to 6000 milligrams of cured lubricant per square foot.

In order to obtain a smooth, hard coat which will adhere to the billet, the coated billet is heated above the melting point of the lubricant. The temperature is, therefore, dependent on the choice of lubricating agent and may be varied from 200° F. to 500° F. The heating time required depends on the heat capacity and surface to volume ratios of the billet, the heating being continued until the reaction is complete. The heated billet is tacky, or sticky, and it is, therefore, necessary to cool the billet below the tacky point prior to handling. As indicated above, the wetting agent, if used, affects the tacky point. If the billet is tacky at room temperature, too much wetting agent has been included in the emulsion. The above indicated process of forming a coated billet, using the cold extrusion lubricant provides a billet having a slippery, smooth, coat of lubricant which adheres firmly, through chemical reaction, to the metal.

The following are specific examples of the composition of the cold extrusion lubricant, the process by which it is applied to the billet, and the results of the extrusion of coated metal billets at temperatures below the recrystallization temperatures thereof.

In each of the examples given, the materials used are of commercial grade unless otherwise specifically indicated. In the extrusions, a Lake Erie 2500-ton horizontal extrusion press was used.

EXAMPLE I

Formulation of cold extrusion lubricant

The following individual constituents were weighed out in the quantities indicated:

- 200 grams Span 60
- 200 grams Tween 60
- 50 grams green dye (oil soluble—No. 3126 distributed by Mefford Chemical Co.)
- 100 grams carboxymethylcellulose
- 100 grams gum tragacanth
- 1,000 grams stearic acid
- 11,400 grams lithium stearate
- 7,600 grams zinc stearate

To a conventional colloid and blending mill having a 100 gallon vat and a cooling jacket surrounding the vat was added 50 gallons of hot water (160° F.). The 200 grams of Span 60 was then added, the solution being continuously agitated by a mechanical mixer. After the Span 60 dissolved, the Tween 60 and green dye were added and allowed to dissolve. To this solution 1900 milliliters of ammonia water (26° Baumé, 28% NH₃) was added and then a mixture of carboxymethylcellulose and gum tragacanth was sprinkled in slowly and allowed to dissolve. The stearic acid was then added slowly and

when the mixture had become homogeneous, water was introduced into the cooling jacket to lower the temperature of the solution in the vat. The lithium stearate and zinc stearate were then added together with an additional 1900 milliliters of ammonia water (26° Baumé). The resulting slurry was agitated continuously for 1½ hours to break up the large aggregates and homogenize the mixture. After such agitation, the colloid mill was started, to form the final mixture. The use of the colloid mill is particularly advantageous if the lubricant is to be applied to the billets by a spray gun, it being my experience that the needle valves of the spray guns become clogged unless the colloidal suspension is finely divided. Any standard colloid mill is satisfactory. The purpose of the milling and colloidizing is merely to form a homogeneous, finely divided colloidal suspension. The emulsion was milled until a finely dispersed, uniform emulsion was formed (approximately ¾ of an hour) and the finished lubricant collected into a 55 gallon storage drum.

Preparation of billets

Prior to the application of the lubricant to the billets the exposed surface areas were cleaned in the following manner: A hollow aluminum cylinder (commercial aluminum with minimum impurities) 23¾ inches long having an internal diameter of 4.97 inches and an external diameter of 6.51 inches was immersed in a concentrated nitric acid bath at room temperature for one minute, water-rinsed for one minute, washed with 1% caustic soda at 175° F. for three minutes, water-rinsed at room temperature for one minute, washed again with nitric acid for one minute, water-rinsed at room temperature for one minute, and finally, thoroughly washed with water having a temperature of 132° F. The billet was then air-dried for two hours on an inclined ramp to allow the interior bore to drain.

Application of lubricant

The prepared cold extrusion lubricant was sprayed on the external surfaces of the cleaned metal billet, using a DeVilbiss M.B.C. spray gun with an FX-type needle valve. The bore of the billet was sprayed with a ¾ inch by 30 inch extension on the spray gun having a 360° spray-head. The lubricant was supplied to the spray gun from a 5 gallon pot. The pressure on the lubricant was 50 p.s.i. and the air pressure on the gun was 60 p.s.i. Spraying was continued until a uniform coat as determined by clear color density throughout was obtained. Spraying was accomplished in the following manner. The etched billet was loaded on an angle iron track approximately 30 feet long. The bore of the billet was sprayed with the extended gun for approximately 3½ seconds. The billet was then placed on a set of rotating wheels to permit rotation of the billet, the rate of rotation being adjusted to approximately 7½ r.p.m. The billet was permitted to make two complete revolutions while spraying back and forth for approximately 25 seconds, the spraying covering the entire external surface. Examination of the resulting coating showed that there was approximately 1500 milligrams of solvent free lubricant per square foot of surface area. The coated billet was then transported to an indirectly heated oven. The temperature of the oven was maintained at 470° F. The billet was placed in the oven for curing and allowed to cure for 35 minutes. It was observed that the temperature of the billet in the oven was raised to 400° F. After curing the billet was removed from the oven and allowed to cool. It was noted that the tacky point was approximately 215° F. Below that temperature the surface of the billet was smooth, hard, and slippery. The billet was then ready for extrusion.

Extrusion of billet

As indicated above, a Lake Erie 2500-ton horizontal extrusion press was used. The die had a minimum bore diameter of 5 inches. The punch head was ground to

0.015 inch smaller than the bore diameter. A mandrel having an O.D. of 4.910 inches was positioned on the punch. The die was preheated to 145° F. and the mandrel heated to 280° F. The billet was then preheated to 220° F., inserted into the press and extruded at a pressure of approximately 950 tons p.s.i. A Washing bath was positioned at the exit of the extrusion die through which the extruded aluminum tube passed. The tube, in passing through the bath was cooled and allowed to pass out onto a cooling tray. The heel was cut off and the extruded tube allowed to cool. The resulting extruded product was an aluminum tube having a mean O.D. of 5.000 inches, a mean I.D. of 4.910 inches and a mean wall thickness of 0.045 inch. The tube was approximately 32 feet in length and had a clear, regular surface with a minimum of discoloration and die or extrusion marks. The reduction and surface ratio was determined to be approximately 20 to 1.

The following are examples of cold extrusion lubricants which may be prepared and applied to metal billets by the methods shown in Example I. In these examples the quantities are indicated in parts by weight. The temperatures to which the billet should be heated to achieve a satisfactory glaze are indicated at the end of each example.

EXAMPLE II

90 parts zinc stearate
10 parts stearic acid
1 part Span 60
1 part Tween 60
1 part gum tragacanth
10 parts concentrated ammonium hydroxide
900 parts water
Glazing temperature approximately 220° F.

EXAMPLE III

90 parts lithium stearate
10 parts stearic acid
1 part Span 60
1 part Tween 60
1 part gum tragacanth
10 parts concentrated ammonium hydroxide
900 parts water
Glazing temperature approximately 450° F.

EXAMPLE IV

54 parts lithium stearate
36 parts zinc stearate
1 part Span 60
1 part Tween 60
.25 part oil soluble green No. 3126
1 part gum tragacanth
10 parts concentrated ammonium hydroxide
900 parts water
10 parts stearic acid
Glazing temperature approximately 350° F.

EXAMPLE V

54 parts lithium stearate
36 parts zinc stearate
1 part Span 60
1 part Tween 60
.25 part oil soluble green No. 3126
1 part of tragacanth
10 parts concentrated ammonium hydroxide
900 parts water
Glazing temperature approximately 380° F.

EXAMPLE VI

54 parts lithium stearate
36 parts zinc stearate
10 parts 12 hydroxystearic acid
1 part Span 60
1 part Tween 60
.25 part of oil soluble green No. 3126

1 part gum tragacanth
10 parts concentrated ammonium hydroxide
900 parts water
Glazing temperature approximately 350° F.

EXAMPLE VII

90 parts zinc palmitate
10 parts palmitic acid
15 parts triethanolamine
900 parts water
Glazing temperature 280° F.

EXAMPLE VIII

90 parts zinc laurate
20 parts pelargonic acid
15 parts morpholine
900 parts ethyl alcohol
Glazing temperature approximately 240° F.

EXAMPLE IX

90 parts lithium laurate
10 parts phenylstearic acid
2 parts polyoxyethylene nonylphenol
1 part gum tragacanth
16 parts concentrated ammonia hydroxide
0.25 part of oil soluble green No. 3126
1.0 part sorbitan borate
900 parts of water
Glazing temperature approximately 420° F.

EXAMPLE X

30 parts lanolin
40 parts lithium stearate
5 parts stearic acid
25 parts zinc stearate
1 part gum tragacanth
1 part alkylaryl sulfonate
14 parts ammonia hydroxide 28%
0.25 part of oil soluble green No. 3126
900 parts water
Glazing temperature approximately 240° F.

EXAMPLE XI

95 parts hydrogenated jojoba oil
5 parts arachidic acid
2 parts carboxymethylcellulose
1 part ricinoleate polyoxyethylene ester
15 parts morpholine
10 parts mica (300 mesh)
300 parts water
Glazing temperature approximately 175° F.

EXAMPLE XII

95 parts beeswax (yellow)
5 parts behenic acid
2 parts methoxycellulose
1 part sulfonated castor oil
15 parts monoethanol amine
10 parts graphite
300 parts isopropyl alcohol
Glazing temperature approximately 145° F.

EXAMPLE XIII

90 parts calcium behenate
10 parts capric acid
1 part poloxypropylene glycol
1 part ethylene glycol
0.25 part oil soluble green No. 3126
15 parts isopropylamine
15 parts water
900 parts kerosene
Glazing temperature approximately 300° F.

The following are examples of additional metals to which the cold extrusion lubricant has been successfully applied:

EXAMPLE XIV

A brass cylinder (70% copper, 30% zinc), 1.85 inches in diameter and 6 inches long was annealed for one hour at 1200° F. It was etched for 1½ minutes in 10% nitric acid at 70° F. and thoroughly washed with water. The lubricant as described in Example I was applied by a spray gun and cured at 400° F. and allowed to cool. The glazed billet was extruded to a 0.925 inch diameter rod at 4 to 1 reduction in the manner described in Example I except that the billet temperature was 230° F., the press pressure was 266 tons and the pressure on the billet was 198,000 pounds p.s.i. The Brinell hardness of the cylinder at the various state was as follows:

Before annealing 80
After annealing 54.3
After extrusion 138

EXAMPLE XV

An iron cylinder (supplied by Great Western Steel Company) having the same dimensions as in Example XIV, was etched for two minutes in 5% sulfuric acid at 150° F. and then thoroughly washed with water. The lubricant was applied and cured as in Example XIV. The extrusion conditions were the same as in Example XIV except that the billet temperature was 240° F., the press pressure was 304 tons and the pressure on the billet was 226,000 pounds p.s.i. The resulting extruded cylinder had the same dimensions and the same extrusion ratio as in Example XIV. The Brinell hardness of the cylinder was as follows:

Before extrusion 95
After extrusion 176

EXAMPLE XVI

A magnesium cylinder (Dow F.S.-1 magnesium supplied by Reliance Magnesium Company), having the same dimensions as in Example XIV was annealed for 3 hours at 700° F. The cylinder was then etched with 15% nitric acid for 10 seconds at 70° F., and thoroughly washed with water. The cold extrusion lubricant as described in Example III above was applied to the billet in the manner described in Example I. The extrusion conditions were the same as in Example I, except that the billet temperature was 480° F., the press pressure was 95 tons and the pressure on the billet was 68,000 p.s.i. The Brinell hardness of the cylinder was as follows:

Before annealing 53
After annealing 52
After extrusion 66

The following table illustrates additional extrusions which have been made using the cold extrusion lubricants. In each of these examples the metal was aluminum.

Billet	Surface Ratios		Reduction Ratio	Extrusion
	Inside	Outside		
60 Tube.....	5:1 to 25:1	3.08:1 to 15.4:1	5:1 to 25:1	Forward.
Shot shell case...	9.6:1	3.68:1	7.5:1	Backward.
3" pipe.....	20:1	14:1	20:1	Forward.
1" rod.....		2.38:1	5.6:1	Do.
65 ½" hexagonal rod.....		4.56:1	21:1	Do.
5/8" rod.....		3.8:1	14.4:1	Do.
0.412" rod.....		5.75:1	33:1	Do.
4" pipe.....	20:1	14.8:1	20:1	Do.

In the above examples other ammoniacal compounds such as hydrazine, pyridine, hydroxylamine, acetamide, aniline or other compounds containing a basic nitrogen atom may be substituted for the reactant specified. In addition, other fatty acids, their metallic salts or esters may be substituted for the lubricating agent specified.

It is to be understood that as the chain length of the fatty acid or its derivative is decreased, the maximum reduction and surface ratios obtainable must be decreased.

In these examples parting compounds such as talc, mica, graphite, chalk or borax may be included to increase the ease of extrusion, particularly when shorter chain lubricating agents are used.

In addition to commercial aluminum, the following alloys of aluminum have been successfully lubricated and extruded using the lubricant and methods indicated in the examples:

61S	CS11
52S	11S
17S	3S
J51S	2S
14S	

It will also be apparent, it is believed, that the lubricant will be satisfactory in cold forming processes other than extrusion such as, for example, cold rolling.

Finally, it will be apparent, it is believed, that the selection of the constituents of the cold extrusion lubricant in extruding a particular metal or its alloy will depend upon the particular reduction and surface ratios desired, the conditions of extrusion and the form, shape and chemical characteristics of the metal billet.

Having fully described my invention, it is to be understood that I do not wish to be limited to the precise details of the examples set forth but my invention is of the full scope of the appended claims.

I claim:

1. A cold forming lubricant consisting essentially of: a mixture of a reactant, a lubricating agent and an inert volatile solvent; said reactant being a basic nitrogenous compound selected from the group consisting of ammonia, ammonium hydroxide, hydrazine, hydroxylamine, methylamine, ethylamine, isopropylamine, allylamine, benzylamine, monoethanolamine, diethanolamine, triethanolamine, morpholine, pyridine, aniline, acetamide and propionamide; and said lubricating agent being a compound having the general structure



where n is 1, 2, or 3, R_1 is a monovalent nonpolar organic radical having at least 7 carbon atoms and R_2 is a radical selected from the group consisting of H, a metallic ion, and saturated organic radicals; the by weight ratio of said reactant to said lubricating agent in said mixture being not less than 1 to 100 and the ratio by weight of solvent to lubricating agent being in the range of about 400–2,000:100.

2. An emulsified cold extrusion lubricant consisting essentially of: a reactant, a lubricating agent and water; said reactant being a basic ammoniacal compound selected from the group consisting of ammonia, ammonium hydroxide, hydrazine, hydroxylamine, methylamine, ethylamine, isopropylamine, allylamine, benzylamine, monoethanolamine, diethanolamine, triethanolamine, morpholine, pyridine, aniline, acetamide and propionamide; said lubricating agent being a mixture of at least two compounds selected from the group consisting of fatty acids having more than 7 carbon atoms, the insoluble metal salts and esters thereof; the by weight ratio of reactant to lubricating agent being in the range of from 1:100 to 15:100; the by weight ratio of water to lubricating agent being in the range of from 400:100 to 2000:100;

the pH of said lubricant being in the range of from 6.2 to 12.

3. An emulsified cold extrusion lubricant for coating a piece of unformed metal stock and the like consisting essentially of the following ingredients by weight: a lubricating agent selected from the group consisting of fatty acids having more than 7 carbon atoms, the insoluble metal salts and esters thereof, and any mixture of at least two of the recited ingredients, 100 parts; a reactant selected from the group consisting of ammonia, ammonium hydroxide, hydrazine, hydroxylamine, methylamine, ethylamine, isopropylamine, allylamine, benzylamine, monoethanolamine, diethanolamine, triethanolamine, morpholine, pyridine, aniline, acetamide and propionamide, 1–15 parts; an inert volatile solvent, 400–2000 parts; a wetting agent, 0.5–5 parts; a binder selected from the group consisting of gum tragacanth, starch, dextrine, casein, and glue, 0.5–5 parts.

4. A coating composition in accordance with claim 3, wherein the lubricating agent is a mixture of zinc stearate and stearic acid.

5. A coating composition in accordance with claim 3 wherein the reactant is ammonia.

6. A cold forming lubricant consisting essentially of: a mixture of ammonia, zinc stearate, lithium stearate and an inert volatile solvent, the by weight ratio of said ammonia to the combined weight of the zinc stearate and lithium stearate in said mixture being not less than 1:100 and the ratio by weight of said solvent to the combined weight of the zinc stearate and lithium stearate being in the range of about 400–2000:100.

7. An emulsified cold extrusion lubricant consisting essentially of: ammonium hydroxide, stearic acid, zinc stearate and water, the by weight ratio of ammonia to the combined weight of stearic acid and zinc stearate being in the range of from 1:100 to 15:100; the by weight ratio of water to the combined weight of stearic acid and zinc stearate being in the range of from 400:100 to 2000:100; the pH of said lubricant being in the range of from 6.2 to 12.

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