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(54) **OIL COMPOSITION FOR ALUMINUM WORKING WITH MINIMAL QUANTITY LUBRICATION**

(57) The present invention provides an oil for minimal quantity lubrication aluminum processing. In aluminum processing such as cutting, grinding, and form-rolling, the oil composition can improve the processing efficiency, tool life, and handleability in higher levels in a well-balanced manner and further is highly biodegradable and

thus environment friendly. The oil composition comprises an alcohol compound having 1 to 8 hydroxyl groups and 2 to 27 carbon atoms, in an amount of 16 to 100 percent by mass on the basis of the total mass of the composition.

EP 2 397 535 A1

Description

[0001] The present invention relates to oil compositions for minimal quantity lubrication aluminum processing.

[0002] Examples of aluminum processing include cutting, grinding, form-rolling, forging, pressing, drawing, and rolling.

These aluminum processing operations are usually carried out using lubricating oils.

For example, in cutting and grinding operations, cutting and grinding oils have been used in order to extend the working life of tools such as drills, end mills, tool bits, grinding stones and the like, improve the roughness of the finished surface of a workpiece, and improve the processing efficiency thereby, resulting in an improvement in the productivity of machining.

[0003] Cutting or grinding oils are roughly classified into two main types of oils, i.e., water-soluble oils which are put in use after diluting the surface-active agent and lubricant component contained therein with water, and water-insoluble oils which contain a mineral oil as a main component and are used as it is, i.e., in the form of a stock solution. In the conventional cutting and grinding operations, a relatively large amount of a cutting and grinding oil is supplied to processing spots of a workpiece regardless of which type of oil is used.

[0004] The most basic and important functions of cutting and grinding oils are lubricating and cooling functions. In general, water-insoluble cutting and grinding oils are superior in lubricating properties, while water-soluble ones are superior in cooling properties. It is thus necessary to supply the water-insoluble cutting and grinding oil in large amounts, ranging from several liters to over ten liters per minute.

[0005] Cutting and grinding oils, which are effective in improving processing efficiency have undesirable aspects, from different viewpoints. A typical example of such aspects is environmental impacts. Regardless of whether water-soluble or water-insoluble, the oils tend to gradually deteriorate during the use thereof and finally become incapable of further use. For instance, a water-soluble oil becomes unable to be used when it undergoes the separation of the components or deteriorates the environmental sanitation, caused by deteriorated stability due to the growth of microorganisms. A water-insoluble oil becomes unusable when the acidic components generated with the progress of oxidation make a workpiece corrode, or the viscosity is significantly changed. Furthermore, the oil is spent by adhering to metal chips or machining swarf and becomes wastes.

[0006] In such a case, the deteriorated oil is disposed and then replaced with a fresh oil. The oil disposed as wastes is necessarily subjected to various treatments so as to avoid the waste oil from adversely affecting the environment. For instance, cutting or grinding oils that are developed for the primary purpose of improving processing efficiency, contain a large amount of chlorine-containing components which may generate harmful dioxin during thermal disposal. Removal of such components is thus required. As the result, cutting or grinding oils that are free of chlorine-containing components have been developed. However, even though the oils contain no chlorine-containing component, they would adversely affect the environment if their waste disposal volume is large. The water-soluble oils may pollute the surrounding water area, and are, therefore, necessarily subjected to highly-developed treatments that require large costs.

[0007] The use of cooling by cold air blowing instead of the use of cutting and grinding oils has just been studied in order to deal with the problems as described above. However, in this case, the other functions of cutting and grinding oils, i.e., lubricity can not be obtained.

[0008] Under these circumstances, a minimal quantity lubrication cutting and grinding processing system has been developed, which is carried out by supplying oil in a trace amount of 1/100000 to 1/1000000 of the amount of oil used for conventional cutting and grinding to processing spots, together with a compressed fluid (for example, compressed air). This system can obtain a cooling effect with compressed air and can reduce the amount of wastes due to the use of a minimal quantity of oil, resulting in an improvement in effects on the environment that is caused by large amounts of waste disposal (see, for example, patent literature 1 below).

In such a minimal quantity lubrication cutting and grinding processing method, additives such as oiliness improvers and extreme pressure additives were conventionally used to improve the processing efficiency. In particular, oiliness improvers such as alcohols, carboxylic acids, sulfides of unsaturated carboxylic acids, polyoxyalkylene compounds, esters, hydrocarbyl ethers of polyhydric alcohols, and amines are used and added in an amount of usually 0.1 to 15 percent by mass on the basis of the total mass of a composition (see, for example, patent literature 2 below).

Citation List**Patent Literature**

[0009]

Patent Literature 1: WO02/08160

Patent Literature 2: Japanese Patent Laid-Open Publication No. 2006-249369

Summary of Invention

Technical Problem

5 [0010] Recently, the above-mentioned lubricating oil used for aluminum processing have been required to be further improved in properties. For example, in cutting and grinding processing utilizing the minimal quantity lubrication system (MQL system), it is required to provide a workpiece with excellent finished surfaces even though the amount of oil to be supplied is minimal, to reduce the wear of tools, and to carry out cutting and grinding efficiently. Therefore, the cutting and grinding oil used for the system is required to have high quality properties. So far, an ester has been used to reduce the friction and wear possibly occurring during processing such as aluminum cutting. The ester has been used not only as an additive but also as a base oil composing the majority of an oil because of its high lubricity and stability. However, an oil containing mainly an ester has a certain limit in its properties. A processing oil that is more highly efficient has been sought in order to further enhance productivity, and it has thus become an urgent matter to develop such a processing oil.

Solution to Problem

[0011] The present invention was accomplished in view of these circumstances and has an object to provide an aluminum processing oil composition suitable for MQL system and achievable of enhanced processing properties.

20 As the results of extensive studies and research carried out to achieve the foregoing object, the present invention was accomplished on the basis of the finding that the object was able to be achieved using an oil composition comprising an alcohol compound with a specific structure in a specific amount.

[0012] That is, the present invention relates to an oil composition for minimal quantity lubrication aluminum processing, comprising an alcohol compound having 1 to 8 hydroxyl groups and 2 to 27 carbon atoms, in an amount of 16 to 100 percent by mass on the basis of the total mass of the composition.

Advantageous Effects of Invention

30 [0013] In cutting, grinding and form-rolling aluminum processing, the oil composition for minimal quantity lubrication aluminum processing can improve the processing efficiency, tool life and handleability sufficiently in a well-balance manner.

Description of Embodiments

35 [0014] The present invention will be described below.

[0015] The oil composition for aluminum processing by minimal quantity lubrication system is an alcohol compound having 1 to 8 hydroxyl groups and 2 to 27 carbon atoms (hereinafter, referred to as "the alcohol compound of the present invention"). The use of the alcohol compound of the present invention as the oil composition can improve the processing efficiency, tool life and handleability in higher levels and in a well-balance manner.

40 [0016] The alcohol compound may be an monohydric alcohol, and is preferably a straight-chain or branched alcohol having 3 to 18 carbon atoms or a cycloalkyl alcohol or alkylcycloalkyl alcohol, having 5 to 10 carbon atoms. Specific examples include straight-chain or branched propanol (n-propanol, 1-methylethanol), straight-chain or branched butanol (n-butanol, 1-methylpropanol, 2-methylpropanol), straight-chain or branched pentanol (n-pentanol, 1-methylbutanol, 2-methylbutanol, 3-methylbutanol), straight-chain or branched hexanol (n-hexanol, 1-methylpentanol, 2-methylpentanol, 3-methylpentanol), straight-chain or branched heptanol (n-heptanol, 1-methylhexanol, 2-methylhexanol, 3-methylhexanol, 4-methylhexanol, 5-methylhexanol, 2,4-dimethylpentanol), straight-chain or branched octanol (n-octanol, 2-ethylhexanol, 1-methylheptanol, 2-methylheptanol), straight-chain or branched nonanol (n-nonanol, 1-methyldecanol, 3,5,5-trimethylhexanol, 1-(2'-methylpropyl)-3-methylbutanol), straight-chain or branched decanol (n-decanol, iso-decanol), straight-chain or branched undecanol (n-undecanol), straight-chain or branched dodecanol (n-dodecanol, iso-dodecanol), straight-chain or branched tridecanol, straight-chain or branched tetradecanol (n-tetradecanol, iso-tetradecanol), straight-chain or branched pentadecanol, straight-chain or branched hexadecanol (n-hexadecanol, iso-hexadecanol), straight-chain or branched heptadecanol, straight-chain or branched octadecanol (n-octadecanol, iso-octadecanol), cyclopentanol, cyclohexanol, methylcyclohexanol, dimethylcyclohexanol, and cycloheptanol.

55 [0017] Alternatively, the alcohol compound of the present invention may be a polyhydric alcohol having 2 to 8 hydroxyl groups.

[0018] Specific examples of the dihydric alcohol (diols) include ethylene glycol, 1,2-propane diol (propylene glycol), 1,3-propane diol, 1,4-butane diol, 1,2-butane diol, 2-methyl-1,2-propane diol, 2-methyl-1,3-propane diol, 1,3-butane diol, 1,4-butane diol, 1,2-pentane diol, 1,3-pentane diol, 1,4-pentane diol, 1, 5-pentane diol, neopentyl glycol, 1,6-hexane

diol, 2-ethyl-2-methyl-1,3-propane diol, 1,7-heptane diol, 2-methyl-2-propyl-1,3-propanediol, 2,2-diethyl-1,3-propane diol, 1,8-octane diol, 1,9-nonane diol, 1,10-decane diol, 1,11-undecane diol, and 1,12-dodecane diol.

[0019] Specific examples of the alcohols of trihydric or more include polyhydric alcohols such as trimethylolethane, trimethylolpropane, trimethylolbutane, di-(trimethylolpropane), tri-(trimethylolpropane), pentaerythritol, di-(pentaerythritol), tri-(pentaerythritol), glycerin, polyglycerin (dimer to eicosamer thereof), 1,3,5-pentanetriol, sorbitol, sorbitan, sorbitol-glycerin condensate, adonitol, arabitol, xylitol, and mannitol; saccharide such as xylose, arabinose, ribose, rhamnose, glucose, fructose, galactose, mannose, sorbose, cellobiose, maltose, isomaltose, trehalose, sucrose, raffinose, gentianose, and melezitose; and partial-etherified products and methylglucoside (glycosides) thereof. Preferred examples include hindered alcohols such as neopentyl glycol, trimethylolethane, trimethylolpropane, trimethylolbutane, di-(trimethylolpropane), tri-(trimethylolpropane), pentaerythritol, di-(pentaerythritol), and tri-(pentaerythritol).

[0020] When any of the above-mentioned polyhydric alcohols is used, it may be a partial ester in which some of the hydroxyl groups are esterified.

[0021] Particularly preferred examples of the alcohol compound of the present invention include branched saturated monohydric alcohols in view of processability of aluminum.

The alcohol compound of the present invention may be a mixture of two or more of the above-described alcohols.

[0022] The content of the alcohol compound of the present invention is necessarily 16 percent by mass or more, preferably 18 percent by mass or more, more preferably 20 percent by mass or more on the basis of the total mass of the composition with the objective of improving processing efficiency and tool life. The content is 100 percent by mass or less, preferably 95 percent by mass or less, more preferably 90 percent by mass or less, most preferably 80 percent by mass or less on the basis of the total mass of the composition in view of handleability.

[0023] The base oil of the aluminum processing oil composition of the present invention may be composed of the alcohol compound of the present invention alone or alternatively may be a mixture thereof with a base oil that is used for an ordinary lubricant to an extent that the processing efficiency, tool life and treatability are not impaired. Such a base oil may be a mineral oil or a synthetic oil. These oils may be mixed.

[0024] Examples of the mineral oils include paraffinic or naphthenic mineral oils produced by subjecting a lubricating oil fraction resulting from atmospheric and vacuum distillation of crude oil, to any one or more refining treatments selected from solvent deasphalting, solvent extraction, hydrocracking, solvent dewaxing, catalytic dewaxing, hydrotreating, sulfuric acid treatment, and clay treatment.

[0025] Examples of the synthetic oil include poly- α -olefins such as propylene oligomer, polybutene, polyisobutylene, 1-octene oligomer, 1-decene oligomer, cooligomers of ethylene and propylene, cooligomers of ethylene and 1-octene, and cooligomers of ethylene and 1-decene, and hydrogenated compounds of these compounds; isoparaffin; alkylbenzenes such as monoalkylbenzenes, dialkylbenzenes and polyalkylbenzenes; alkylnaphthalenes such as monoalkylnaphthalenes, dialkylnaphthalenes and polyalkylnaphthalenes; dibasic acid esters such as dioctyl adipate, di-2-ethylhexyl adipate, disodecyl adipate, ditridecyl adipate, di-2-ethylhexyl sebacate, and ditridecyl glutarate; tribasic acid esters such as trimellitic acid; polyolesters such as trimethylolpropane caprylate, trimethylolpropane pelargonate, pentaerythritol-2-ethyl hexanoate, and pentaerythritol pelargonate; polyglycols such as polyethylene glycol, polypropylene glycol, polyoxyethyleneoxypropylene glycol, polyethyleneglycol monoether, polypropylene glycol monoether, polyoxyethyleneoxypropylene glycol monoether, polyethylene glycol diether, polypropylene glycol diether, and polyoxyethyleneoxypropylene glycol diether; phenyl ethers such as monoalkyldiphenyl ether, dialkyldiphenyl ether, monoalkyltriphenyl ether, dialkyltriphenyl ether, tetraphenyl ether, monoalkyltetraphenyl ether, dialkyltetraphenyl ether, and pentaphenyl ether; silicone oil; and fluoroethers such as perfluoroether. These may be used alone or in combination.

[0026] Among the above-mentioned base oils, preferred are monoesters and/or diesters (excluding alicyclic dicarboxylic acid ester compounds), more preferred are the following (a) to (c) esters, and more preferred are (a) and (b) with the objective of further improving the handleability of the oil composition:

- (a) an ester of a monohydric alcohol and a monobasic acid ester;
- (b) an ester of a dihydric alcohol and a monobasic acid ester;
- (c) an ester of a monohydric alcohol and a dibasic acid ester.

[0027] Examples of the monohydric alcohol and dihydric alcohol are the same as the monohydric alcohols and dihydric alcohols exemplified with respect to the alcohol compounds of the present invention.

[0028] The monobasic acid is usually a fatty acid having 2 to 24 carbon atoms, which may be straight-chain or branched and saturated or unsaturated. Specific examples include fatty acids such as acetic acid, propionic acid, straight-chain or branched butanoic acid, straight-chain or branched pentanoic acid, straight-chain or branched hexanoic acid, straight-chain or branched heptanoic acid, straight-chain or branched octanoic acid, straight-chain or branched nonanoic acid, straight-chain or branched decanoic acid, straight-chain or branched undecanoic acid, straight-chain or branched dodecanoic acid, straight-chain or branched tridecanoic acid, straight-chain or branched tetradecanoic acid, straight-chain or branched pentadecanoic acid, straight-chain or branched hexadecanoic acid, straight-chain or branched heptadeca-

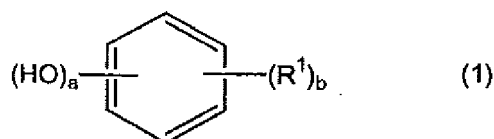
noic acid, straight-chain or branched octadecanoic acid, straight-chain or branched nonadecanoic acid, straight-chain or branched eicosanoic acid, straight-chain or branched heneicosanoic acid, straight-chain or branched docosanoic acid, straight-chain or branched tricosanoic acid, and straight-chain or branched tetracosanoic acid; unsaturated fatty acids such as acrylic acid, straight-chain or branched butenoic acid, straight-chain or branched pentenoic acid, straight-chain or branched hexenoic acid, straight-chain or branched heptenoic acid, straight-chain or branched octenoic acid, straight-chain or branched nonenoic acid, straight-chain or branched decenoic acid, straight-chain or branched undecenoic acid, straight-chain or branched dodecenoic acid, straight-chain or branched tridecenoic acid, straight-chain or branched tetradecenoic acid, straight-chain or branched pentadecenoic acid, straight-chain or branched hexadecenoic acid, straight-chain or branched heptadecenoic acid, straight-chain or branched octadecenoic acid, straight-chain or branched nonadecenoic acid, straight-chain or branched eicosenic acid, straight-chain or branched heneicosenic acid, straight-chain or branched docosenic acid, straight-chain or branched tircosenic acid, and straight-chain or branched tetracosenic acid; and mixtures thereof. Among these, in view of processing efficiency, tool life, and handleability, preferred are saturated fatty acids having 3 to 20 carbon atoms, unsaturated fatty acids having 3 to 22 carbon atoms, and mixtures thereof. More preferred are saturated fatty acids having 4 to 18 carbon atoms, unsaturated fatty acids having 4 to 18 carbon atoms, and mixtures thereof. In view of anti-sticking properties, most preferred are saturated fatty acids having 4 to 18 carbon atoms.

[0029] The dibasic acid may be a dibasic acid having 2 to 16 carbon atoms, which may be straight-chain or branched and saturated or unsaturated. Specific examples include ethanedioic acid, propanedioic acid, straight-chain or branched butanedioic acid, straight-chain or branched pentanedioic acid, straight-chain or branched hexanedioic acid, straight-chain or branched heptanedioic acid, straight-chain or branched octanedioic acid, straight-chain or branched nonanedioic acid, straight-chain or branched decanedioic acid, straight-chain or branched undecanedioic acid, straight-chain or branched dodecandioic acid, straight-chain or branched tridecanedioic acid, straight-chain or branched tetradecanedioic acid, straight-chain or branched heptadecanedioic acid, and straight-chain or branched hexadecanedioic acid, straight-chain or branched hexenedioic acid, straight-chain or branched heptenedioic acid, straight-chain or branched octenedioic acid, straight-chain or branched nonenedioic acid, straight-chain or branched decenedioic acid, straight-chain or branched undecenedioic acid, straight-chain or branched dodecenedioic acid, straight-chain or branched tridecenedioic acid, straight-chain or branched tetradecenedioic acid, straight-chain or branched heptadecenedioic acid, straight-chain or branched hexadecenedioic acid, and mixtures thereof.

[0030] The base oil of the oil composition for aluminum processing may be the alcohol compound of the present invention, the content of which may be 16 percent by mass or more on the basis of the total mass of the composition. The contents and type of base oils other than the alcohol compound of the present invention are not limited as long as the properties of the composition are not impaired.

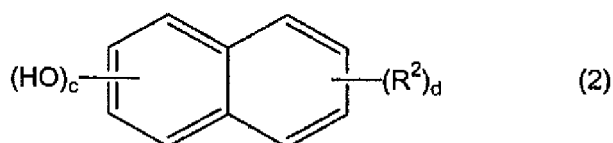
[0031] With the objective of improving processing efficiency and tool life, the oil composition for aluminum processing contains preferably an oiliness improver. Examples of such an oiliness improver include (A) carboxylic acids, (B) sulfides of unsaturated carboxylic acids, (C) compounds represented by formula (1) below, (D) compounds represented by formula (2) below, (E) polyoxyalkylene compounds, (F) esters, (G) hydrocarbonyl ethers of polyhydric alcohols, and (H) amines.

[0032]



[0033] [In formula (1), R^1 is a hydrocarbon group having 1 to 30 carbon atoms, a is an integer of 1 to 6, and b is an integer of 0 to 5.]

[0034]



[0035] [In formula (2), R^2 is a hydrocarbon group having 1 to 30 carbon atoms, c is an integer of 1 to 6, and d is an

integer of 0 to 5.]

[0036] Component (A), i.e., carboxylic acids may be monobasic or polybasic acids. With the objective of improving processing efficiency and tool life, preferred are monocarboxylic acids having 1 to 40 carbon atoms, more preferred are carboxylic acids having 5 to 25 carbon atoms, and most preferred are carboxylic acids having 5 to 20 carbon atoms. These carboxylic acids may be straight-chain or branched and saturated or unsaturated. However, in view of anti-sticking properties, the carboxylic acids are preferably saturated carboxylic acids. Specific examples include the monobasic acids and polybasic acid that are the same as those exemplified with respect to the above-described ester.

[0037] Examples of (B) sulfides of unsaturated carboxylic acids include sulfides of unsaturated carboxylic acids selected from the above described (A) carboxylic acids. Preferred examples include sulfides of oleic acid.

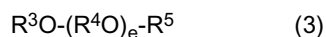
[0038] In (C) compounds represented by formula (1) above, examples of the hydrocarbon group having 1 to 30 carbon atoms represented by R^1 include straight-chain or branched alkyl groups having 1 to 30 carbon atoms, cycloalkyl groups having 5 to 7 carbon atoms, alkylcycloalkyl groups having 6 to 30 carbon atoms, straight-chain or branched alkenyl groups having 2 to 30 carbon atoms, aryl groups having 6 to 10 carbon atoms, alkylaryl groups having 7 to 30 carbon atoms, and arylalkyl groups having 7 to 30 carbon atoms. Among these hydrocarbons, preferred are straight-chain or branched alkyl groups having 1 to 30 carbon atoms, more preferred are straight-chain or branched alkyl groups having 1 to 20 carbon atoms, more preferred are straight-chain or branched alkyl groups having 1 to 10 carbon atoms, and most preferred are straight-chain or branched alkyl groups having 1 to 4 carbon atoms. Examples of the straight-chain or branched alkyl groups having 1 to 4 carbon atoms include ethyl, methyl, straight-chain or branched propyl, and straight-chain or branched butyl groups.

[0039] The position of the hydroxyl group may vary. However, in the case of the compound having two or more hydroxyl groups, they are preferably positioned at adjacent carbon atoms. Preferably, the letter "a" is an integer of 1 to 3, more preferably 2. Preferably, the letter "b" is an integer of 0 to 3, more preferably 1 or 2. Examples of compounds represented by formula (1) include p-tert-butylcatechol.

[0040] In (D) compounds represented by formula (2) above, examples of the hydrocarbon group having 1 to 30 carbon atoms represented by R^2 include those that are the same as those exemplified with respect to the hydrocarbon groups having 1 to 30 carbon atoms represented by R^1 , and preferred examples are also the same as those for R^1 . The position of the hydroxyl group may vary. However, in the case of the compound having two or more hydroxyl groups, they are preferably positioned at adjacent carbon atoms. Preferably, the letter "c" is an integer of 1 to 3, more preferably 2. Preferably, the letter "d" is an integer of 0 to 3, more preferably 1 or 2. Examples of compounds represented by formula (2) include 2,2-dihydroxynaphthalene and 2,3-dihydroxynaphthalene.

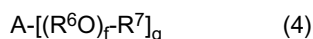
[0041] Examples of (E) polyoxyalkylene compounds include compounds represented by formulas (3) and (4) below.

[0042]



[In formula (3), R^3 and R^5 are each independently hydrogen or a hydrocarbon group having 1 to 30 carbon atoms, R^4 is an alkylene group having 2 to 4 carbon atoms, e is such an integer that the number-average molecular weight is from 100 to 3500.]

[0043]



[In formula (4), A is a residue resulting from removal of all or some of the hydrogen atoms of the hydroxyl groups of a polyhydric alcohol having 3 to 8 hydroxyl groups, R^6 is an alkylene group having 2 to 4 carbon atoms, R^7 is hydrogen or a hydrocarbon group having 1 to 30 carbon atoms, f is such an integer that the number-average molecular weight is from 100 to 3500, and g indicates the same number as the number of the hydrogen atoms having been removed from the hydroxyl groups for A.

[0044] In formula (3), at least either one of R^3 or R^5 is preferably hydrogen. Examples of the hydrocarbon group having 1 to 30 carbon atoms represented by R^3 and R^5 are the same as those exemplified with respect to the hydrocarbon groups having 1 to 30 carbon atoms represented by R^1 , and preferred examples are also the same as those for R^1 . Specific examples of alkylene groups represented by R^4 include ethylene, propylene (methylethylene), and butylene (ethylethylene) groups. Preferably, the letter "e" is such an integer to provide a number-average molecular weight of 300 to 2000, more preferably 500 to 1500.

[0045] Examples of the polyhydric alcohol having 3 to 8 carbon atoms constituting the residue A are the same as those exemplified with respect to the alcohol compounds of the present invention.

Examples of the alkylene groups having 2 to 4 carbon atoms represented by R^6 are the same as those represented by R^4 in formula (3). Examples of the hydrocarbon group having 1 to 30 carbon atoms represented by R^7 include those that are the same as those exemplified with respect to the hydrocarbon groups having 1 to 30 carbon atoms represented

by R¹, and preferred examples are also the same as those for R¹. Preferably, at least one of the R⁷ groups the number of which is represented by the letter "g" is preferably hydrogen atoms, and more preferably, all of the R⁷ groups are hydrogen atoms. Preferably, the letter "f" is such an integer to provide a number-average molecular weight of 300 to 2000, more preferably 500 to 1500.

[0046] Esters for the above-mentioned (F) esters may be those whose alcohol may be a monohydric alcohol or a polyhydric alcohol and whose carboxylic acid may be a monobasic acid or a polybasic acid.

[0047] Examples of the monohydric alcohol and polyhydric alcohol constituting the esters include those that are the same as the monohydric and polyhydric alcohols exemplified with respect to the alcohol compounds of the present invention. Examples of the monobasic acid and polybasic acid include those that are the same as the monobasic and polybasic acids exemplified with respect to the above-described esters for the base oil.

[0048] When the ester is produced using a polyhydric alcohol as the alcohol component, the resulting ester may be a full ester in which all of the hydroxyl groups of the polyhydric alcohol are esterified, or a partial ester in which some the hydroxyl groups remain unesterified. In the case of using a polybasic acid as the carboxylic acid component, the resulting ester may be a full ester in which all of the carboxyl groups are esterified, or a partial ester in which some of the carboxyl groups remain unesterified.

[0049] No particular limitation is imposed on the total carbon number of the ester. However, with the objective of improving processing efficiency and tool life, the ester is an ester having a total carbon number of preferably 7 or more, more preferably 9 or more, most preferably 11 or more. With the objective of preventing the generation of stain or corrosion and improving compatibility with organic materials, the ester is an ester having a total carbon number of preferably of 60 or less, more preferably 45 or less, more preferably 26 or less, more preferably 24 or less, most preferably 22 or less.

[0050] Polyhydric alcohols constituting (G) hydrocarbyl ethers of polyhydric alcohols may be those of usually dihydric to octahydric, preferably dihydric to hexahydric. Specific examples of polyhydric alcohols having 3 to 8 hydroxyl groups are the same as those of the alcohol compounds of the present invention. These polyhydric alcohols may be used alone or in combination.

Preferred polyhydric alcohols include ethylene glycol, propylene glycol, neopentyl glycol, glycerin, trimethylolethane, trimethylolpropane, pentaerythritol, sorbitan, and mixtures thereof. Among these polyhydric alcohols, most preferred is glycerin with the objective of improving processing efficiency and tool life.

[0051] Examples of (G) hydrocarbyl ethers of polyhydric alcohols include those wherein all or some of the hydroxyl groups of the above polyhydric alcohols are hydrocarbyl-etherified. Preferred are those wherein some of the hydroxyl groups of a polyhydric alcohol is hydrocarbyl-etherified (partial etherified product) with the objective of improving processing efficiency and tool life. The hydrocarbyl used herein refers to a hydrocarbon group having 1 to 24 carbon atoms, such as an alkyl group having 1 to 24 carbon atoms, an alkenyl group having 2 to 24 carbon atoms, a cycloalkyl group having 5 to 7 carbon atoms, an alkylcycloalkyl group having 6 to 11 carbon atoms, an aryl group having 6 to 10 carbon atoms, an alkylaryl group having 7 to 18 carbon atoms, and an arylalkyl group having 7 to 18 carbon atoms.

[0052] Among these hydrocarbyl groups, preferred are straight-chain or branched alkyl groups having 2 to 18 carbon atoms and straight-chain or branched alkenyl groups having 2 to 18 carbon atoms, and more preferred are straight-chain or branched alkyl group having 3 to 12 carbon atoms and oleyl group (residue resulting from removal of the hydroxyl groups from oleyl alcohol).

[0053] Preferably, (H) amines are monoamines. The carbon number of the monoamines is preferably from 6 to 24, more preferably from 12 to 24. The carbon number used herein refers to the total number of carbons contained in a monoamine, and refers to the total carbon number when a monoamine has two or more hydrocarbon groups.

[0054] The monoamines that can be used in the present invention are primary monoamines, secondary monoamines, or tertiary monoamines. Preferred are primary monoamines with the objective of improving processing efficiency and tool life.

[0055] Hydrocarbon groups bonding to nitrogen atoms of the monoamines may be alkyl, alkenyl, cycloalkyl, alkylcycloalkyl, aryl, alkylaryl, and arylalkyl groups. Preferred are alkyl and alkenyl groups with the objective of improving processing efficiency and tool life. Alkyl and alkenyl groups may be straight-chain or branched but are preferably straight-chain with the objective of improving processing efficiency and tool life.

[0056] Preferred monoamine used in the present invention include hexylamine (including all isomers), heptylamine (including all isomers), octylamine (including all isomers), nonylamine (including all isomers), decylamine (including all isomers), undecylamine (including all isomers), dodecylamine (including all isomers), tridecylamine (including all isomers), tetradecylamine (including all isomers), pentadecylamine (including all isomers), hexadecylamine (including all isomers), heptadecylamine (including all isomers), octadecylamine (including all isomers), nonadecylamine (including all isomers), eicosylamine (including all isomers), heneicosylamine (including all isomers), docosylamine (including all isomers), tricosylamine (including all isomers), tetracosylamine (including all isomers), octadecenylamine (including all isomers) (including oleylamine and the like), and mixtures of two or more thereof. Preferred are primary monoamines having 12 to 24 carbon atoms, more preferred are primary monoamines having 14 to 20 carbon atoms, and more

preferred are primary monoamines having 16 to 18 carbon atoms.

[0057] Any one or more of the above-described oiliness improvers (A) to (H) may be used in the present invention. Among these oiliness improvers, one type or a mixture of two or more types selected from (A) carboxylic acids and (H) amines are preferably used with the objective of improving processing efficiency and tool life.

[0058] No particular limitation is imposed on the content of the above-described oiliness improvers. However, with the objective of improving processing efficiency and tool life, the content is preferably 0.01 percent by mass or more, more preferably 0.05 percent by mass or more, more preferably 0.1 percent by mass or more on the basis of the total mass of the oil composition. In view of safety, the content is preferably 15 percent by mass or less, more preferably 10 percent by mass or less, more preferably 5 percent by mass or less on the basis of the total mass of the oil composition.

[0059] Preferably, the oil composition of the present invention further contains an extreme pressure additive. Preferred extreme pressure additives are sulfur compounds and phosphorus compounds.

[0060] No particular limitation is imposed on the sulfur compounds as long as the properties of the oil composition are not impaired. However, preferred for use are dihydrocarbylpolysulfide, sulfidizing esters, sulfidizing mineral oils, zinc dithiophosphate compounds, zinc dithiocarbamate compounds, molybdenum dithiophosphate compounds and molybdenum dithiocarbamate compounds.

[0061] Dihydrocarbylpolysulfides are sulfur compounds generally referred to as polysulfides or olefin sulfides, and specifically are represented by the following formula (5):



wherein R^8 and R^9 may be the same or different and are each independently a straight-chain or branched alkyl group having 3 to 20 carbon atoms, an aryl group having 6 to 20 carbon atoms, an alkylaryl group having 7 to 20 carbon atoms or an arylalkyl group having 7 to 20 carbon atoms, and h is an integer of 2 to 6, preferably 2 to 5.

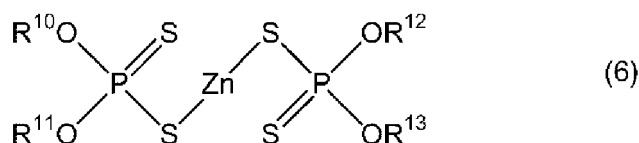
[0062] R^8 and R^9 in formula (5) are preferably branched alkyl groups having 3 to 18 carbon atoms derived from ethylene or propylene, particularly preferably branched alkyl groups having 6 to 15 carbon atoms derived from ethylene or propylene.

[0063] Specific examples of the sulfidizing esters include those produced by sulfidizing vegetable fats such as beef tallow, lard, fish oil, rapeseed oil and soybean oil; unsaturated fatty acid esters produced by reacting unsaturated fatty acids (including oleic acid, linoleic acid and fatty acids extracted from the aforementioned animal and vegetable fats) and various alcohols; and mixtures thereof, by any desired methods.

[0064] The sulfidizing mineral oil refers to a mineral oil in which elemental sulfur is dissolved. No particular limitation is imposed on the mineral oil for use in the sulfide mineral oil. However, specific examples include paraffinic mineral oils and naphthenic mineral oils produced by refining lubricating oil fractions that are produced by atmospheric distillation and vacuum distillation of crude oil, by one of or an appropriate combination of two or more of refining treatments such as solvent deasphalting, solvent extraction, hydrocracking, solvent dewaxing, catalytic dewaxing, hydrotreating, sulfuric acid washing, clay treatment or the like. The elemental sulfur may be in a massive, powdery or molten liquid form but is preferably in a powdery or molten liquid form because it can be efficiently dissolved in the base oil. It is advantageous to mix the elemental sulfur in a molten liquid state and the base oil, both of which are liquid because the dissolution operation can be completed in an extremely short period of time. However, because the elemental sulfur must be handled at a temperature equal to or higher than its melting point, an extra heating apparatus is required therefor and a risk is accompanied due to the high temperature atmosphere handling. The molten liquid elemental sulfur is not always handled easily. Whereas, the elemental sulfur in powder form is preferably used because it is inexpensive and easy to handle and can be dissolved in a sufficiently short period of time. No particular limitation is imposed on the sulfur content in the sulfide mineral oil. However, the content is preferably from 0.05 to 1.0 percent by mass, more preferably from 0.1 to 0.5 percent by mass on the basis of the total mass of the sulfide mineral oil.

[0065] The above-mentioned zinc dithiophosphate compounds, zinc dithiocarbamate compounds, molybdenum dithiophosphate compounds and molybdenum dithiocarbamate compounds are compounds represented by the following formulas (6) to (9), respectively:

[0066]



$$\begin{array}{c} \text{R}^{14} \\ \diagdown \\ \text{N} - \text{C}(=\text{S}) - \text{S} - \text{Zn} - \text{S} - \text{C}(=\text{S}) - \text{N} \\ \diagup \\ \text{R}^{15} \end{array} \quad \begin{array}{c} \text{S} \\ \parallel \\ \text{C} \end{array} \quad \begin{array}{c} \text{S} \\ \parallel \\ \text{C} \end{array} \quad \begin{array}{c} \text{R}^{16} \\ \diagup \\ \text{N} \\ \diagdown \\ \text{R}^{17} \end{array} \quad (7)$$

[0068]

$$\begin{array}{c}
 \text{R}^{18}\text{O} \quad \text{S} \quad \text{X}^1 \quad \text{X}^1 \quad \text{S} \quad \text{OR}^{20} \\
 \diagup \quad \diagdown \quad \parallel \quad \diagup \quad \parallel \quad \diagdown \\
 \text{P} \quad \text{Mo} \quad \text{Mo} \quad \text{P} \\
 \diagdown \quad \diagup \quad \diagdown \quad \diagup \quad \diagdown \quad \diagup \\
 \text{R}^{19}\text{O} \quad \text{S} \quad \text{X}^1 \quad \text{X}^1 \quad \text{S} \quad \text{OR}^{21}
 \end{array} \quad (8)$$

[0069]

$$\begin{array}{c}
 \text{R}^{22} \quad \quad \quad \text{X}^2 \quad \text{X}^2 \quad \text{X}^2 \\
 \diagdown \quad \quad \diagup \quad \diagdown \quad \diagup \quad \diagdown \\
 \text{N} - \text{C} = \text{S} \quad \text{Mo} \quad \text{Mo} \quad \text{S} = \text{C} - \text{N} \\
 \diagup \quad \quad \diagdown \quad \diagup \quad \diagdown \quad \diagup \\
 \text{R}^{23} \quad \quad \quad \text{X}^2 \quad \text{X}^2 \quad \text{X}^2 \\
 \quad \quad \quad \diagdown \quad \diagup \quad \diagdown \quad \diagup \\
 \quad \quad \quad \text{S} \quad \text{S} \quad \text{S} \quad \text{S}
 \end{array}
 \quad (9)$$

[0070] In formulas (6) to (9), R¹⁰, R¹¹, R¹², R¹³, R¹⁴, R¹⁵, R¹⁶, R¹⁷, R¹⁸, R¹⁹, R²⁰, R²¹, R²², R²³, R²⁴ and R²⁵ may be the same or different from each other and each independently a hydrocarbon group having one or more carbon atom, and X¹ and X² are each independently oxygen or sulfur and may be the same or different from each other.

[0071] In the present invention, among the above-mentioned sulfur compounds, at least one type selected from the group consisting of dihydrocarbyl polysulfides and sulfidizing esters is preferably used because the effects of improving processing efficiency and tool life can be achieved at further higher levels.

[0072] No particular limitation is imposed on the content of the above-described sulfur compound. With the objective of improving processing efficiency and tool life, the content is preferably 0.01 percent by mass or more, more preferably 0.05 percent by mass or more, more preferably 0.1 percent by mass or more on the total mass of the oil composition. With the objective of preventing abnormal wear, the content is preferably 50 percent by mass or less, more preferably 40 percent by mass or less, more preferably 30 percent by mass or less, particularly preferably 20 percent by mass or less.

[0073] Examples of the phosphorus compounds used as an extreme pressure additive include phosphoric acid esters, acidic phosphoric acid esters, acidic phosphoric acid ester amine salts, chlorinated phosphoric acid esters, phosphorous acid esters, and phosphorothionates. These phosphorus compounds may also be esters of phosphoric acid, phosphorous acid or thiophosphoric acid with alkanols or polyether alcohols, or derivatives thereof.

[0074] Among the above-described phosphorus compounds, preferred are phosphoric acid esters, acidic phosphoric acid esters, and acidic phosphoric acid ester amine salts.

[0075] As described below, the oil composition for aluminum processing of the present invention can also be suitably used as an oil for lubricating other parts of a metal processing machine. When the oil composition of the present invention is used for sliding surfaces, acidic phosphorus acid esters and amine salts thereof are preferably used. Alternatively, the oil composition is used as a hydraulic oil, phosphorus acid esters are preferably used. Furthermore, the oil composition of the present invention is used both as an oil for sliding surfaces and as a hydraulic oil, at least one type selected from acidic phosphorus acid esters and amine salts thereof is preferably used in combination with a phosphorus acid ester.

[0076] The oil composition for aluminum processing of the present invention may contain either one or both of sulfur

compounds and/or phosphorus compounds as an extreme pressure additive. However, with the objective of improving processing efficiency and tool life, the oil composition contains preferably phosphorus compounds or both sulfur compounds and phosphorus compounds, more preferably both sulfur compounds and phosphorus compounds.

[0077] No particular limitation is imposed on the content of the above-described extreme pressure additive. With the objective of improving processing efficiency and tool life, the content is preferably 0.005 percent by mass or more, more preferably 0.01 percent by mass or more, more preferably 0.05 percent by mass or more on the basis of the total mass of the composition. With the objective of preventing abnormal wear, the content of the phosphorus compound is preferably 15 percent by mass or less, 10 percent by mass or less, 5 percent by mass or less on the basis of the total mass of the composition.

[0078] In the present invention, either one of the above-described oiliness improver or extreme pressure additive may be used. However, the oiliness improver and extreme pressure additive are preferably used in combination because the effects of improving processing efficiency and tool life can be achieved at further higher levels.

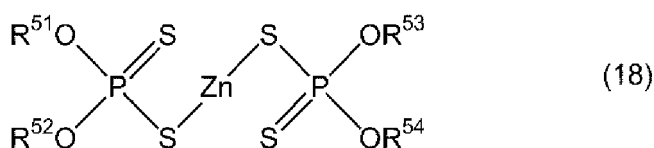
[0079] Preferably, the oil composition for aluminum processing further contains an antioxidant. Examples of the antioxidant that can be used include phenolic antioxidants, amine antioxidants, zinc dithiophosphate-based antioxidants, and antioxidants used as food additives.

[0080] No particular limitation is imposed on the phenolic antioxidants since they may be any phenolic compounds that have been used as antioxidants for lubricating oils. Preferable examples include alkylphenol compounds.

[0081] No particular limitation is imposed on the amine antioxidants since they may be any amine compounds that have been used as antioxidants for lubricating oils. Examples of the amine antioxidant include phenyl- α -naphthylamines, N-p-alkylphenyl- α -naphthylamines, and p,p'-dialkyldiphenylamines. Specific examples of the amine antioxidants include 4-butyl-4'-octyldiphenylamine, phenyl- α -naphthylamine, octylphenyl- α -naphthylamine, dodecylphenyl- α -naphthylamine, and mixtures thereof.

[0082] Specific examples of the zinc dithiophosphate-based antioxidants include zinc dithiophosphates represented by the following formula (18).

[0083]



[0084] In formula (18), R^{51} , R^{52} , R^{53} and R^{54} may be the same or different from each other and are each independently a hydrocarbon group.

[0085] Antioxidants that have been used as food additives may also be used. Although such antioxidants partially overlap with the above-mentioned phenolic antioxidants, examples of such antioxidants include 2,6-di-tert-butyl-p-cresol (DBPC), 4,4'-methylenebis(2,6-di-tert-butylphenol), 4,4'-bis(2,6-di-tert-butylphenol), 4,4'-thiobis(6-tert-butyl-o-cresol), ascorbic acid (vitamin C), ascorbic acid fatty acid esters, tocopherol (vitamin E), 3,5-di-tert-butyl-4-hydroxyanisole, 2-tert-butyl-4-hydroxyanisole, 3-tert-butyl-4-hydroxyanisole, 1,2-dihydro-6-ethoxy-2,2,4-trimethylquinoline (ethoxyquin), 2-(1,1-dimethyl)-1,4-benzenediol (TBHQ) and 2,4,5-trihydroxybutyrophenone (THBP).

[0086] Among these antioxidants, preferred are phenolic antioxidants, amine antioxidants, and the above-mentioned antioxidants that have been used as food additives. When it is considered that biodegradability is important, preferred are the above-mentioned food additive antioxidants among which more preferred are ascorbic acid (vitamin C), ascorbic acid fatty acid esters, tocopherol (vitamin E), 2,6-di-tert-butyl-p-cresol (DBPC), 3,5-di-tert-butyl-4-hydroxyanisole, 2-tert-butyl-4-hydroxyanisole, 3-tert-butyl-4-hydroxyanisole, 1,2-dihydro-6-ethoxy-2,2,4-trimethylquinoline (ethoxyquin), 2-(1,1-dimethyl)-1,4-benzenediol (TBHQ) and 2,4,5-trihydroxybutyrophenone (THBP), among which more preferred are ascorbic acid (vitamin C), ascorbic acid fatty acid esters, tocopherol (vitamin E), 2,6-di-tert-butyl-p-cresol (DBPC) and 3,5-di-tert-butyl-4-hydroxyanisole.

[0087] No particular limitation is imposed on the content of the antioxidant. However, with the objective of maintaining excellent heat/oxidation stability, the content is preferably 0.01 percent by mass or more, more preferably 0.05 percent by mass or more, most preferably 0.1 percent by mass or more on the basis of the total mass of the oil composition. Since a further improvement in effects of addition of the antioxidant as balanced with the content can not be expected, the content is preferably 10 percent by mass or less, more preferably 5 percent by mass or less, most preferably 3 percent by mass or less.

[0088] The oil composition of the present invention may further contain various conventional additives in addition to

those exemplified above. Examples of such additives include extreme pressure additives (including chlorine-based extreme pressure agents) other than the aforesaid phosphorus compounds and sulfur compounds; moistening agents such as diethyleneglycol monoalkylethers; film-forming agents such as acrylic polymers, paraffin wax, microwax, slack wax and polyolefin wax; water displacement agents such as fatty acid amine salts; solid lubricants such as graphite, fluorinated graphite, molybdenum disulfide, boron nitride and polyethylene powder; corrosion inhibitors such as amines, alkanolamines, amides, carboxylic acids, carboxylic acid salts, sulfonic acid salts, phosphoric acid, phosphoric acid salts and polyhydric alcohol partial esters; metal deactivators such as benzotriazoles and thiadiazoles; antifoaming agents such as methylsilicone, fluorosilicone and polyacrylates; and ashless dispersants such as alkenylsuccinic imides, benzylamines and polyalkenylamineaminoamides. No particular limitation is imposed on the contents of these known additives when used in combination. However, the additives are generally added in amounts so that the total content of thereof is from 0.1 to 10 percent by mass on the basis of the total mass of the oil composition.

[0089] No particular limitation is imposed on the kinematic viscosity of the aluminum processing oil composition of the present invention. With the objective of making it easier to supply the oil to processing spots, the kinematic viscosity at 40°C is preferably 200 mm²/s or lower, more preferably 100 mm²/s or lower, more preferably 75 mm²/s or lower, most preferably 50 mm²/s or lower. With the objective of improving processing efficiency and tool life, the kinematic viscosity at 40°C is preferably 1 mm²/s or greater, more preferably 3 mm²/s or greater, more preferably 5 mm²/s or greater.

Examples

[0090] Hereinafter, the present invention will be described in more detail by way of the following examples and comparative examples set forth in Table 1, which should not be construed as limiting the scope of the invention.

[Examples 1 to 9, Comparative Examples 1 to 6]

[0091] Sample oils 1 to 14 that are oil compositions for aluminum processing were prepared using the following Base Oils a to c, Alcohols A to C, and Additives A to E.

(1) Base Oils

[0092] Base Oil a: mineral oil (kinematic viscosity at 40°C: 32 mm²/s)

Base Oil b: trioleate of trimethylolpropane

Base Oil c: poly- α -olefin (kinematic viscosity at 40°C: 30 mm²/s)

(2) Alcohol

[0093] Alcohol A: branched tridecanol

Alcohol B: 1,8-octanediol

Alcohol C: neopentyl glycol monooleate

(3) Additive

[0094] Additive A: tricresyl phosphate

Additive B: sulfidizing esters

Additive C: glycerin monooleate

Additive D: butyl stearate

Additive E: oleic acid

(4) Sample Oil

[0095]

Sample Oil 1: Base Oil a (75 mass%), Alcohol A (25 mass%)

Sample Oil 2: Base Oil b (75 mass%), Alcohol A (25 mass%)

Sample Oil 3: Base Oil a (73 mass%), Alcohol A (25 mass%), Additive A (1 mass%), Additive B (1 mass%)

Sample Oil 4: Base Oil a (75 mass%), Alcohol B (25 mass%)

Sample Oil 5: Base Oil a (75 mass%), Alcohol C (25 mass%)

Sample Oil 6: Base Oil b (20 mass%), Alcohol A (80 mass%)

Sample Oil 7: Base Oil b (2 mass%), Alcohol A (98 mass%)

EP 2 397 535 A1

Sample Oil 8: Base Oil c (75 mass%), Alcohol A (25 mass%)

Sample Oil 9: Base Oil a (84 mass%), Alcohol A (16 mass%)

Sample Oil 10: Base Oil a (90 mass%), Alcohol A (10 mass%)

Sample Oil 11: Base Oil a (75 mass%), Additive C (25 mass%)

Sample Oil 12: Base Oil a (73 mass%), Additive D (25 mass%), Additive A (1 mass%), Additive B (1 mass%)

Sample Oil 13: Base Oil a (2 mass%), Additive D (98 mass%)

Sample Oil 14: Base Oil a (75 mass%), Additive E (25 mass%)

[0096] The following evaluation tests were carried out using oil compositions for aluminum processing of Examples 1 to 9 and Comparative Examples 1 to 5.

(Tapping Test)

[0097] Processability of each of the aluminum processing oil compositions of Examples 1 to 9 and Comparative Examples 1 to 5 was evaluated using a comparative standard oil that was diisodecyl adipate. More specifically, a tapping test was carried out under the following conditions using each of Examples 1 to 9 or each of Comparative Examples 1 to 5 alternately with diisodecyl adipate. In Comparative Example 6, the same tapping test was carried out only by blowing compressed air without using any oil.

[0098]

Workpiece: AC8A

Tool Diameter: 8mm

Tap Pitch: 1.25 mm

Tap Cutting Angle: 1.5 degree

Tap Chamfer Angle: 10 degrees

Bored Hole Diameter: 7.4 mm

Revolution: 360 rpm

Standard Oil: DIDA (diisodecyl adipate)

Supply Method: injected to a processing spot with MQ4 manufactured by TACO Co., Ltd.

Oil Supply Amount: 15 ml/h

Injected Air Pressure: 0.45 MPa

[0099] Tapping energy in the above test was measured, and tapping energy efficiency (%) was calculated using the following formula.

Tapping energy efficiency (%) = (Tapping energy derived when the standard oil was used)/(Tapping energy derived when each of the oil compositions)

The results are set forth in Table 1. Higher tapping energy efficiency in the table means higher lubricity.

(Antiwear Evaluation Test)

[0100] In order to evaluate the antiwear properties for tools, the tapping energy efficiencies of each of the aluminum processing oil compositions of Examples 1 to 9 and Comparative Examples 1 to 5 against the standard oil were measured twice, i.e., after 10 holes were tapped and after 150 holes were tapped, under the following conditions so as to calculate a reduction rate of the energy efficiency after 10 holes were tapped against that after 150 holes were tapped.

It was deemed that the degree of reduction in tapping energy efficiency due to the increased number of tapping was caused by tool wear. The test was carried out, removing the aluminum adhering to the tool with a 10% sodium hydroxide solution every 10-hole tapping.

Workpiece: AC8A

Tool Diameter: 8mm

Tap Pitch: 1.25 mm

Tap Cutting Angle: 1.5 degree

Tap Chamfer Angle: 10 degrees

Bored Hole Diameter: 7.4 mm

Revolution: 360 rpm

Number of holes: 10, 150 holes

Standard Oil: DIDA (diisodecyl adipate)

Supply Method: injected to a processing spot without using air (DIDA), injected to a processing spot together with air with MQ4 manufactured by TACO Co., Ltd (sample oils) . Oil Supply Amount: 4.0 ml/min (DIDA), 15 ml/h

(sample oils)

Injected Air Pressure: 0.4 MPa

(Evaluation Test of Discoloration)

[0101] Two sheets of aluminum plate A-1050 (60 mm x 80 mm x 1.2 mm) defined in JIS H 4000 were prepared, on one of which 0.1 g of each oil composition was poured dropwise and the other of which was placed thereon to sandwich the oil. The sheets was applied with a load of 100 g from the top and were allowed for stand at a temperature of 50°C and a humidity of 95% for 100 hours. Thereafter, the surface on which the oil composition was poured was observed to see whether the oil discolored or not.

The same evaluation was carried out using panels of cold-reduced carbon steel sheet SPCC (60 mm x 80 mm x 1.2 mm) defined in JIS G 3141.

[0102]

[Table 1]

		Tapping Energy Efficiency (%)	Reduction Rate in Tapping Energy Efficiency (%)	Discoloration	
				A-1050	SPCC
Example 1	Sample Oil 1	124	5.0	NO	NO
Example 2	Sample Oil 2	119	4.6	NO	NO
Example 3	Sample Oil 3	124	5.2	NO	NO
Example 4	Sample Oil 4	122	5.2	NO	NO
Example 5	Sample Oil 5	125	4.4	NO	NO
Example 6	Sample Oil 6	129	4.3	NO	NO
Example 7	Sample Oil 7	131	4.3	NO	NO
Example 8	Sample Oil 8	127	4.5	NO	NO
Example 9	Sample Oil 9	120	5.2	NO	NO
Comparative Example 1	Sample Oil 10	103	7.2	NO	NO
Comparative Example 2	Sample Oil 11	111	8.2	NO	NO
Comparative Example 3	Sample Oil 12	118	6.7	NO	NO
Comparative Example 4	Sample Oil 13	105	5.0	NO	NO
Comparative Example 5	Sample Oil 14	119	8.8	Yes	Yes
Comparative Example 6	-	91	Toolbroken at 9th hole	-	-

[0103] It is apparent from the results in Table 1 that the aluminum processing oil compositions of the present invention are higher in tapping energy efficiency and thus excellent in lubricity and also low in tapping energy reduction rate and thus excellent in antiwear properties. It is also confirmed that the oil compositions of the present invention did not discolor the aluminum panels.

Applicability in the Industry

[0104] The aluminum processing oil composition of the present invention can be used suitably for aluminum processing such as cutting, grinding, form-rolling, forging, pressing, drawing, or rolling. In particular, the oil composition is significantly useful as an oil for cutting, grinding, or form-rolling. The oil composition is supplied to spots to be processed by a minimal

quantity lubrication system and particularly suitable for use in minimal quantity lubrication cutting and grinding operations. Furthermore, the oil composition can be used as a lubricant for bearing portions, hydraulic devices, and gear portions so that these parts can be lubricated with a single oil composition.

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Claims

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1. An oil composition for minimal quantity lubrication aluminum processing, comprising an alcohol compound having 1 to 8 hydroxyl groups and 2 to 27 carbon atoms, in an amount of 16 to 100 percent by mass on the basis of the total mass of the composition.

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2. The oil composition for minimal quantity lubrication aluminum processing according to claim 1, wherein the alcohol compound is a straight-chain or branched alcohol having 3 to 18 carbon atoms or a cycloalkyl alcohol or alkylcycloalkyl alcohol having 5 to 10 carbon atoms.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/007162

A. CLASSIFICATION OF SUBJECT MATTER <i>C10M105/10</i> (2006.01) i, <i>C10M105/40</i> (2006.01) n, <i>C10M129/06</i> (2006.01) n, <i>C10M129/76</i> (2006.01) n, <i>C10N30/00</i> (2006.01) n, <i>C10N30/06</i> (2006.01) n, <i>C10N40/20</i> (2006.01) n, <i>C10N50/04</i> (2006.01) n According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) <i>C10M105/10</i> , <i>C10M105/40</i> , <i>C10M129/06</i> , <i>C10M129/76</i> , <i>C10N30/00</i> , <i>C10N30/06</i> , <i>C10N40/20</i> , <i>C10N50/04</i> Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2010 Kokai Jitsuyo Shinan Koho 1971-2010 Toroku Jitsuyo Shinan Koho 1994-2010 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2007-31517 A (Yushiro Chemical Industry Co., Ltd.), 08 February 2007 (08.02.2007), claims; paragraphs [0003], [0007]; example 1 (Family: none)	1-2 1-2
X Y	WO 2008/001933 A1 (Kyodo Yushi Co., Ltd.), 03 January 2008 (03.01.2008), claims; paragraph [0005]; example 5 & CN 101490224 A & EP 2039740 A1 & JP 2008-7700 A & KR 10-2009-0015142 A & US 2009/0298730 A1	1-2 1-2
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “E” earlier application or patent but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed “T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art “&” document member of the same patent family		
Date of the actual completion of the international search 12 February, 2010 (12.02.10)		Date of mailing of the international search report 23 February, 2010 (23.02.10)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/007162

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2001/030945 A1 (Nippon Mitsubishi Oil Corp.), 03 May 2001 (03.05.2001), claims; page 9, lines 11 to 17; page 12, lines 9 to 15; example 9 & CN 1337990 A & JP 2001-192685 A & JP 2001-192686 A & JP 2001-192690 A & JP 2001-192691 A & JP 2006-52413 A & JP 2006-52414 A & JP 2006-52415 A & JP 2006-83397 A & US 2002/0035043 A1	1-2

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2006249369 A [0009]