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(54) Lubricating oil composition

(57) A lubricating oil composition useful for metal rolling essentially comprises water added in the range of from 5 to 89.95 percent by mass; an oxygen-containing compound added in the range of from 10 to 94.95 percent by mass and represented by the formula

$$R^1O\text{-}(R^3\text{-}O)_p\text{-}R^2 \qquad (I)$$

where R^1 and R^2 each independently are hydrogen or hydrocarbon groups of 1-18 carbon atoms, R^3 is an alkylene group of 1-6 carbon atoms, p is an integer of 1-30; and a salt of fatty acid added in the range of from 0.05 to 10 percent by mass and selected from the group consisting of an alkaline metal salt of fatty acid of 6-22 carbon atoms, a salt of fatty acid of 6-22 carbon atoms and an alkanol amine of 1-15 carbon atoms, and a salt of fatty acid of 6-22 carbon atoms and a nitrogen-containing compound of the formula

$$\genfrac{}{}{0pt}{}{R^4}{X} \!>\! N\text{-}(R^5\text{-}O)_q\text{-}H \qquad \cdots\cdots\; (II)$$

where R^4 is a hydrocarbon group of 1-24 carbon atoms, R^5 is an ethylene or propylene group, q is an integer of 1-30, X is hydrogen, a hydrocarbon group of 1-24 carbon atoms or a group of the formula $-(R^6\text{-}O)_rH$ where R^6 is an ethylene or propylene group and r is an integer of 1-30; the sum of the water and the compound of the formula (I) being in the range of from 80 to 99.95 percent by mass based on total composition.

The components as defined and their contents as specified are conducive to improved rolling performance and high surface gloss of rolled products.

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Description

This invention relates generally to lubricating oil compositions and particularly to such compositions which are useful in the production of rolled metal products of stainless steel, copper, aluminum, alloys thereof and the like.

There are known both hot and cold rolling methods for rolling a metallic material into sheet or foil. Lubricants find essential use in cold rolling and extensive use even in hot rolling of a certain class of metals such as aluminum and its alloys.

Old conventional rolling lubricants typically were comprised of low-viscosity mineral oils and synthetic oils such as esters blended with various additives. These oils were soon shunned away because of their high flammability giving rise to fire hazards when used in high speed rolling.

During recent years an increasing interest has appeared in the utilization of water properties such as nonflammability and cooling ability for emulsifying low-viscosity mineral oils, synthetic oils, palm oil, or fats and oils in the presence of suitable emulsifiers. However, these emulsion-type rolling oils are poor in emulsion stability and non-homogeneous, leading to gloss irregularities in rolled metal surfaces and oil loss in the system when filtering out abrasion dust and scum.

Japanese Laid-Open Patent Publication No. 60-118790 discloses a water-soluble metal processing oil comprising salts or amides of acids such as carboxylic acid, sulfonic acid, naphthenic acid, an alkyleneglycol, a mineral or synthic oil or fat and oil, and water. Such metal processing oil is laudable for being flame-retardant, but has a drawback in that it is not satisfactorily capable of cooling and subject to wide variation in viscosity depending upon the quantity of water used.

The present invention seeks to provide a lubricating oil composition suitable for use in the production of rolled metal products, which composition is substantially fire-proof, highly efficient in cooling, highly conducive to rolling performance, capable of retaining good surface gloss of rolled metal and filtering out abrasion dust or scum resulting from the rolling operation, with high storage stability and resistance to stain.

It has now been found that the foregoing various physical properties can be obtained by providing a lubricating oil composition which consists of a majority of nonflammable, cooling-efficient water and which comprises a selected oxygen-containing compound, a selected salt of fatty acid and water respectively blended in a specified range of quantities.

According to a preferred embodiment of the invention, there is provided a lubricating oil composition which comprises (A) water added in the range of from 5 to 89.95 percent by mass; (B) an oxygen-containing compound added in the range of from 10 to 94.95 percent by mass and represented by the formula

$$R^1O\text{-}(R^3\text{-}O)_p\text{-}R^2 \qquad \text{(I)}$$

where R^1 and R^2 each independently are hydrogen or hydrocarbon groups of 1-18 carbon atoms, R^3 is an alkylene group of 1-6 carbon atoms, p is an integer of 1-30; and (C) a salt of fatty acid added in the range of from 0.05 to 10 percent by mass and selected from the group consisting of (a) an alkaline metal salt of fatty acid of 6-22 carbon atoms, (b) a salt of fatty acid of 6-22 carbon atoms and an alkanol amine of 1-15 carbon atoms, and (c) a salt of fatty acid of 6-22 carbon atoms and a nitrogen-containing compound of the formula

$$\begin{matrix} R^4 \searrow \\ X \nearrow \end{matrix} N\text{-}(R^5\text{-}O)_q\text{-}H \qquad \ldots\ldots\ \text{(II)}$$

where R^4 is a hydrocarbon group of 1-24 carbon atoms, R^5 is an ethylene or propylene group, q is an integer of 1-30, X is hydrogen, a hydrocarbon group of 1-24 carbon atoms or a group of the formula $-(R^6\text{-}O)_rH$ where R^6 is an ethylene or propylene group and r is an integer of 1-30; the sum of the water and the compound of the formula (I) being in the range of from 80 to 99.95 percent by mass based on total composition.

The inventive lubricating oil composition finds extensive application not only in the cold-rolling of stainless steel, copper, aluminum and alloys thereof but also in the hot-rolling of aluminum and its alloys. There is no particular restriction as to the manner in which the inventive lubricant is applied. However, its prominent lubricating and cooling capabilities lead to a preferred mode of use in which the inventive lubricant is applied by means of jet spraying to or adjacent the nip between working rolls for rolling a metal substrate.

The term water as used herein as Component (A) designates all sorts of water ranging from hard water, soft water, drinking water, industrial water, ion-exchanged water to distilled water. The lower limit of contents of this water is generally 5 percent by mass, preferably 15 percent by mass, more preferably 25 percent by mass based on the total amount of the resultant composition. Its upper limit is generally 89.95 mass %, preferably 79.9 mass %, more preferably 69.8 mass % based on total composition. Amounts of water less than 5 percent by mass would result in reduced cooling capability of the oil composition, hence leading to seized metal during rolling, and amounts exceeding 89.95 percent by mass would result in reduced lubricity.

The oxygen-containing compound (B) according to the invention is represented by the formula

$$R^1O\text{-}(R^3\text{-}O)_p\text{-}R^2 \qquad (2)$$

where R^1 and R^2 each independently are hydrogen or hydrocarbon groups of 1-18 carbon atoms, R^3 is an alkylene group of 1-6 carbon atoms, p is an integer of 1-30. R^1 and R^2 may be the same or different. The hydrocarbon groups of 1-18 carbon atoms include an alkyl group such as methyl group, ethyl group, n-propyl group, isopropyl group, n-butyl group, isobutyl group, sec-butyl group, tert-butyl group, straight or branched pentyl group, straight or branched hexyl group, straight or branched heptyl group, straight or branched octyl group, straight or branched nonyl group, straight or branched decyl group, straight or branched undecyl group, straight or branched dodecyl group, straight or branched tridecyl group, straight or branched tetradecyl group, straight or branched pentadecyl group, straight or branched hexadecyl group, straight or branched heptadecyl group and straight or branched octadecyl group; an alkenyl group of 5-18 carbon atoms such as straight or branched pentenyl group, straight or branched hexenyl group, straight or branched heptenyl group, straight or branched octenyl group, straight or branched nonenyl group, straight or branched decenyl group, straight or branched undecenyl group, straight or branched dodecenyl group, straight or branched tridecenyl group, straight or branched tetradecenyl group, straight or branched pentadecenyl group, straight or branched hexadecenyl group, straight or branched heptadecenyl group and straight or branched octadecenyl group; a cycloalkyl group of 5-7 carbon atoms such as cyclopentyl group, cyclohexyl group and cycloheptyl group; an alkylcycloalkyl group of 6-11 carbon atoms such as methylcyclopentyl group, dimethylcyclopentyl group (inclusive of all isomers), methylethylcyclopentyl group (inclusive of all isomers), diethylcyclopentyl group (inclusive of all isomers), methylcyclohexyl group, dimethylcyclohexyl group (inclusive of all isomers), methylethylcyclohexyl group (inclusive of all isomers), diethylcyclohexyl group (inclusive of all isomers), methylcycloheptyl group, dimethylcycloheptyl group (inclusive of all isomers), methylethylcycloheptyl group (inclusive of all isomers) and diethylcycloheptyl group (inclusive of all isomers); an aryl group such as phenyl group and naphthyl group; an alkylaryl group of 7-18 carbon atoms such as tolyl group, xylyl group (inclusive of all isomers), ethylphenyl group, straight or branched propylphenyl group, straight or branched butylphenyl group, straight or branched pentylphenyl group, straight or branched hexylphenyl group, straight or branched heptylphenyl group, straight or branched octylphenyl group, straight or branched nonylphenyl group, straight or branched decylphenyl group, straight or branched undecylphenyl group and straight or branched dodecylphenyl group; and an arylalkyl group of 7-12 carbon atoms such as benzyl group, phenylethyl group, phenylpropyl group (including isomers of propyl group), phenylbutyl group (including isomers of butyl group), phenylpentyl group (including isomers of pentyl group) and phenylhexyl group (including isomers of hexyl group).

R^1 and R^2 in the formula (I) each independently are preferably hydrogen, an alkyl or phenyl group 1-18 carbon atoms, or an alkylaryl group of 7-15 carbon atoms with a consideration given to compatibility of the two Components (B) and (A).

R^3 in the formula (I) includes methylene group; methylmethylene group (ethylidene group) and ethylene group; ethylmethylene group (propylidene group), dimethylmethylene group (isopropylidene group), methylethylene group (propylene group) and trimethylene group; n-propylmethylene group (butylidene group), isopropylmethylene group (isobutylidene group), ethylmethylmethylene group, ethylethylene group, 1,1-dimethylethylene group, 1,2-dimethylethylene group, 1-methyltrimethylene group, 2-methyltrimethylene group and tetramethylene group; n-butylmethylene group (pentylidene group), sec-butylmethylene group, isobutylmethylene group (isopentylidene group), tetr-butylmethylene group, n-propylmethylmethylene group, isopropylmethylmethylene group, diethylmethylene group, n-propylethylene group, isopropylethylene group, 1-ethyl-1-methylethylene group, 1-ethyl-2-methylethylene group, trimethylethylene group, 1-ethyltrimethylene group, 2-ethyltrimethylene group, 1,1-dimethyltrimethylene group, 1,2-dimethyltrimethylene group, 1,3-dimethyltrimethylene group, 2,2-dimethyltrimethylene group, 1-methyltetramethylene group, 2-methyltetramethylene group and pentamethylene group; and n-pentylmethylene group (hexylidene group), (1-methylbutyl group) methylene group, isopentylmethylene group (isopentylidene group), (1,2-dimethylpropyl) methylene group, n-butylmethylmethylene group, isobutylmethylmethylene group, ethyl-n-propylmethylene group, ethylisopropylmethylene group, butylethylene group, isobutylethylene group, 1-(n-propyl)-1-methylethylene group, 1-(n-propyl)-2-methylethylene group, 1-isopropyl-1-methylethylene group, l-isopropyl-2-methylethylene group, 1,2-diethylethylene group, 1-ethyl-2,2-dimethylethylene group, tetramethylethylene group, 1-n-propyltrimethylene group, 2-n-propyltrimethylene group, 1-isopropyltrimethylene group, 2-isopropyltrimethylene group, 1-ethyl-3-methyltrimethylene group, 1-ethyl-2-methyltrimethylene group, 1,1,2-trimethyltrimethylene group, 1,1,3-trimethyltrimethylene group, 1-ethyltetramethylene group, 1,1-dimethyltetramethylene group, 1,3-dimethyltetramethylene group, 1,4-dimethyltetramethylene group, 2,2-dimethyltetramethylene group, 1-methylpentamethylene group, 2-methylpentamethylene group and hexamethylene group.

With further consideration given to compatibility of Component (B) with Component (A), R^3 is preferably an alkylene group of 2-6 carbon atoms.

p in the formula (I) is an integer of 1-30, preferably 1-20.

$-(R^3\text{-}O)_p-$ in the formula (I) denotes an oxyalkylene group which includes, where p is greater than 2, polyoxyalkylene groups derived from random-, alternating- or block-copolymerization of two or more structurally different oxyalkylene groups.

Oxygen-containing compounds (B) eligible for the purpose of the invention particularly from the point of view of compatibility with Component (A), i.e. water, are those represented by an embodiment of the formula (I) wherein R^1 is hydrogen, straight or branched alkyl or phenyl group of 1-6 carbon atoms, or straight or branched alkylaryl group of 7-15 carbon atoms, R^2 is hydrogen, R^3 is an alkylene group of 2-6 carbon atoms, and p is an integer of 1-10. Specific examples of such oxygen-containing compounds (B) include (i) ethylene glycol, propylene glycol (inclusive of all isomers), butylene glycol (inclusive of all isomers), pentylene glycol (inclusive of all isomers) and hexylene glycol (inclusive of all isomers); (ii) polyglycols (exemplarily diglycol, triglycol and tetraglycol) derived from homopolymerization of one of the glycols (i); (iii) polyglycols (exemplarily polyoxyethyleneoxypropylene glycol) derived from random-, alternating-, or block-copolymerization of two or more of the glycols (i); (iv) monoalkylether compounds (having straight or branched alkyl groups of 1-6 carbon atoms) of glycols (i) and polyglycols (ii), (iii); (v) monophenylether compounds of glycols (i)-(iii); (vi) monoalkylphenylether compounds (having straight or branched alkyl groups of 1-9 carbon atoms) of glycols (i)-(iii); and (vii) two or more mixtures of compounds (i)-(vi).

Of the various compounds (i)-(vii), particularly preferred is a copolymeric polyglycol having an ethylene glycol copolymerized with another alkylene glycol in a mole ratio of between 1-9 and 9-1, preferably between 2-8 and 8-2 as such polyglycol is readily comiscible with water.

While substantially all oxygen-containing compounds (B) defined by the formula (I) are applicable for the purpose of the invention, there are some readily homogeneously soluble and others not so soluble with water when added in specified amounts appearing in the examples hereinafter given.

The lower limit of contents of the Component (B) in the inventive composition is generally 10, preferably 20, more preferably 30 percent by mass based on total composition, and the upper limit thereof is generally 94.95, preferably 84.9, more preferably 74.8 percent by mass based on total composition. Less than 10 mass % would lead to aggravated lubricating performance, while greater than 94.95 mass % would result in reduced surface gloss of a rolled metal product.

The lower limit of the sum of Components (A) and (B) should be 80 %, preferably 90 %, more preferably 95 % by mass based on total composition, and the upper limit should be 99.95 %, preferably 99.9 % and more preferably 99.8 % by mass based on total composition. Less than 80 mass % would result in poor surface finish of a rolled metal product, while more than 99.95 mass % would aggravate lubricity.

The Component (C), namely, a salt of fatty acid, used in the invention is selected from the group consisting of (a) an alkaline metal salt of fatty acid of 6-22 carbon atoms, (b) a salt of fatty acid of 6-22 carbon atoms and an alkanol amine of 1-15 carbon atoms, and (c) a salt of fatty acid of 6-22 carbon atoms and a nitrogen-containing compound of the formula

$$\begin{matrix} R^4 \searrow \\ X \nearrow \end{matrix} N-(R^5-O)_q-H \qquad \cdots\cdots\cdots \quad (II)$$

where R^4 is a hydrocarbon group of 1-24 carbon atoms, R^5 is an ethylene or propylene group, q is an integer of 1-30, X is hydrogen, a hydrocarbon group of 1-24 carbon atoms or a group of the formula $-(R^6\text{-}O)_rH$ where R^6 is an ethylene or propylene group and r is an integer of 1-30.

Fatty acids in each of the listed salts (a), (b) and (c) may be saturated or unsaturated, of straight-chain or branched-chain, provided their carbon number remains in the range of 6-22. Such fatty acids exemplarily include straight and branched saturated fatty acids such as hexanoic acid, heptanoic acid, octanoic acid, nonanoic acid, decanoic acid, undecanoic acid, dodecanoic acid, tridecanoic acid, tetradecanoic acid, pentadecanoic acid, hexadecanoic acid, heptadecanoic acid, octadecanoic acid, nonadecanoic acid, eicosanoic acid, heneicosanoic acid and docosanoic acid; and straight and branched unsaturated fatty acids such as hexenoic acid, heptenoic acid, octenoic acid, nonenoic acid, decenoic acid, undecenoic acid, dodecenoic acid, tridecenoic acid, tetradecenoic acid, pentadecenoic acid, hexadecenoic acid, heptadecenoic acid, octadecenoic acid, nonadecenoic acid, eicosenoic acid, heneicosenoic acid and docosenoic acid.

With solubility in water taken into account, there may be used preferably such fatty acids of 10-18 carbon atoms as n-dodecanoic acid (lauric acid), n-tridecanoic acid, n-tetradecanoic acid (myristic acid), n-pentadecanoic acid, n-hexadecanoic acid (palmitic acid), n-heptadecanoic acid, n-octadecanoic acid (stearic acid), n-dodecenoic acid, n-tridecenoic acid, n-tetradecenoic acid, n-pentadecenoic acid, n-hexadecenoic acid, n-heptadecenoic acid and n-octadecenoic acid (oleic acid). These fatty acids are eligible for reaction in common with an alkaline metal, an alkanol amine and a nitrogen-containing compound of the formula (II). The basic component of the salt of fatty acid (a) is usually sodium or potassium. The salt (a) may be formed from one or more of the above fatty acids and one or more of alkaline metals.

The basic component of the salt of fatty acid (b) includes monomethanol amine, dimethanol amine, trimethanol amine, monoethanol amine, diethanol amine, triethanol amine, mono-n-propanol amine, monoisopropanol amine, di-n-propanol amine, diisopropanol amine, tri-n-propanol amine, triisopropanol amine, monobutanol amine (inclusive of all isomers), dibutanol amine (inclusive of all isomers), tributanol amine (inclusive of all isomers), monopentanol amine (inclusive of all isomers), dipentanol amine (inclusive of all isomers), tripentanol amine (inclusive of all isomers), monohexanol amine (inclusive of all isomers), dihexanol amine (inclusive of all isomers), monoheptanol amine (inclusive of all isomers), diheptanol amine (inclusive of all isomers) and monooctanol amine (inclusive of all isomers). Alkanol amines of 1-9 carbon atoms are particularly preferred when considering the solubility in water. One or more of these amines are used preferably with unsaturated, straight-chain fatty acids of 12-18 carbon atoms with better results.

The basic component of the salt of fatty acid (c) is a nitrogen-containing compound of the formula (II) where R^4 is a hydrocarbon group of 1-24 carbon atoms. This hydrocarbon group includes an alkyl group such as methyl group, ethyl group, n-propyl group, isopropyl group, n-butyl group, isobutyl group, sec-butyl group, tert-butyl group, straight or branched pentyl group, straight or branched hexyl group, straight or branched heptyl group, straight or branched octyl group, straight or branched nonyl group, straight or branched decyl group, straight or branched undecyl group, straight or branched dodecyl group, straight or branched tridecyl group, straight or branched tetradecyl group, straight or branched pentadecyl group, straight or branched hexadecyl group, straight or branched heptadecyl group, straight or branched octadecyl group, straight or branched nonadecyl group, straight or branched eicosyl group, straight or branched heneicosyl group, straight or branched docosyl group, straight or branched tricosyl group and straight or branched tetracosyl group; an alkenyl group of 5-24 carbon atoms such as straight or branched pentenyl group, straight or branched hexenyl group, straight or branched heptenyl group, straight or branched octenyl group, straight or branched nonenyl group, straight or branched decenyl group, straight or branched undecenyl group, straight or branched dodecenyl group, straight or branched tridecenyl group, straight or branched tetradecenyl group, straight or branched pentadecenyl group, straight or branched hexadecenyl group, straight or branched heptadecenyl group, straight or branched octadecenyl group, straight or branched nonadecenyl group, straight or branched eicosenyl group, straight or branched heneicosenyl group, straight or branched docosenyl group, straight or branched tricosenyl group and straight or branched tetracosenyl group; a cycloalkyl group of 5-7 carbon atoms such as cyclopentyl group, cyclohexyl group and cycloheptyl group; an alkylcycloalkyl group of 6-11 carbon atoms such as methylcyclopentyl group, dimethylcyclopentyl group (inclusive of all isomers), methylethylcyclopentyl group (inclusive of all isomers), diethylcyclopentyl group (inclusive of all isomers), methylcyclohexyl group, dimethylcyclohexyl group (inclusive of all isomers), methylethylcyclohexyl group (inclusive of all isomers), diethylcyclohexyl group (inclusive of all isomers), methylcycloheptyl group, dimethylcycloheptyl group (inclusive of all isomers), methylethylcycloheptyl group (inclusive of all isomers) and diethylcycloheptyl group (inclusive of all isomers); an aryl group such as phenyl group and naphthyl group; an alkylaryl group of 6-24 carbon atoms such as tolyl group, xylyl group (inclusive of all isomers), ethylphenyl group, straight or brancehd propylphenyl group, straight or brancehd butylphenyl group, straight or brancehd pentylphenyl group, straight or brancehd hexylphenyl group, straight or brancehd heptylphenyl group, straight or brancehd octylphenyl group, straight or brancehd nonylphenyl group, straight or branched decylphenyl group, straight or branched undecylphenyl group, straight or branched dodecylphenyl group, straight or branched tridecylphenyl group, straight or branched tetradecylphenyl group, straight or branched pentadecylphenyl group, straight or branched hexadecylphenyl group, straight or branched heptadecylphenyl group and straight or branched octadecylphenyl group; and an arylalkyl group of 7-12 carbon atoms such as benzyl group, phenylethyl group, phenylpropyl group (including isomers of propyl group), phenylbutyl group (including isomers of butyl group), phenylpentyl group (including isomers of pentyl group) and phenylhexyl group (including isomers of hexyl group). Of the above listed bases are particularly preferred alkyl groups of 1-18 carbon atoms, alkenyl groups of 5-18 carbon atoms, and cyclohexyl groups or alkylcyclohexyl groups of 7-11 carbon atoms for reaction with the recited fatty acids to form their respective salts having a desired softening point conducive to the preparation of the inventive lubricant compositions.

R^5 in the formula (II) is an ethylene group or a propylene group (methylethylene group); however, the former is preferred for ease of dissolution in water.

The designation "q" in the formula (II) is an integer of 1-30, preferably 3-20.

X in the formula (II) is hydrogen, a hydrocarbon group of 1-24 carbon atoms or a group of $-(R^6\text{-}O)_rH$. The C_{1-24} hydrocarbon group is the same as deseribed for R^4, of which are preferred C_{1-18} alkyl groups, C_{5-18} alkenyl groups, cyclohexyl groups or C_{7-11} alkylcyclohexyl groups. R^6 in the hydrocarbon formula is an ethylene or propylene (methylethylene) group, the former being preferred for better water solubility. r is 1-30, preferably 3-20.

The nitrogen-containing compound of the formula (II) may be derived from reacting an ethylene or propylene oxide with monoamines of the formula (III) or diamines of the formula (IV).

$$R^4\text{-}NH_2 \qquad \text{(III)}$$

$$\begin{matrix} R^4 \searrow \\ \quad NH \\ R^7 \nearrow \end{matrix} \qquad \text{......... (IV)}$$

where R^4 is the same as defined in formula (II) and R^7 is the same as C_{1-24} hydrocarbon groups as defined in connection with X in formula (II).

The basic component of the salt of fatty acid (c) is preferably a nitrogen-containing compound having R^4 and X = C_{1-18} straight or branched alkyl group, C_{5-18} straight or branched alkenyl group, cyclohexyl group or C_{7-11} alkylcyclohexyl group, R^5 = ethylene group, and q = 3-20, which is hereinafter designated as Nitrogen-Containing Compound (y), and more preferably a compound having R^4 and X = C_{1-18} straight or branched alkyl group, cyclohexyl group or C_{7-9} straight or branched alkylcyclohexyl group, R^5 = ethylene and q = 3-20, which is hereinafter designated as Nitrogen-Containing Compound (z). Most preferred is the combination of the nitrogen-containing compound (z) with C_{12-18} saturated or unsaturated straight-chain fatty acids.

One or more of the salts (a), (b) and (c) may be used for the component (C). These salts may be formed in situ in the reaction system by adding a selected fatty acid and a selected base separately. Alternatively, they may be preformed. In either case, however, the lower allowable limit of addition of the salts is 0.05, preferably 0.1, more preferably 0.2 mass % based on total composition and the upper allowable limit of the same is 10, preferably 5, more preferably 3 mass % based on total composition. Less than 0.05 mass % would lead to declined lubricating performance, while more than 10 mass % would make the salt less soluble in water and the resultant composition less glossy.

In the practice of the invention, the component (C) is either completely dissolved or finely dispersed in a solution of components (A) and (B).

The lubricating oil compositions comprising specified amounts of components (A), (B) and (C), respectively, according to the invention may be readily put to use per se particularly in the manufacture of rolled metal products and may be, if desired, further added with suitable additives. Such additives exemplarily include: anion-based surface active agents such as sulfuric ester and sulfonate, and Nonion-based surface acitve agents such as polyoxyethylene compound; rust inhibitors such as sulfonate, phosphoric acid and phosphate, and boron compounds; antioxidants such as phenol-based, amine-based, sulfur-based, phosphorus-based and chlorine-based; nitrogen compounds such as benzotriazole, and corrosion inhibitors such as sulfur- and nitrogen-containing compound; antiseptics such as of phenol-based, formaldehyde donative compound and salicylamid-based compound; and silicone grease. These may be added in amounts of less than 10, preferably less than 5, more preferably less than 2 percent by mass based on the total mass of the composition.

A choice should be made of such additives which are readily soluble in water or dispersible as a continuous phase in water.

Whereas, mineral oils or hydrocarbon-based synthetic oils are not eligible for addition to the inventive lubricant composition whether they be used for emulsion-type or water-soluble rolling oils. Such non-eligible additives include paraffinic or naphthenic mineral oils derived from refining treatment of crude oil distillates such as by solvent-deasphalting, solvent-extraction, hydrocracking, solvent-dewaxing, contact dewaxing, hydrogenation, sulfur-washing, clay treatment and the like.

It has been found that rolling oil compositions, wherein water is not in a continuous phase, or mineral or synthetic oils are blended, would result in irregularities in the surface gloss of rolled product, poor emulsion stability, oil stains and increased consumption of oil in the removal of rolling abrasion dust or scum.

The inventive lubricating oil composition made up of the three components (A), (B) and (C) blended in the specified quantities may be stored as it is or with the component (A), i.e. water, added initially in an amount smaller than specified and later upon use supplemented to a desired level of dilution.

The invention will be further described by way of the following examples.

Inventive Example 1

Drinking water	25.8 mass %
Diethylene glycol	74.0 mass %
Sodium Oleate	0.2 mass %

Inventive Example 2

Drinking water	39.0 mass %
Dipropylene glycol	60.0 mass %
Triethanolamine oleate	1.0 mass %

Inventive Example 3

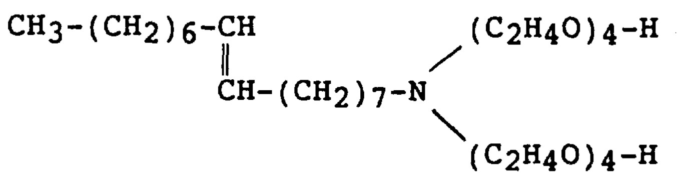
Drinking water	29.5 mass %
Hexylene glycol	70.0 mass %
Salt of oleic acid and dicyclohexylamine ethylene oxide adduct*1 (20 mole %)	0.5 mass %

*1 predominantly 2-methyl-2,4-pentanediol

Inventive Example 4

Drinking water	25.5 mass %
Tripropylene glycol	74.0 mass %
Lauric acid and oleylamine ethylene oxide adduct *2	0.5 mass %

*2



Inventive Example 5

Drinking water	69.8 mass %
Polyoxyethyleneoxypropylene glycol mono-n-butyl ether*3	30.0 mass %
Sodium oleate	0.2 mass %

*3 n-C_4H_9O-$(OE\text{-}OP)_2$-H

where -$(OE\text{-}OP)_2$- designates a random polymerization of 1 mole oxyethylene group and 1 mole oxypropylene group.

Inventive Example 6

Drinking water	49.0 mass %
Polyoxyethyleneoxypropylene glycol mono-n-butyl ether*3	50.0 mass %
Diethanolamine laurate	1.0 mass %

*3 n-C_4H_9O-$(OE\text{-}OP)_2$-H

Inventive Example 7

Drinking water	69.0 mass %
Polyoxyethyleneoxypropylene glycol mono-n-butyl ether*4	30.0 mass %
Diethanolamine oleate	1.0 mass %

*4 $n\text{-}C_4H_9O\text{-}(OE\text{-}OP)_{12}\text{-}H$

where $\text{-}(OE\text{-}OP)_{12}\text{-}$ designates a random polymerization of 6 moles oxyethylene group and 6 moles oxypropylene group.

Inventive Example 8

Drinking water	79.0 mass %
Polyoxyethyleneoxypropylene glycol mono-n-butyl ether*4	20.0 mass %
Triethanolamine oleate	1.0 mass %

*4 $n\text{-}C_4H_9O\text{-}(OE\text{-}OP)_{12}\text{-}H$

Comparative Example 1

Drinking Water	99.8 mass %
Sodium oleate	0.2 mass %

Comparative Example 2

Drinking Water	26.0 mass %
Sodium oleate	74.0 mass %

Comparative Example 3

Drinking Water	25.8 mass %
Diethylene glycol	44.0 mass %
Sodium oleate	0.2 mass %
Sorbitan monooleate	30.0 mass %

Comparative Example 4

Paraffinic refined mineral oil (dynamic viscosity 7 mm^2/s @40°C)	84.4 mass %
Butylstearate	15.0 mass %
Alkenyl succinate	0.6 mass %

Comparative Example 5

Paraffinic refined mineral oil (dynamic viscosity 7 mm^2/s @40°C)	49.4 mass %
Dioctyl sebacate	50.0 mass %
Alkenyl succinate	0.6 mass %

Comparative Example 6

Drinking water	90.0 mass %
Paraffinic refined mineral oil (dynamic viscosity 7 mm^2/s @40°C)	7.3 mass %
Butylstearate	1.5 mass %
Polyoxyethylene glycol mononophenyl ether	0.6 mass %
Sodium petroleum sulfonate	0.6 mass %

Comparative Example 7

Drinking water	20.0 mass %
Diethylene glycol	1.5 mass %
Paraffinic refined mineral oil (dynamic viscosity 7 mm^2/s @40°C)	57.0 mass %
Polyoxyethylene glycol mononophenyl ether	10.0 mass %
Sodium petroleum sulfonate	10.0 mass %
Oleic acid	1.5 mass %

Each of the foregoing exemplified lubricating oil compositions was tested for rolling performance with the results shown in Table 1.

Rolling Test Parameters

Substrate:	stainless steel SUS 430 2B measuring 0.5 mm thick and 50 mm wide
Work roll diameter:	51 mm
Work roll coarseness:	Ra 0.03 µm
Rolling speed:	100 m/min.
Pressure drop:	25 %
Oil supply:	Spray-nozzle was used for spraying over the substrate and the roll separately prior to rolling.

Performance Evaluation

Gloss: Each of the substrates that had been rolled three times under the above conditions was measured for surface gloss by a conventional glossmeter with an incident light directed at 30° with respect to the plane of the rolled metal, the resulting reflectance being checked against a standard black-color substrate.

Rollability: The substrate was rolled initially three times under the above rolling conditions. The next fourth cycle of rolling was commenced with pressure drop increased to 30 %. Thereafter, rolling was continued with pressure drop progressively increased up to a maximum rollable level. This level was taken to determine rollability.

Table 1

Lubricant Composition	Gloss (%)	Rollability (%)
Inventive Example		
1	480	60
2	500	60
3	500	60
4	480	60
5	520	58
6	520	58
7	520	60
8	480	58
Comparative Example		
1	480	42
2	380	45
3	400	45
4	450	42
5	450	44
6	380	40
7	380	40

The above tabulated data demonstrate superiority of the inventive compositions to the comparative counterparts in respect of contribution to the rolling performance as well as to the surface gloss of the rolled metal product.

Claims

1. A lubricating oil composition which comprises (A) water added in the range of from 5 to 89.95 percent by mass; (B) an oxygen-containing compound added in the range of from 10 to 94.95 percent by mass and represented by the formula

$$R^1O\text{-}(R^3\text{-}O)_p\text{-}R^2 \qquad (I)$$

where R^1 and R^2 each independently are hydrogen or hydrocarbon groups of 1-18 carbon atoms, R^3 is an alkylene group of 1-6 carbon atoms, p is an integer of 1-30; and (C) a salt of fatty acid added in the range of from 0.05 to 10 percent by mass and selected from the group consisting of (a) an alkaline metal salt of fatty acid of 6-22 carbon atoms, (b) a salt of fatty acid of 6-22 carbon atoms and an alkanol amine of 1-15 carbon atoms, and (c) a salt of fatty acid of 6-22 carbon atoms and a nitrogen-containing compound of the formula

$$\begin{matrix} R^4 \\ X \end{matrix} \Big> N\text{-}(R^5\text{-}O)_q\text{-}H \qquad \ldots\ldots\ (II)$$

where R^4 is a hydrocarbon group of 1-24 carbon atoms, R^5 is an ethylene or propylene group, q is an integer of 1-30, X is hydrogen, a hydrocarbon group of 1-24 carbon atoms or a group of the formula $-(R^6\text{-}O)_rH$ where R^6 is an ethylene or propylene group and r is an integer of 1-30; the sum of the water and the compound of the formula (I) being in the range of from 80 to 99.95 percent by mass based on total composition.

2. A lubricating oil composition according to claim 1 wherein $-(R^3\text{-}O)_p-$ in said formula (I) designates polyoxyalkylene groups of a single structure or two or more structurally different oxyalkylene groups resulting from random-, alternating- or block-copolymerization.

3. A lubricating oil composition according to claim 1 wherein said salt (b) is a salt of C_{12-18} saturated or unsaturated straight-chain fatty acid and C_{1-9} alkanol amine.

4. A lubricating oil composition according to claim 1 wherein said component (C) is completely dissolved or finely

dispersed in a solution of said components (A) and (B).

5. A lubricating oil composition according to claim 1 wherein said composition further contains less than 10 percent by mass of additives to provide improved lubricating performance.

6. A lubricating oil composition according to claim 1 wherein said composition is substantially free of mineral oils or hydrocarbon-based synthetic oils.

7. A method of rolling a metallic material with a lubricating oil composition defined in the preceding claims.

8. A method of rolling a metallic material according to claim 7 which comprises applying the lubricating oil composition to or adjacent the nip between working rolls for rolling the metallic material.