DESCRIPTION

LUBRICATING OIL FOR ALUMINUM WORKING

Technical Field

[0001] The present invention relates to a lubricating oil for aluminum working.

Background Art

[0002] In heat exchangers used in refrigerating systems such as refrigerators or air-conditioners, aluminum fins are used. Aluminum fins are manufactured by deformation processing such as overhang processing, drawing, punching, curling and ironing of a plate-like aluminum member (aluminum material).

[0003] The working of these aluminum fin materials is normally performed using an oil. This oil is a synthetic hydrocarbon such as an isoparaffin or the like (e.g., Japanese Laid-open Patent Publication No. Hei 2-133495).

Disclosure of the Invention

[0004] The oil which remains to the aluminum fin material after working must be removed by heating. For this purpose, the oil is required to have at least a certain volatility.

[0005] However, if the volatility of the oil is high, its viscosity decreases and sufficient working qualities are not obtained. Also, if the oil remaining to the aluminum fin material obtained vaporizes before an oil removal step, the aluminum fins come into direct contact with each other

in the storage, transport and assembly steps. This leads to scratches, and lubricity during assembly are inadequate. On the other hand, if an oil which does not easily vaporize is used to prevent scratches, the oil can no longer be completely removed in the oil removal step.

[0006] For this purpose, the oil is required to vaporize with difficulty at room temperature, but on the other hand to vaporize quickly and sufficiently at the set temperature in the oil removal step. Further, from the viewpoint of preventing unpleasant odor and skin irritation, an oil which is not excessively volatile is desired.

[0007] However, the oils available in the prior art could not be said to satisfy all these requirements.

[0008] It is therefore an object of the present invention, which was conceived in view of the above problems, to provide a lubricating oil for aluminum working which has good working qualities, can be completely removed in the oil removal step and can also prevent scratching of worked materials as well as unpleasant odor and skin irritation.

[0009] To solve the above problems, as a result of intensive studies, the inventor has discovered that by using a mineral oil having specific qualities, a lubricating oil for aluminum working which did not easily vaporize at room temperature but vaporized rapidly and completely in the oil removal step, these two qualities being carefully balanced, was obtained, and this led to the present invention.

[0010] Namely, the lubricating oil for aluminum working of the present invention comprises a mineral oil in which the aromatics content is 5 % by volume or less, the naphthenics content is 10-85 % by volume, the initial boiling point is 150°C or higher, the end point is 320°C or lower, the difference between the initial boiling point and end point is 100°C or less, and the kinematic viscosity at 40°C is 1.2-3.0mm^2/s.

Best Modes for Carrying Out the Invention

[0011] Hereinafter, preferred embodiments of the present invention are explained.

[0012] The lubricating oil for aluminum working of the present invention comprises a mineral oil having an aromatics content of 5 % by volume or less, a naphthenics content of 10-85 % by volume, and an initial boiling point of 150°C or higher, an end point of 320°C or lower, wherein the difference between the initial boiling point and end point is 100°C or less, and the kinematic viscosity at 40°C is 1.2-3.0mm^2/s. This mineral oil can be used as a base oil for the lubricating oil for aluminum working of the present invention.

[0013] The aromatics content of the mineral oil is 5 % by volume or less, preferably 3 % by volume or less, more preferably 2 % by volume or less and still more preferably 1 % by volume or less. By setting the aromatics content to be not higher than the aforesaid upper limit, unpleasant

odor and skin irritation can be prevented. Aromatics content in the context of the present invention means a value measured by the fluorescence indicator adsorption method of JIS K 2536 "Petroleum Product-Hydrocarbon Type Test".

[0014] The naphthenics content of the mineral oil is 10 % by volume or higher, preferably 15 % by volume or higher, more preferably 20 % by volume or higher, still more preferably 25% % by volume or higher and most preferably 30 % by volume or higher. By setting the naphthenics content to be not lower than aforesaid lower limit, oil removal property in the oil removal step and working properties are good. On the other hand, the naphthenics content is 85 % by volume or less, preferably 80 % by volume or less and more preferably 90 % by volume or less. By setting the naphthenics content to be not higher than the aforesaid upper limit, volatilization of the oil at room temperature can be prevented.

[0015] The paraffinics content of the mineral oil is not particularly limited, but the paraffinics content is preferably 15 % by volume or higher, more preferably 20 % by volume more, and still more preferably 25 % by volume or higher. By setting the paraffinics content to be not lower than the aforesaid lower limiting value, the unpleasant odor of the oil can be prevented. On the other hand, the paraffinics content is preferably 85 % by volume or less, more preferably 80 % by volume or less and still more

preferably 90 % by volume or less. By setting the paraffinics content to be not higher than the aforesaid upper limit, an anti-adhesion effect during working can be enhanced.

[0016] The naphthene and paraffinics contents are calculated after determining these proportions ratios with the molecular ion strength obtained by mass spectrometry by FI ionization (using a glass reservoir). The measurement method is shown in detail below.

(1) 120g of silica gel (Grade 923, Fuji Davison Chemicals) having a nominal diameter of 74-149μm and activated by drying at about 175°C for 3 hours, is packed in an 18mm adsorption tube for elution chromatography having a length of 980mm.

(2) 75ml of n-pentane is introduced to wet the silica gel beforehand.

(3) About 2g of sample is accurately weighed, diluted with the same volume of n-pentane, and the obtained solution is introduced.

(4) When the surface of the sample solution reaches the upper end of the silica gel, 140ml of n-pentane is introduced to separate saturated hydrocarbon components, and the eluate is collected from the lower end of the adsorption tube.

(5) The solvent is distilled off by putting the eluate from (4) on a rotary evaporator, and a saturated hydrocarbon component is thereby obtained.

(6) Type analysis is performed on the saturated hydrocarbon component obtained from (5) with a mass spectrometer. As

the ionizing method for the mass analysis, the FI ionizing method which employs a glass reservoir is used.

The mass spectrometer used is JMS-AX 505H, JEOL Co., Ltd.

The measurement conditions are as follows:

Accelerating voltage: 3.0kV

Cathode voltage: -5 ~ 6kV

Analyzing power: Approx. 500

Emitter: Carbon emitter

Current: 5mA

Test range: Mass number 35-700

Auxiliary oven temperature: 300°C

Filter temperature: 300°C

Main oven temperature: 350°C

Sample injection rate: 1μm

(7) Isotope correction is performed on the molecular ions obtained by the mass analysis of (6), and from the mass number, a classification into two types, i.e., paraffins (C_nH_{2n+2}) and naphthenes (C_nH_{2n}, C_nH_{2n-2}, C_nH_{2n-4} ...), is made. Next, the molar fractions of the ionic strengths of each type are calculated, and the amount of each type in the total saturated hydrocarbon components is determined. The paraffinics content and naphthenics content in the total sample are also calculated based on the amount of saturated hydrocarbon component obtained in (5).

[0017] Details of data processing based on the type analysis method in mass spectrometry by FI ionization are

given in "Nippon Oil Review", Vol. 33, No. 4, pp. 135-142, especially paragraph "2.2.3: Data Processing."

[0018] The initial boiling point of the mineral oil is 150°C or higher, preferably 160°C or higher, and more preferably 155°C or higher. By setting the initial boiling point of the mineral oil to be not lower than the aforesaid lower limit, volatilization of the oil at room temperature can be completely prevented. On the other hand, the end point of the mineral oil is 320°C or lower, but preferably 320°C or lower and more preferably 300°C or lower. By setting the end point of the mineral oil to be not higher than the aforesaid upper limiting value, oil removal properties in the oil removal step are satisfactory. Further, the temperature difference between the initial boiling point and end point of the mineral oil is 100°C or less, preferably 90°C or less and more preferably 80°C or less. By setting this temperature difference to be not more than the aforesaid upper limit, the dual objective of preventing volatilization of oil at room temperature and facilitating oil removal in the oil removal step can be achieved. Herein, the initial boiling point and end point in the present invention means a value measured based on JIS K 2254: "Petroleum Product Distillation Test Method."

[0019] The kinematic viscosity of the mineral oil at 40°C is 1.2-3.0mm^2/s. Specifically, the kinematic viscosity of the mineral oil at 40°C is 1.2mm^2/s or higher,

preferably 1.3mm^2/s or higher and more preferably 1.4mm^2/s or higher. By setting the kinematic viscosity to be not lower than the aforesaid lower limit, working properties can be improved. On the other hand, the kinematic viscosity of the mineral oil at 40°C is 3.0mm^2/s or lower, preferably 2.8mm^2/s or lower and more preferably 2.7mm^2/s or lower. By setting the kinematic viscosity to be not higher than the aforesaid upper limit, the dual objective of preventing volatilization of oil at room temperature and facilitating oil removal in the oil removal step can be achieved.

[0020] The mineral oil used in the present invention can be obtained by subjecting the fraction obtained by distilling crude oil at normal pressure to one, or a suitable combination of two or more, refining techniques such as solvent deasphalting, solvent extraction, hydrocracking, solvent dewaxing, hydrorefining, sulfuric acid treatment and clay treatment so that the initial boiling point is 150°C or higher, the end point is 320°C or lower, and the difference between the initial boiling point and end point is 100°C or less.

[0021] Based on the total amount of lubricating oil, the mineral oil content in the lubricating oil for aluminum working of the present invention is preferably 60 % by mass or higher, more preferably 65 % by mass or higher, and still more preferably 70 % by mass or higher. By setting the mineral oil content to be not less than the aforesaid lower

limit, working environment is improved in terms of absence of unpleasant odor and skin roughening and oil removal property in the oil removal step is satisfactory. This lubricating oil may comprise only the aforesaid mineral oil, or may further contain base oils (henceforth "other base oils") and various additives other than this mineral oil. When this lubricating oil contains various other base oils and various additives, the mineral oil content is not particularly limited. But the mineral oil content is preferably 99.9 % by mass or less and more preferably 99.5 % by mass or less based on the total amount of lubricating oil.

[0022] The lubricating oil for aluminum working of the present invention can contain the following optional components.

[0023] The lubricating oil for aluminum working of the present invention can also contain an oxygen-containing compound. This oxygen-containing compound may be at least one oxygen-containing compound selected from a group comprising the following components (A1)-(A8):

(A1) Alkylene oxide adduct of a polyhydric alcohol having 3-6 hydroxyl groups and a number average molecular weight of 100 to 1000

(A2) Hydrocarbyl ether or hydrocarbyl ester of the aforesaid component (A1)

(A3) Polyalkylene glycol having a number average molecular

weight of 100 to 1000

(A4) Hydrocarbyl ether or hydrocarbyl ester of the aforesaid component (A3)

(A5) Dihydric alcohol having 2-20 carbon atoms

(A6) Hydrocarbyl ether or hydrocarbyl ester of the aforesaid component (A5)

(A7) Trihydric alcohol having 3-20 carbon atoms

(A8) Hydrocarbyl ether or hydrocarbyl ester of the aforesaid component (A7)

[0024] The polyhydric alcohol which forms component (A1) has 3-6 hydroxyl groups. Examples of a polyhydric alcohol having 3-6 hydroxyl groups include the following polyhydric alcohols, and also saccharides.

[0025] Examples of such polyhydric alcohols include glycerol, polyglycerol (dimers - tetramers of glycerol such as diglycerol, triglycerol, tetraglycerol), trimethyloyl alkane (e.g., trimethylolethane, trimethylolpropane, trimethyloylbutane) and dimers-tetramers thereof, pentaerythritol, dipenta erythritol, 1,2,4-butanetriol, 1,3,5-pentanetriol, 1,2,6-hexanetriol, 1,2,3,4-butanetetrol, sorbitol, sorbitan, sorbitol glycerin condensate, ribitol, arabitol, xylitol, mannitol, iditol, talitol, dulcitol and allitol.

[0026]

Examples of saccharides are xylose, arabinose, ribose, rhamnose, glucose, fructose, galactose, mannose, sorbose,

cellobiose, maltose, isomaltose, trehalose and sucrose.

[0027] Among these, from the viewpoint of excellent working properties, trimethyloyl alkane and sorbitol are preferred. As the alkylene oxide which forms component (A1), an alkylene oxide having 2-6 carbon atoms but preferably 2-4 carbon atoms is used.

[0028] Examples of an alkylene oxide having 2-6 carbon atoms are ethylene oxide, propylene oxide, 1,2-epoxy butane (α-butylene oxide), 2,3-epoxybutane (β-butylene oxide), 1,2-epoxy-1-methylpropane, 1,2-epoxyheptane and 1,2-epoxyhexane. Among these, from the viewpoint of excellent working properties, ethylene oxide, propylene oxide and butylene oxide are preferred, but ethylene oxide and propylene oxide are more preferred.

[0029] When two or more types of alkylene oxide are used, there is no particular limitation on the type of polymerization of the oxyalkylene group, which may be random copolymerization or block copolymerization. Further, when the alkylene oxide is added to the polyhydric alcohol having 3-6 hydroxyl groups, it may be added to all the hydroxyl groups, or it may be added only to some hydroxyl groups. Among these, from the viewpoint of excellent working properties, it is preferred to add it to all the hydroxyl groups.

[0030] The number average molecular weight (Mn) of component (A1) is 100 to 1000, and preferably 100 to 800.

If Mn is less than 100, the solubility with respect to the mineral oil falls which is undesirable. On the other hand, if Mn is more than 1000, oil may remain on the surface of the work piece after working in the oil removal step, which is undesirable. Mn in the present invention means the number average molecular weight converted to standard polystyrene by gel permeation chromatography (GPC).

[0031] The component (A1) is obtained by reaction between the alkylene oxide and the polyhydric alcohol having 3-6 hydroxyl groups so that Mn is 100 to 1000. Alternatively, a mixture of alkylene oxide adducts of polyhydric alcohols having 3-6 hydroxyl groups obtained by any desired method or a mixture of commercial alkylene oxide adducts of polyhydric alcohols having 3-6 hydroxyl groups may also be separated by distillation or chromatography so that Mn is 100 to 1000. The component (A1) may be used alone, or two or more may be used in admixture.

[0032] The component (A2) is the hydrocarbyl ether or hydrocarbyl ester of the alkylene oxide adduct of the polyhydric alcohol having 3-6 hydroxyl groups whereof Mn is 100 to 1000, and preferably 100 to 800.

[0033] The component (A2) is obtained by hydrocarbyl-etherification or esterification of part or all of the terminal hydroxyl groups of the alkylene oxide adduct of component (A1). This hydrocarbyl group may be a hydrocarbon group having 1-24 carbon atoms, such as an alkyl

group having 1-24 carbon atoms, alkenyl group having 2-24 carbon atoms, cycloalkyl group having 5-7 carbon atoms, alkylcycloalkyl having 6-11 carbon atoms, aryl group having 6-10 carbon atoms, alkylaryl group having 7-18 carbon atoms and arylalkyl group having 7-18 carbon atoms.

[0034] Examples of an alkyl group having 1-24 carbon atoms are methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl, straight or branched chain pentyl, straight or branched chain hexyl, straight or branched chain heptyl, straight or branched chain octyl group, straight or branched chain nonyl, straight or branched chain decyl, straight or branched chain undecyl, straight or branched chain dodecyl, straight or branched chain tridecyl, straight or branched chain tetradecyl, straight or branched chain pentadecyl, straight or branched chain hexadecyl, straight or branched chain heptadecyl, straight or branched chain octadecyl, straight or branched chain nonadecyl, straight or branched chain icosyl group, straight or branched chain henicosyl, straight or branched chain docosyl, straight or branched chain tricosyl and straight or branched chain tetracosyl.

[0035] Examples of an alkenyl group having 2-24 carbon atoms are vinyl, straight or branched chain propenyl, straight or branched chain butenyl, straight or branched chain pentenyl, straight or branched chain hexenyl, straight or branched chain heptenyl, straight or branched chain

octenyl, straight or branched chain nonenyl, straight or branched chain decenyl, straight or branched chain undecenyl, straight or branched chain dodecenyl, straight or branched chain tridecenyl, straight or branched chain tetradecenyl, straight or branched chain pentadecenyl, straight or branched chain hexadecenyl, straight or branched chain heptadecenyl, straight or branched chain octadecenyl group, straight or branched chain nonadecenyl group, straight or branched chain icosenyl, straight or branched chain henicosenyl, straight or branched chain docosenyl, straight or branched chain tricosenyl, and straight or branched chain tetracosenyl.

[0036] Examples of a cycloalkyl group having 5-7 carbon atoms are cyclopentyl, cyclohexyl and cycloheptyl. Examples of a alkylcycloalkyl group having 6-11 carbon atoms are methylcyclopentyl, dimethylcyclopentyl group (including all structural isomers), methylethylcyclopentyl (including all structural isomers), diethylcyclopentyl (including all structural isomers), methylcyclohexyl, dimethylcyclohexyl (including all structural isomers), methylethylcyclohexyl (including all structural isomers), diethylcyclohexyl (including all structural isomers), methylcycloheptyl, dimethylcycloheptyl (including all structural isomers), methylethylcycloheptyl (including all structural isomers) and diethylcyclo heptyl (including all structural isomers).

[0037] Examples of an aryl group having 6-10 carbon atoms are phenyl and naphthyl. Examples of an arylalkyl group having 7-18 carbon atoms are tolyl (including all structural isomers), xylyl (including all structural isomers), ethylphenyl (including all structural isomers), straight or branched chain propylphenyl (including all structural isomers), straight or branched chain butylphenyl (including all structural isomers), straight or branched chain pentylphenyl (including all structural isomers), straight or branched chain hexylphenyl (including all structural isomers), straight or branched chain heptylphenyl (including all structural isomers), straight or branched chain octylphenyl (including all structural isomers), straight or branched chain nonylphenyl (including all structural isomers), straight or branched chain decylphenyl (including all structural isomers), straight or branched chain undecylphenyl (including all structural isomers) and straight or branched chain dodecyl phenyl (including all structural isomers).

[0038] Examples of an arylalkyl group having 7-12 carbon atoms are benzyl, phenyl ethyl, phenylpropyl (including propyl isomers), phenylbutyl (including butyl isomers), phenylpentyl (including pentyl isomers), and phenylhexyl (including hexyl isomers).

[0039] Among these, from the viewpoint of excellent working properties, straight or branched chain alkyl groups

having 2-18 carbon atoms and straight or branched chain alkenyl groups having 2-18 carbon atoms are preferred, and straight or branched alkyl groups and oleyl groups (residue obtained by removing a hydroxyl group from oleyl alcohol) having 3-12 carbon atoms are more preferred.

[0040] The acid used for esterification is usually a carboxylic acid. This carboxylic acid may be a monobasic acid or a polybasic acid, but a monobasic acid is usually used. Examples of a monobasic acid are fatty acids having 6-24 carbon atoms, and straight or branched chain acids may be used. The monobasic acid may be a saturated fatty acid, unsaturated fatty acid or a mixture of both.

[0041] Examples of a saturated fatty acid are straight or branched chain hexanoic acid, straight or branched chain octanoic acid, straight or branched chain nonanoic acid, straight or branched chain decanoic acid, straight or branched chain undecanoic acid, straight or branched chain dodecanoic acid, straight or branched chain tridecanoic acid, straight or branched chain tetradecanoic acid, straight or branched chain pentadecanoic acid, straight or branched chain hexadecanoic acid, straight or branched chain octadecanoic acid, straight or branched chain hydroxyoctadecanoic acid, straight or branched chain nonadecanoic acid, straight or branched chain eicosanoic acid, straight or branched chain heneicosanoic acid, straight or branched chain docosanoic acid, straight or

branched chain tricosanoic acid, and straight or branched chain tetracosanoic acid.

[0042] Examples of an unsaturated fatty acid are straight or branched chain hexenoic acid, straight or branched chain heptenoic acid, straight or branched chain octenoic acid, straight or branched chain nonenoic acid, straight or branched chain decenoic acid, straight or branched chain undecenoic acid, straight or branched chain dodecenoic acid, straight or branched chain tridecenoic acid, straight or branched chain tetradecenoic acid, straight or branched chain pentadecenoic acid, straight or branched chain hexadecenoic acid, straight or branched chain octadecenoic acid, straight or branched chain hydroxyoctadecenoic acid, straight or branched chain nonadecenoic acid, straight or branched chain eicosenoic acid, straight or branched chain heneicosenoic acid, straight or branched chain docosenoic acid, straight or branched chain tricosenoic acid, and straight or branched chain tetracosenoic acid.

[0043] Among these, saturated fatty acids having 8-20 carbon atoms and unsaturated fatty acids having 8-20 carbon atoms, and their mixtures, are preferred. The component (A2) may be used alone, or two or more may be used in admixture.

[0044] Component (A3) is a polyalkylene glycol whereof Mn is 100 to 1000, and is obtained by homopolymerization or copolymerization of an alkylene oxide having 2-6 carbon

atoms or preferably 2-4 carbon atoms. Examples of an alkylene oxide having 2-6 carbon atoms are the alkylene oxides mentioned in the description of component (A1). Among these, from the viewpoint of excellent working properties, ethylene oxide, propylene oxide and butylene oxide are preferred, but ethylene oxide and propylene oxide are more preferred.

[0045] When two or more types of alkylene oxide are used in the preparation of the polyalkylene glycol, the type of polymerization of the oxyalkylene group is not particularly limited, i.e., block copolymerization may be performed or random copolymerization may be performed.

[0046] For the component (A3), Mn of the polyalkylene glycol must be 100 to 1000, and preferably 120 to 700. A polyalkylene glycol having Mn of less than 100 is undesirable since its solubility in the mineral oil is low. On the other hand, a polyalkylene glycol having Mn of more than 1000 is undesirable since it may cause oil remaining on the surface of the worked material after the oil removal step.

[0047] For the component (A3), when the alkylene oxide is polymerized, the material used may be such that Mn is 100 to 1000. Also, a polyalkylene glycol mixture obtained by any desired method or a mixture of commercial polyalkylene glycols may be separated by distillation or chromatography so that Mn is 100 to 1000. The component (A3) may be used alone, or two or more may be used in admixture.

[0048] The component (A4) is obtained by hydrocarbyl etherification or hydrocarbyl esterification of a polyalkylene glycol for which Mn is 100 to 1000, and preferably 120 to 700. As the component (A4), part or all of the terminal hydroxyl groups in the polyalkylene glycol of component (A3) may be hydrocarbyl-etherified or hydrocarbyl-esterified. Herein, the hydrocarbyl group is a hydrocarbon group having 1-24 carbon atoms, specific examples being the groups mentioned in the description of component (A2). Among these, from the viewpoint of excellent working properties, straight or branched chain alkyl groups having 2-18 carbon atoms and straight or branched chain alkenyl groups having 2-18 carbon atoms are preferred, and alkyl groups and oleyl groups (residue obtained by removing a hydroxyl group from oleyl alcohol) having 3-12 carbon atoms are more preferred.

[0049] As component (A4), the product of esterifying terminal hydroxyl groups in the polyalkylene glycol of component (A3) may also be used. The acids used for esterification may be the usual carboxylic acids. This carboxylic acid may be a monobasic acid or a polybasic acid, but a monobasic acid is usually used. Specific examples are the acids mentioned in the description of component (A2). The component (A4) may be used alone, or two or more may be used in admixture.

[0050] The component (A5) is a divalent alcohol having

2-20 carbon atoms, but preferably 3-18 carbon atoms. Herein, divalent alcohol means that there is no ether linkage in the molecule. Examples of a divalent alcohol having 2-20 carbon atoms are ethylene glycol, 1,3-propane diol, propylene glycol, 1,4-butane diol, 1,2-butane diol, 2-methyl-1,3-propane diol, 1,5-pentane diol, neopentyl glycol, 1,6-hexane diol, 2-ethyl-2-methyl-1,3-propane diol, 2-methyl-2,4-pentane diol, 1,7-heptane diol, 2-methyl-2-propyl-1,3-propane diol, 2,2-diethyl-1,3-propane diol, 1,8-octane diol, 1,9-nonane diol, 2-butyl-2-ethyl-1,3-propane diol, 1,10-decane diol, 1,11-undecane diol, 1,12-dodecane diol, 1,13-tridecane diol, 1,14-tetradecane diol, 1,15-heptadecane diol, 1,16-hexadecane diol, 1,17-heptadecane diol, 1,18-octa decane diol, 1,19-nonadecane diol and 1,20-icosadecane diol.

[0051] From the viewpoint of excellent working properties, 4-butane diol, 1,5-pentane diol, neopentyl glycol, 1,6-hexane diol, 2-methyl-2,4-pentane diol, 2-ethyl-2-methyl-1,3-propanediol, 1,7-heptane diol, 1,8-octane diol, 1,9-nonane diol, 1,10-decane diol, 1,11-undecane diol and 1,12-dodecane diol are preferred. The component (A5) may be used alone, or two or more may be used in admixture.

[0052] The component (A6) is obtained by hydrocarbyl etherification or hydrocarbyl esterification of a divalent

alcohol having 2-20 carbon atoms, and preferably 3-18 carbon atoms (excluding those having an ether linkage in the molecule). As the component (A6), part or all of the terminal hydroxyl groups in the dibasic alcohol of component (A5) may be hydrocarbyl-etherified or hydrocarbyl-esterified. Herein, the hydrocarbyl group is a hydrocarbon group having 1-24 carbon atoms, specific examples being the groups mentioned in the description of component (A2). Among these, from the viewpoint of excellent working properties, straight or branched chain alkyl groups having 2-18 carbon atoms and straight or branched chain alkenyl groups having 2-18 carbon atoms are preferred, but alkyl groups and oleyl groups (residue obtained by removing a hydroxyl group from oleyl alcohol) having 3-12 carbon atoms are more preferred.

[0053] The component (A6) may also be obtained by esterification of one or both of the terminal hydroxyl groups in the dibasic acid of component (A5). The acids used for esterification may be the usual carboxylic acids. This carboxylic acid may be a monobasic acid or a polybasic acid, but a monobasic acid is usually used. Specific examples are those mentioned in the description of component (A2). Also, in the esterification of component (A6), only one of the terminal hydroxyl groups (partial ester), or both of the terminal hydroxyl groups (full ester) of the divalent alcohol of component (A5) may be esterified. Among these, from the viewpoint of excellent working properties, the

partial ester is preferred. The component (A6) may be used alone, or two or more may be used in admixture.

[0054] The component (A7) is a trivalent alcohol having 3-20 carbon atoms, and preferably 3-18 carbon atoms. Herein, the trivalent alcohol does not have an ether linkage in the molecule. Examples of a trivalent alcohol having 3-20 carbon atoms are glycerin, 1,2,3-butane triol, 1,2,4-butane triol, 1,2, 5-pentane triol, 1,3,5-pentane triol, 1,2,3-pentane triol, 1,2,4-pentane triol, 1,2,6-hexane triol, 1,2,3-hexane triol, 1,2,4-hexane triol, 1,2,5-hexane triol, 1,3,4-hexane triol, 1,3,5-hexane triol, 1,3,6-hexane triol, 1,4,5-hexane triol, 1,2,7-heptane triol, 1,2,8-octane triol, 1,2,9-nonane triol, 1,2,10-decane triol, 1,2,11-undecane triol, 1,2,12-dodecane triol, 1,2,13-tridecane triol, 1,2,14-tetradecane triol, 1,2,15-pentadecane triol, 1,2,16-hexadecane triol, 1,2,17-heptadecane triol, 1,2,18-octadecane triol, 1,2,19-nonadecane triol and 1,2,20-icosane triol.

[0055] Among these, from the viewpoint of excellent working properties, 1,2,12-dodecane triol, 1,2,13-tridecane triol, 1,2,14-tetradecane triol, 1,2,15-pentadecane triol, 1,2,16-hexadecane triol, 1,2,17-heptadecane triol and 1,2,18-octadecane triol are preferred. The component (A7) may be used alone, or two or more may be used in admixture.

[0056] The component (A8) is obtained by hydrocarbyl-etherification or esterification of a trivalent alcohol having 3-20 carbon atoms, and preferably 3-18 carbon atoms (excluding those with an ether linkage in the molecule). As the component (A8), part or all of the terminal hydroxyl groups in the trivalent alcohol of component (A7) may be hydrocarbyl-etherified or hydrocarbyl-esterified. Herein, the hydrocarbyl group is a hydrocarbon group having 1-24 carbon atoms, specific examples being the groups mentioned in the description of component (A2). Among these, from the viewpoint of excellent working properties, straight or branched chain alkyl groups having 2-18 carbon atoms and straight or branched chain alkenyl groups having 2-18 carbon atoms are preferred, and alkyl groups and oleyl groups (residue obtained by removing a hydroxyl group from oleyl alcohol) having 3-12 carbon atoms are more preferred.

[0057] The component (A8) may also be obtained by esterification of one or all of the terminal hydroxyl groups in the tribasic acid of component (A7). The acids used for esterification may be the usual carboxylic acids. This carboxylic acid may be a monobasic acid or a polybasic acid, but a monobasic acid is usually used. Specific examples are those mentioned in the description of component (A2). Also, in the esterification of component (A8), only one of the terminal hydroxyl groups (partial ester) or all of the

terminal hydroxyl groups (full ester) of the trivalent alcohol of component (A7) may be esterified. Among these, from the viewpoint of excellent working properties, the partial ester is preferred.

[0058] The component (A8) is the hydrocarbyl ether or partial ester of, among components (A7), 1,2,3-butane triol, 1,2,4-butane triol, 1,2, 5-pentane triol, 1,3,5-pentane triol, 1,2,3-pentane triol, 1,2,4-pentane triol, 1,2,6-hexane triol, 1,2,3-hexane triol, 1,2,4-hexane triol, 1,2,5-hexane triol, 1,3,4-hexane triol, 1,3,5-hexane triol, 1,3,6-hexane triol and 1,4,5-hexane triol. As component (A8), one of these compounds may be used alone, or two or more may be used in admixture.

[0059] In the present invention, one oxygen-containing compound selected from the above components (A1)-(A8), or a composition of two or more oxygen-containing compounds of different structure, may be used. Among the aforesaid components (A1)-(A8), from the viewpoint of excellent working properties, component (A3), component (A4), component (A5) and component (A8) are preferred, but component (A3), component (A4) and component (A8) are more preferred.

[0060] The amount of oxygen-containing compound in the lubricating oil for aluminum working of the present invention is preferably 0.01 to 5 % by mass of the total amount of lubricating oil. Specifically, the amount of

oxygen-containing compound is 0.01 % by mass or more, preferably 0.05 % by mass or more, and preferably 0.1 % by mass or more. On the other hand, the amount of oxygen-containing compound is 5 % by mass or less, preferably 2.5 % by mass or less and more preferably 2.0 % by mass or less. If the amount of oxygen-containing compound is too small, working properties may be poor, and if the amount is too large, an amount-related effect may not be obtained.

[0061] The lubricating oil for aluminum working of the present invention may further contain an oily agent. To enhance working properties, the oily agent is preferably at least one type of oily agent selected from among the following components (B1)-(B3). The oily agent also includes oily agents which are usually used in lubricating oil.

(B1) Esters

(B2) Monovalent alcohols

(B3) Carboxylic acids

[0062] The ester which is component (B1) is obtained by reacting an alcohol and a carboxylic acid. The alcohol may be a monovalent alcohol or a polyhydric alcohol. The carboxylic acid may be a monobasic acid or a polybasic acid.

[0063] The monovalent alcohol is usually a monovalent alcohol having 1-24 carbon atoms. This alcohol may be straight or branched chain. Examples of a monovalent alcohol having 1-24 carbon atoms are methanol, ethanol,

straight or branched chain propanol, straight or branched chain butanol, straight or branched chain octanol, straight or branched chain nonanol, straight or branched chain decanol, straight or branched chain undecanol, straight or branched chain dodecanol, straight or branched chain tridecanol, straight or branched chain tetradecanol, straight or branched chain pentadecanol, straight or branched chain hexadecanol, straight or branched chain heptadecanol, straight or branched chain octadecanol, straight or branched chain nonadecanol, straight or branched chain eicosanol, straight or branched chain heneicosanol, straight or branched chain tricosanol and straight or branched chain tetracosanol.

[0064] The polyhydric alcohol is usually a polyhydric alcohol having a valency of 2-10 but preferably 2-6. Examples of an alcohol having a valency of 2-10 are ethylene glycol, diethylene glycol, polyethylene glycol (3-15 ethylene oxide units), propylene glycol, dipropylene glycol, polypropylene glycol (3-15 propylene oxide units), 1,3-propanediol, 1,2-propanediol, 1,3-butanediol, 1,4-butanediol, 2-methyl-1,2-propane diol, 2-methyl-1,3-propanediol, 1,2-pentane diol, 1,3-pentane diol, 1,4-pentane diol, 1,5-pentane diol, neopentyl glycol, glycerin, polyglycerins (2-8 glycerin units, e.g., diglycerol, triglycerol, tetraglycerol), trimethyloylalkanes (e.g., trimethylolethane,

trimethylolpropane, trimethyloylbutane) and dimers-octamers thereof, pentaerythritol and dimers-tetramers thereof, 1,2,4-butane triol, 1,3,5-pentane triol, 1,2,6-hexane triol, 1,2,3,4-butane tetrol, sorbitol, sorbitan, sorbitol glycerin condensate, ribitol, arabitol, xylitol and mannitol.

[0065] Saccharides such as xylose, arabitol, ribose, rhamnose, glucose, fructose, galactose, mannose, sorbose, cellobiose, maltose, isomaltose, trehalose and sucrose, can also be used.

[0066] Among these, polyhydric alcohols having a valency of 2-6 such as ethylene glycol, diethylene glycol, polyethylene glycol (more preferably 3-10 ethylene oxide units), propylene glycol, dipropylene glycol, polypropylene glycol (more preferably 3-10 propylene oxide units), 1,3-propanediol, 2-methyl-1,2-propanediol, 2-methyl-1,3-propanediol, neopentyl glycol, glycerol, diglycerol, triglycerol, trimethyloylalkanes (e.g., trimethylolethane, trimethylol propane, trimethyloylbutane) and dimers-tetramers thereof, pentaerythritol, dipentaerythritol, 1,2,4-butane triol, 1,3,5-pentane triol, 1,2,6-hexane triol, 1,2,3,4-butane tetrol, sorbitol, sorbitan, sorbitol glycerin condensate, ribitol, arabitol, xylitol and mannitol, and mixtures thereof, are more preferred. Further, ethylene glycol, propylene glycol, neopentyl glycol, glycerin,

trimethylolethane, trimethylol propane, pentaerythritol, sorbitan and mixtures thereof are still more preferred.

[0067] The monobasic acid which forms the ester oil may be a straight or branched chain fatty acid having 6-24 carbon atoms. The monobasic acid may be a saturated fatty acid, unsaturated fatty acid, or a mixture thereof.

[0068] Examples of a saturated fatty acid are straight or branched chain hexanoic acid, straight or branched chain octanoic acid, straight or branched chain nonanoic acid, straight or branched chain decanoic acid, straight chain r branched undecanoic acid, straight or branched chain dodecanoic acid, straight or branched chain tridecanoic acid, straight or branched chain tetradecanoic acid, straight or branched chain pentadecanoic acid, straight or branched chain hexadecanoic acid, straight or branched chain octadecanoic acid, straight or branched chain hydroxyoctadecanoic acid, straight or branched chain nonadecanoic acid, straight or branched chain eicosanoic acid, straight or branched chain heneicosanoic acid, straight or branched chain docosanoic acid, straight or branched chain tricosanoic acid, and straight or branched chain tetracosanoic acid.

[0069] Examples of an unsaturated fatty acid are straight or branched chain hexenoic acid, straight or branched chain heptenoic acid, straight or branched chain octenoic acid, straight or branched chain nonenoic acid,

straight or branched chain decenoic acid, straight or branched chain undecenoic acid, straight or branched chain dodecenoic acid, straight or branched chain tridecenoic acid, straight or branched chain tetradecenoic acid, straight or branched chain pentadecenoic acid, straight or branched chain hexadecenoic acid, straight or branched chain octadecenoic acid, straight or branched chain hydroxyoctadecenoic acid, straight or branched chain nonadecenoic acid, straight or branched chain eicosenoic acid, straight or branched chain heneicosenoic acid, straight or branched chain docosenoic acid, straight or branched chain tricosenoic acid, and straight or branched chain tetracosenoic acid. Among these, saturated fatty acids having 8-20 carbon atoms, unsaturated fatty acids having 8-20 carbon atoms and mixtures thereof are preferred.

[0070] Examples of a polybasic acid forming the ester oil are dibasic acids having 2-16 carbon atoms, and trimellitic acid. The dibasic acid having 2-16 carbon atoms may be straight or branched chain, and may be a saturated dibasic acid or unsaturated dibasic acid, or a mixture thereof.

[0071] Examples of a saturated dibasic acid are ethanedioic acid, propanedioic acid, straight or branched chain butanedioic acid, straight or branched chain pentanedioic acid, straight chain or hexanedioic acid, straight or branched chain octanedioic acid, straight or

branched chain nonanedioic acid, straight or branched chain decanedioic acid, straight or branched chain undecanedioic acid, straight or branched chain dodecanedioic acid, straight or branched chain tridecanedioic acid, straight or branched chain tetradecanedioic acid, straight or branched chain heptadecanedioic acid, and straight or branched chain hexadecanedioic acid.

[0072] Examples of an unsaturated dibasic acid are straight chain or hexenedioic acid, straight or branched chain octenedioic acid, straight or branched chain nonenedioic acid, straight or branched chain decenedioic acid, straight or branched chain undecenedioic acid, straight or branched chain dodecenedioic acid, straight or branched chain tridecenedioic acid, straight or branched chain tetradecenedioic acid, straight or branched chain heptadecenedioic acid, and straight or branched chain hexadecenedioic acid.

[0073] Examples of the ester oil are the following components (1b)-(7b). The ester oil may be an ester obtained by reaction of any alcohol and carboxylic acid as shown by the following typical components, but is not particularly limited thereto:

(1b) Ester of a monohydric alcohol and a monobasic acid

(2b) Ester of a polyhydric alcohol and a monobasic acid

(3b) Ester of a monohydric alcohol and a polybasic acid

(4b) Ester of a polyhydric alcohol and a polybasic acid

(5b) Mixed ester of a mixture of a monohydric alcohol and polyhydric alcohol, and a polybasic acid

(6b) Mixed ester of a polyhydric alcohol and a mixture of a monobasic acid and a polybasic acid

(7b) Mixed ester of a mixture of a monohydric alcohol and a polyhydric alcohol, and a mixture of a monobasic acid and a polybasic acid

[0074] When a polyhydric alcohol is used as the aforesaid alcohol component, the ester is a perfect ester wherein all the hydroxyl groups in the polyhydric alcohol are esterified. When a polybasic acid is used as the aforesaid carboxylic acid component, the ester may be a perfect ester wherein all the carboxyl groups in the polybasic acid are esterified, or a partial ester wherein part of the carboxyl groups remain without being esterified.

[0075] The ester oil may be any of the above. Among the above, from the viewpoint of excellent working properties, (1b), the ester of a monohydric alcohol and monobasic acid, is preferred.

[0076] The total number of carbon atoms in the ester used as an oily agent is not particularly limited, but from the viewpoint of enhancing working properties, the total number of carbon atoms in the ester is preferably 7 or more, more preferably 9 or more, and most preferably 11 or more. If the total number of carbon atoms in the ester is too large, there is a greater possibility of increasing stains or

corrosion, so the total number of carbon atoms is preferably 26 or less, more preferably 24 or less and most preferably 22 or less.

[0077] The monohydric alcohol of component (B2) may be one of the compounds enumerated as an alcohol forming the ester in the description of the aforesaid component (B1). From the viewpoint of excellent working properties, the total number of carbon atoms in the monohydric alcohol is preferably 6 or more, but more preferably 8 or more and most preferably 10 or more. If the total number of carbon atoms is too large, there is a greater possibility of increasing stains or corrosion, so the total number of carbon atoms is preferably 20 or less, more preferably 18 or less and most preferably 16 or less.

[0078] The carboxylic acid of component (B3) may be a monobasic acid or a polybasic acid. This carboxylic acid may be one of the compounds mentioned as a carboxylic acid forming the ester in the description of the aforesaid component (B1). Among these, from the viewpoint of excellent working properties, a monobasic acid is preferred. Also, from the viewpoint of excellent working properties, the total number of carbon atoms in the carboxylic acid is preferably 6 or more, but more preferably 8 or more and most preferably 10 or more. If the total number of carbon atoms is too large, there is a greater possibility of increasing stains or corrosion, so the total number of carbon atoms

is preferably 20 or less, more preferably 18 or less and most preferably 16 or less.

[0079] The oily agent used in the lubricating oil for aluminum working of the present invention may be only one, or a mixture of two or more, selected from among the various oily agents mentioned above, but from the viewpoint of enhancing working properties, (1) an ester having a total of 7-26 carbon atoms obtained from a monohydric acid and monobasic acid, (2) a monohydric alcohol having 6-20 carbon atoms, (3) a monobasic acid having 6-20 carbon atoms, and mixtures thereof, are preferred.

[0080] The amount of oily agent is preferably 0.01-10 % by mass based on the total weight of lubricating oil for aluminum working of the present invention. From a viewpoint of working properties, the amount of oily agent is preferably 0.01 % by mass or more, more preferably 0.05 % by mass or more and still more preferably 0.07 % by mass or more. On the other hand, if the amount is too large, there is a greater possibility of increasing stains or corrosion, so the amount of oily agent is preferably 10 % by mass or less, more preferably 7 % by mass or less and still more preferably 5 % by mass or less.

[0081] The lubricating oil for aluminum working of the present invention can further contain an alkylbenzene having a kinematic viscosity of 1-60mm^2/s at 40°C. By using this alkylbenzene and the aforesaid oily agent in conjunction,

the addition effect of the oily agent can be further enhanced.

[0082] If the kinematic viscosity at 40°C of the alkylbenzene is less than 1mm^2/s, it may not be possible to obtain an addition effect. On the other hand, if the kinematic viscosity exceeds 60mm^2/s, the oil remaining on the workpiece surface after working may increase. From this viewpoint, the kinematic viscosity at 40°C of the alkylbenzene is preferably 40mm^2/s or less, and more preferably 20mm^2/s.

[0083] The alkyl group combined with the benzene ring of the alkylbenzene may be straight or branched chain. The number of carbon atoms in the alkyl group is not particularly limited, but an alkyl group having 1-40 carbon atoms is preferred.

[0084] Examples of an alkyl group having 1-40 carbon atoms are methyl, ethyl, straight or branched chain propyl, straight or branched chain butyl, straight or branched chain pentyl, straight or branched chain hexyl, straight or branched chain heptyl, straight or branched chain octyl group, straight or branched chain nonyl, straight or branched chain decyl, straight or branched chain undecyl, straight or branched chain dodecyl, straight or branched chain tridecyl, straight or branched chain tetradecyl, straight or branched chain pentadecyl, straight or branched chain hexadecyl, straight or branched chain heptadecyl, straight or branched chain octadecyl, straight or branched chain nonadecyl,

straight or branched chain icosyl group, straight or branched chain henicosyl, straight or branched chain docosyl, straight or branched chain tricosyl, straight or branched chain tetracosyl, straight or branched chain pentacosyl, straight or branched chain hexacosyl, straight or branched chain heptacosyl, straight or branched chain octacosyl, straight or branched chain nonacosyl, straight or branched chain triacontyl, straight or branched chain hentriacontyl, straight or branched chain dotriacontryl, straight or branched chain tritriacontyl, straight or branched chain tetratriacontyl, straight or branched chain pentatriacontyl, straight or branched chain hexatriacontyl, straight or branched chain heptatriacontyl, straight or branched chain octatriacontyl, straight or branched chain nonatriacontyl, and straight or branched chain tetracontyl.

[0085] The number of substitutions by alkyl groups in the alkylbenzene is usually 1-4, but from the viewpoint of stability and availability, an alkylbenzene having one or two alkyl groups, i.e., a mono-alkylbenzene, di-alkylbenzene or a mixture thereof, are most preferred. The alkylbenzene may not only be an alkylbenzene having a single structure, but also a mixture of alkylbenzenes having different structures.

[0086] The molecular weight of the alkylbenzene is not particularly limited, but from the viewpoint of the addition effect, it is preferably 100 or higher, and more preferably

130 or higher. If the molecular weight is too large, there is a greater possibility that oils remaining on the workpiece surface after working will increase, so the molecular weight is preferably 340 or less, and more preferably 320 or less.

[0087] The method of manufacturing the aforesaid alkylbenzene may be any desired method known in the art and is not particularly limited, but it may for example be manufactured by an alkylation synthesis using the following starting materials.

[0088] Examples of an aromatic compound used as a starting material are benzene, toluene, xylene, ethylbenzene, methylethylbenzene, diethylbenzene and mixtures thereof. The alkylating agent may be a lower mono-olefin, such as ethylene, propylene, butene and isobutene, but preferably a straight or branched chain olefin having 6-40 carbon atoms obtained by polymerization of propylene; a straight or branched chain olefin having 6-40 carbon atoms obtained by pyrolysis of wax, heavy oil, petroleum fraction, polyethylene or polypropylene; a straight or branched chain olefin having 9-40 carbon atoms obtained by separating n-paraffin from petroleum fractions such as light oil or kerosene, and olefination using a catalyst; and mixtures thereof.

[0089] The alkylation catalyst used for alkylation may be a catalyst known in the art, such as a Friedel Crafts catalyst or an acid catalyst. Examples of a Friedel Crafts

catalyst are aluminum chloride and zinc chloride. Examples of an acid catalyst are sulfuric acid, phosphoric acid, tungstosilicic acid, hydrofluoric acid and activated clay.

[0090] To prepare an alkylbenzene having a kinematic viscosity of 1-60mm^2/s at 40°C, it is convenient in practice to separate for example a mixture of an alkylbenzene obtained by the aforesaid method and a commercial alkylbenzene by distillation or chromatography to obtain the alkylbenzene fraction having a kinematic viscosity of 1-60mm^2/s.

[0091] The alkylbenzene amount can be 0.1-50 % by mass of the total amount of lubricating oil for aluminum working of the present invention. From the viewpoint of the addition effect, this amount is preferably 0.1 % by mass or more, more preferably 0.5 % by mass or more, and still more preferably 1 % by mass or more. On the other hand, if the amount is too high, there is a greater possibility that oil remaining on the surface of the workpiece after working will increase, so this amount is preferably 50 % by mass or less, more preferably 40 % by mass or less, and still more preferably 30 % by mass or less.

[0092] The lubricating oil for aluminum working of the present invention may further contain a straight chain olefin having 6-40 carbon atoms. When this lubricating oil contains a straight chain olefin, lubricity is even better. As a straight chain olefin having less than 6 carbon atoms has a low flash point, it is not suitable. In order to have

a flash point of suitable magnitude, the number of carbon atoms is preferably 8 or higher, more preferably 10 or higher, and still more preferably 12 or higher. On the other hand, if the number of carbon atoms exceeds 40, the olefin becomes solid-like making it difficult to use, and as mixing and dissolution in other components (mineral oils and additives) becomes difficult, it is unsuitable. Moreover, a straight chain olefin having more than 40 carbon atoms is not common, and is difficult to procure. In view of these facts, a straight chain olefin having 30 or less carbon atoms is preferred.

[0093] This straight chain olefin may have one, two or more double bonds in the molecule, but an olefin having one double bond is preferred. The position of the double bond is not particularly limited, but from the viewpoint of excelling in lubricity, straight chain olefin having a double bond at the end, i.e., n-α olefin, is preferred.

[0094] The straight chain olefin may be 1-octene, 1-decene, 1-docesene, 1-tetradecene, 1-hexadecene, 1-octadecene or 1-icosene, or a mixture of two or more thereof. Also, straight chains olefin obtained by various manufacturing techniques can be used, such as for example the ethylene oligomer obtained by polymerizing ethylene by the usual methods. The straight chain olefin may be any of these compounds used alone, or a mixture of two or more thereof.

[0095] If the lubricating oil for aluminum working of the present invention contains a straight chain olefin, among the oxygen-containing compounds of the aforesaid components (A1)-(A8), component (A3), component (A4), component (A5) or component (A8) are preferably used in conjunction, and component (A3) or component (A5) are more preferably used in conjunction. If the oxygen-containing compound and straight chain olefin are used together, lubricity further improves due to their synergistic effect, working properties are excellent, and oil removal qualities in the oil removal step also improve.

[0096] The amount of straight chain olefin is arbitrary, but from the viewpoint of enhancing the lubricity of the lubricating oil for aluminum working of the present invention, this amount is preferably 1 % by mass or more, more preferably 3 % by mass or more and still more preferably 5 % by mass or more of the total amount of lubricating oil. On the other hand, from the viewpoint of obtaining an addition-amount related effect, this amount is preferably 30 % by mass or less, more preferably 25 % by mass or less and still more preferably 20 % by mass or less of the total amount of lubricating oil.

[0097] In the lubricating oil for aluminum working of the present invention, in order to further enhance the excellent effect, a synthetic oil (synthetic lubricating oil) may also be blended as required. This synthetic oil

should normally have a kinematic viscosity of 0.5-500mm^2/s and particularly 0.5-30mm^2/s at 40°C. The synthetic oil may be an olefin other than the aforesaid straight chain olefin (e.g., a branched olefin such as polybutene or polypropylene), or the hydride of this olefin may be used. It is particularly preferred that this olefin is a low molecular weight polypropylene, α-olefin oligomer, or a mixture thereof. If the lubricating oil for aluminum working of the present invention contains these synthetic oils, there is not much unpleasant odor during use so the working environment improves, and degreasing qualities of the surface of the workpiece after working also improve. The amount of this synthetic oil is normally 20 % by mass or less, but preferably 15 % by mass or less, based on the total amount of lubricating oil for aluminum working of the present invention.

[0098] In the lubricating oil for aluminum working of the present invention, in order to further enhance its outstanding effects, one, two or more additives such as an extreme-pressure additive, an antioxidant, a rust preventive, a corrosion inhibitor and a defoaming agent, may be further contained as required.

[0099] Examples of an extreme-pressure additive are phosphorus compounds such as tricresyl phosphate and organometallic compounds such as dialkyldithiophosphoric acid zinc. Examples of an antioxidant are phenolic

compounds such as 2,6-di-tert-butyl-p-cresol (DBPC), aromatic amines such as phenyl-α-naphthylamine and organometallic compounds such as dialkyl dithiophosphoric acid zinc. Examples of a rust preventive are salts of fatty acids such as oleic acid, sulfonates such as dinonylnaphthalene sulfonate, partial esters of polyhydric alcohols such as sorbitan mono-oleate, amines and their derivatives, and phosphate esters and their derivatives. An example of a corrosion inhibitor is benzotriazole or the like. An example of a defoaming agent are silicone compounds.

[0100] The total amount of the aforesaid additive is normally 15 % by mass or less, but preferably 10 % by mass or less, based on the total weight of lubricating oil for aluminum working of the present invention.

[0101] The viscosity of the lubricating oil for aluminum working of the present invention is not particularly limited, but it is preferred that the kinematic viscosity at 40°C is 1.0-5.0mm^2/s. Specifically, the kinematic viscosity of the lubricating oil at 40°C. is preferably 1.0mm^2/s or higher, more preferably 1.2mm^2/s or higher, still more preferably 1.3mm^2/s or higher and most preferably 1.4mm^2/s or higher. By setting the kinematic viscosity of the lubricating oil to be not lower than the aforesaid lower limit, good working properties can be obtained. On the other hand, the kinematic viscosity of the lubricating oil at 40°C

is preferably 5.0mm^2/s or lower, more preferably 3.0mm^2/s or lower, still more preferably 2.8mm^2/s or lower and most preferably 2.7mm^2/s or lower. By setting the kinematic viscosity of the lubricating oil to be not higher than the aforesaid upper limit, vaporization of the oil at room temperature can be prevented while good oil removal qualities in the oil removal step can be obtained.

[0102] The lubricating oil of the present invention may be used as an oil for working of aluminum, and it is particularly suitable as an oil for working of an aluminum fin. The aluminum fin is often made of pure aluminum, but an aluminum alloy can also be used. Moreover, the lubricating oil for aluminum working of the present invention can be used for a precoat member wherein the surface of the aluminum fin is given a hydrophilic film treatment, and for a member which has not received such treatment. In general, in the case of a precoat member, it is highly possible that working can be performed using an oil comprising only a mineral oil, but when working a material which has not received precoat treatment, the lubricating oil of the present invention preferably contains the aforesaid oxygen-containing compound.

[0103] In this context, "film" means a film comprising a corrosion-resistant underlayer formed on the aluminum fin and a hydrophilic film formed on this underlayer. The corrosion-resistant underlayer may be an inorganic

underlayer or an organic underlayer. Examples of an inorganic underlayer are a chromate underlayer, boehmite underlayer, silicate underlayer or combinations thereof. Examples of an organic underlayer which are often used are vinyl resins such as polyvinyl chloride-vinyl acetate, polyethylene and polypropylene, acrylic resins, epoxy resins, urethane resins, styrene resins, phenol resins, fluorine resins, silicon resins, diallyl phthalate resin, polycarbonate resins, polyamide resins, alkyde resins, polyester resins, urea melamine resin, polyacetal resin and fiber resins.

[0104] The hydrophilic film may for example be the following components (C1)-(C5):

(C1) a mixture of a low molecular weight organic compound having a carbonyl group and an alkali silicate as its main ingredients,

(C2) special water glass having a product obtained by adding a water-soluble organic polymer compound to the aforesaid component (C1) as its main component,

(C3) a silicate such as sodium silicate, potassium silicate and water glass, silicic acid, silica gel or alumina sol,

(C4) a hydrophilic-modified organic polymer obtained by reacting a crosslinking agent comprising a low molecular weight organic compound having a carbonyl group with a hydrophilic organic polymer,

(C5) a hydrophilic polyvinyl alcohol-modified organic

polymer obtained by reacting a polyvinyl alcohol hydrophilic organic polymer with a water-soluble organic polymer and a crosslinking agent.

[0105] The aluminum fin can be worked by for example overhang working, drawing, punching, curling and ironing wherein a cylindrical wall around a tube insertion hole is drawn up.

[0106] [EXAMPLES]

The present invention will now be described in further detail referring to suitable examples, but it should be understood that the present invention is not limited to these examples.

[0107] <Examples 1-12, Comparative Examples 1-4>

In Examples 1-12 and Comparative Examples 1-4, lubricating oils for aluminum working were prepared using the components shown below. The amount of each component in the lubricating oil for aluminum working of each Example or Comparative Example, is shown in Table 1, respectively.

(Mineral oil)

Mineral oil 1: Aromatics content 0.5 % by volume, naphthenics content 45 % by volume, paraffinics content 54.5 % by volume, initial boiling point 231°C, end point 268°C, kinematic viscosity (40°C) 2.18mm^2/s

Mineral oil 2: Aromatics content 0.3 % by volume, naphthenics content 65.7 % by volume, paraffinics content 34 % by volume, initial boiling point 158°C, end point 179°C, kinematic

viscosity (40°C) 1.85mm^2/s

Mineral oil 3: Aromatics content 2 % by volume, naphthenics content 58 % by volume, paraffinics content 40 % by volume, initial boiling point 244°C, end point 288°C, kinematic viscosity (40°C) 2.63mm^2/s

Mineral oil 4: Isoparaffin 100 % by volume, initial boiling point 161°C, end point 263°C, kinematic viscosity (40°C) 2.45mm^2/s

Mineral oil 5: Aromatics content 14 % by volume, naphthenics content 28 % by volume, paraffinics content 58 % by volume, initial boiling point 211°C, end point 258°C, kinematic viscosity (40°C) 2.11mm^2/s

Mineral oil 6: Aromatics content 0.3 % by volume, naphthenics content 6 % by volume, paraffinics content 93.7 % by volume, initial boiling point 251°C, end point 288°C, kinematic viscosity (40°C) 2.74mm^2/s

Mineral oil 7: Aromatics content 0.8 % by volume, naphthenics content 93 % by volume, paraffinics content 6.2 % by volume, initial boiling point 241°C, end point 277°C, kinematic viscosity (40°C) 2.68mm^2/s

(Oxygen-containing compound)

1: Mixture of glycerin dioleate and trioleate in a mass ratio of 1:1

2: Dilauric acid ester of polyethylene glycol (average molecular weight 200)

3: Mono-butyl ether of polypropylene glycol (average

molecular weight 200)

4: Dilauric acid ester of polyethylene glycol (average molecular weight 200)

5: Mixture of tripropylene glycol (molecular weight 192) and tetrapropylene glycol (molecular weight 250) in a mass ratio of 3:1

6: Mono-oleyl ether of tetraethylene glycol (molecular weight 194)

7: Dioleoyl ether of tetraethylene glycol (molecular weight 194)

8: Distearic acid ester of polyethylene glycol (average molecular weight 300)

9: Propylene oxide adduct of glycerin (average molecular weight 250)

[0108] Table 1

		Ex.1	Ex.2	Ex.3	Ex.4	Ex.5	Ex.6	Ex.7	Ex.8	Ex.9	Ex.10	Ex.11	Ex.12	Comp. Ex.1	Comp. Ex.2	Comp. Ex.3	Comp. Ex.4
Mineral Oil (% by mass)	1	100	99.8	99.8	99.8	99.8	99.8	99.8	99.8	99.8	99.8	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-	-
	4	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-	-
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-
	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	-
	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100
Oxygen-containing compound (% by mass)	1	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-
	4	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-
	5	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-
	6	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-
	7	-	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-
	8	-	-	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-
	9	-	-	-	-	-	-	-	-	-	0.2	-	-	-	-	-	-

[0109] The following evaluation tests were performed on each lubricating oil in Examples 1-12 and Comparative Examples 1-4.

[0110] (Lubricating quality test)

The lubricating oils of Examples 1-12 and Comparative Examples 1-4 were applied to an aluminum plate according to JIS A 1050, and the coefficient of friction was measured by a Bowden test. The load was set to 200g and the sliding velocity was set to 100mm/s. The results are shown in Table 2.

[0111] (Odor test)

The lubricating oils of Examples 1-12 and Comparative Examples 1-4 were heated to 40°C, and an organoleptics test was performed by 10 panelists. Each panelist evaluated odor by assigning points on the following scale, and the average score for all panelists was calculated. An average score of 2.5 points or higher was denoted as A, and less than 2.5 points was denoted as B. The results are shown in Table 2.

One point: There is odor.

Two points: There is a little odor.

Three points: There is no odor.

[0112] (Skin irritation test)

[0113] Commercial adhesive bandages carrying 0.5ml of each of the lubricating oils of Examples 1-12 and Comparative Examples 1-4 were affixed to the inner arms of the 10 panelists, and the state of the skin after 24 hours was observed. The state of each panelist's skin was evaluated by assigning points on the following scale, and the average score for

all panelists was calculated. An average score of 2.5 points or higher was denoted as A, and less than 2.5 was denoted as B. The results are shown in Table 2.

One point: Skin is irritated.

Two points: Skin is slightly irritated.

Three points: No change in the skin.

[0114] (Volatility test 1)

3g of each of the lubricating oils of Examples 1-12 and Comparative Examples 1-4 were placed in a pre-weighed laboratory dish of diameter 7cm, and left in a 30°C thermostat for 7 hours. Subsequently, the laboratory dish was weighed, and the proportion of lubricating oil which had volatilized was calculated. The results are shown in Table 2.

[0115] (Volatility test 2)

A specimen of an aluminum material rinsed with a solvent was left in a 130°C thermostat for 3 minutes, and the weight of the specimen was determined. This was taken as A(g). Next, this specimen was cooled to room temperature in a dessicator, and each lubricating oil of Examples 1-12 and Comparative Examples 1-4 was coated on the specimen to give $2g/cm^2$. The weights of the specimen before and after coating were determined, and were respectively taken as B(g) and C(g). This specimen was left for 3 minutes in a 130°C thermostat, and the weight of the specimen was immediately determined. This was taken as D(g). From the values A, B, C, D, the volatilized amount of each lubricating oil was

calculated according to the following equation. The results are shown in Table 2.

Volatilized amount (% by mass) = 100x(D-A)/(C-B)

[0116] Table 2

	Ex.1	Ex.2	Ex.3	Ex.4	Ex.5	Ex.6	Ex.7	Ex.8	Ex.9	Ex.10	Ex.11	Ex.12	Comp. Ex.1	Comp. Ex.2	Comp. Ex.3	Comp. Ex.4
Friction coefficient (μ)	0.21	0.08	0.10	0.12	0.11	0.09	0.08	0.12	0.09	0.10	0.24	0.19	0.37	0.17	0.43	0.22
Odor	A	A	A	A	A	A	A	A	A	A	A	A	A	B	A	A
Skin irritation	A	A	A	A	A	A	A	A	A	A	A	A	A	B	A	A
Volatility 1 (% by mass)	32	36	41	37	33	35	40	37	38	39	27	34	61	44	33	59
Volatility 2 (% by mass)	99.9	99.6	99.7	99.4	99.4	99.9	99.3	99.6	99.3	99.5	99.9	99.6	99.9	99.1	99.6	99.7

Industrial Applicability

[0117] As described above, the present invention

provides a lubricating oil for aluminum working having sufficient working properties, allowing complete removal of oil in an oil removal step, and which can prevent damage to a workpiece after working, as well as preventing odor and skin irritation.

CLAIMS

1. A lubricating oil for working of aluminum fin, comprising:

a mineral oil in which the aromatics content is 5% by volume or less, the naphthenics contents is 10-85% by volume, the initial boiling point is 150°C or higher, the end point is 288°C or less, the difference between the initial boiling point and end point is 100°C or less, and the kinematic viscosity at 40°C is 1.2-3.0mm^2/s, and

at least one oxygen-containing compound selected from a group comprising the following components (A1)-(A8):

(A1) alkylene oxide adduct of a polyhydric alcohol having 3-6 hydroxyl groups and a number average molecular weight of 100 to 1000

(A2) hydrocarbyl ether or hydrocarbyl ester of the aforesaid component (A1)

(A3) polyalkylene glycol having a number average molecular weight of 100 to 1000

(A4) hydrocarbyl ether or hydrocarbyl ester of the aforesaid component (A3)

(A5) dihydric alcohol having 2-20 carbon atoms

(A6) hydrocarbyl ether or hydrocarbyl ester of the aforesaid component (A5)

(A7) trihydric alcohol having 3-20 carbon atoms

(A8) hydrocarbyl ether or hydrocarbyl ester of the aforesaid component (A7).

2. A method for working of aluminum fin, using the lubricating oil according to Claim 1.