

COMPOSITION FOR MINIMUM QUANTITY LUBRICATION, AND USE OF SAME

The invention concerns a lubricant composition for minimum quantity
5 lubrication in metalworking and the use of the lubricant composition therefor.

In metalworking processes, a differentiation is made between conventional
wet machining in which the cutting tool is flooded with a lubricating coolant
and dry machining without lubrication in which the heat that is produced in the
10 cutting process is transferred mainly to chip, tool, and workpiece. While dry
machining does not employ lubricants, the heat flowing into the workpiece
can disadvantageously affect the component precision; also, the tool can
wear earlier due to the increased thermal load. The lubricating coolants
employed in wet machining provide primarily cooling, lubrication, and chip
15 removal, but at the same time have an effect on auxiliary process times in the
production process due to catching, recycling or disposing of the lubricating
coolants and thus also on the costs for their purchase, recycling, and
disposal. Moreover, care must be taken regarding environmental and health
protection.

20

A compromise between wet machining and dry machining is the minimum
quantity lubrication (MQL) or also minimum quantity cooling lubrication
(MQCL). Precise definitions for the "minimum quantities" do not exist;
depending on the source, up to 20 ml/h, 50 ml/h, 150 ml/h but sometimes
25 even up to 500 ml/h are referred to as MQL - in all cases, there is however a
significant difference to the usual quantities for wet machining of 30,000 to
60,000 ml/h, or even significantly more.

Compared to wet machining, minimum quantity lubrication provides a
30 significant reduction of the supply and disposal technology for the lubricating
coolant, enables longer service lives and reduced processing duration.
Moreover, downstream processes for cleaning the workpieces and also the
tool can be reduced. Since the minimum quantity lubrication means loss

lubrication, only new, i.e., non-recycled or reprocessed, lubricant is employed so that biocides, fungicides, and other additives are not needed.

However, there are higher demands on the lubricant that must be matched to
5 workpiece material, machine parameters, and tool material in order to achieve optimal results.

In general, for MQL either synthetic ester oils or fatty alcohols are employed which are combined in regard to evaporation and flash point for the desired
10 operating range. In this context, synthetic esters are preferred for cutting processes in which an effective lubrication is most important. When using fatty alcohols, the focus is less on the lubrication but on the cooling action.

A composition on the basis of a fatty alcohol for aluminum machining with
15 minimum quantity lubrication is disclosed in EP 2 397 535 A1. The alcohol compound has 1 to 8 hydroxyl groups and 2 to 27 carbon atoms and is contained in the composition in a quantity of 16 to 100 wt.%. The residual quantity can be a mineral oil or synthetic oil, also ester oil. For improving the lubrication action of this composition, various additives are listed which can
20 be added to the composition.

It has been found that, even in minimum quantity lubrication, minimal quantities of the lubricating coolant remain on the workpiece around the cutting location and on the tool. The lubricant residues on the workpiece, on
25 the one hand, can aid in avoiding corrosion at the machining location but, on the other hand, can also have a disadvantageous effect on downstream production processes such as welding, gluing, painting etc. and therefore may possibly require a cleaning step.

30 Water-miscible metalworking liquids that can be cleaned off with water are considered unsuitable for minimum quantity lubrication because they do not have the required lubrication action therefor or the required flash point.

For cleaning off a lubricant based on a saturated aliphatic monohydric C₁₄₋₁₈ alcohol that is formed as film on the surface of the workpiece for cold machining of aluminum, WO 91/06619 describes heating of the workpiece so that the lubricant evaporates.

5

Based on this prior art, it is object of the present invention to provide a minimum quantity lubricant that, without heating, can be cleaned off not only from the workpiece but also from the tool and the machine tool in a simple way.

10 This object is solved by a lubricant composition with the features of claim 1.

Further embodiments of the lubricant composition are disclosed in the dependent claims.

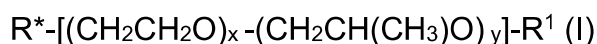
15 The simple cleaning off when using the lubricant composition is disclosed by the features of independent claim 8.

The lubricant composition according to the invention for minimum quantity lubrication for metalworking is comprised of a main proportion of an aliphatic
20 C₁₆₋₂₄ alcohol to which is added a minimal proportion of an emulsifier so that the lubricant can be emulsified with water. In this way, not only the workpiece but also the tool and the machining space (e.g., interior of the machine) can be simply freed from the residues of the lubricant composition according to the invention by emulsifying with water. However, care must be taken that the
25 lubricant composition during storage and supply to the tool does not come into contact with water.

A preferred emulsifier can be a fatty alcohol polyalkylene glycol ether which is contained in the composition with 0.05 to 5 wt.% relative to the total weight of
30 the composition. Alternatively, the emulsifier can be a glycolic acid alkoxylate alkyl ether whose proportion in the composition lies in a range of 0.05 to 5 wt.% relative to the total weight of the composition. However, it is also

conceivable that mixtures of fatty alcohol polyalkylene glycol ether and glycolic acid alkoxylate alkyl ether are used as emulsifier with a weight proportion of 0.05 to 5 wt.% relative to the total weight of the composition. The aliphatic C₁₆₋₂₄ alcohol is then present in a proportion that supplements the composition to 100%, respectively.

The fatty alcohol polyalkylene glycol ether has the formula (I)



wherein R¹ is an aliphatic, branched or linear C₁₆₋₁₈ alkyl or alkylene residue.

R* can be a hydroxyl group. The variables x and y can be 0 to 10 with the condition that the sum of x + y is from 1 to 10. The fatty alcohol polyalkylene glycol ether, also by trivial name fatty alcohol alkoxylate or alkoxylated fatty alcohol, can be comprised only of ethylene oxide units (y = 0) or only of propylene oxide units (x = 0). The polyalkylene glycol ether may however also contain ethylene oxide units as well as propylene oxide units. In this context, the respective proportions as well as sequence of the units (e.g., alternating or in blocks) can vary. A non-limiting exemplary purely ethoxylated fatty alcohol can be based on oleyl or cetyl alcohol: HO-(CH₂CH₂O)_n-R with R = C₁₈ or C₁₆ with n = 5, for example. Deviations with regard to the base alcohol, type and number of alkoxy units are conceivable, of course.

Preferably, the weight proportion of the fatty alcohol polyalkylene glycol ether can amount to 1 to 5 wt.%, wherein smaller proportions, e.g., 1 wt.%, are preferred in particular. Advantageously, the lubricant composition with 1 wt.% fatty alcohol polyalkylene glycol ether exhibits a suitable emulsifier balance with sufficiently good emulsifying properties without negatively affecting the separation behavior in the cleaning device (demulsifying behavior) in this context. While an emulsifier concentration that is too low causes a reduced cleaning action on tool, workpiece, and machine space, concentrations that are too high prevent the oil separation in the cleaning device.

The glycolic acid alkoxylate alkyl ether (also ether carboxylic acid) as an alternative to the fatty alcohol polyalkylene glycol ether has the formula (II)



wherein R^2 is an aliphatic, preferably branched or linear, C_{6-20} alkyl or alkylene residue. In this context, purely ethoxylated, purely propoxylated, or mixed ethoxylated and propoxylated compounds are also conceivable so that x and y
 5 can be selected from 0 to 10 with the condition that the sum $x + y = 1$ to 10. The glycolic acid alkoxyate alkyl ether is preferably a glycolic acid ethoxyate alkyl ether.

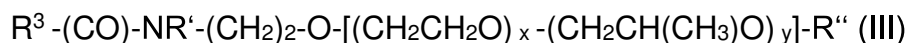
Examples of glycolic acid alkoxyate alkyl ether are poly(oxy-1,2-ethanediyl), α -
 10 (carboxymethyl)- ω -hydroxy-, C_{10-16} and C_{12-20} unsaturated alkyl ethers (e.g., CAS No. 68954-89-2), poly(oxy-1,2-ethanediyl), α -(carboxymethyl)- ω -hydroxy-, C_{16-18} and C_{18} unsaturated alkyl ethers (CAS No. 227310-69-2), poly(oxy-1,2-ethanediyl), α -(carboxymethyl)- ω - octyloxy-, (CAS No. 53563-70-5) or poly(oxy-1,2-ethanediyl), α -(carboxymethyl)- ω - hexyloxy-, (CAS No. 105391-
 15 15-9).

The aliphatic C_{16-24} alcohol which is used in the lubricant composition according to the invention can be a branched alcohol, preferably a Guerbet alcohol (long-chain alcohol that is alkyl-substituted in α position relative to the primary OH
 20 residue), such as e.g. 2-hexyl-1-decanol or 2-octyl-1-dodecanol. The latter C_{20} alcohol can be employed preferably. Due to the low pour point and the reduced adhesion tendency as a result of complete saturation, such alcohols can be used at lower temperatures of use compared to natural linear alcohols.

25 A lubricant composition embodied according to the invention can thus be comprised of only two components, the basic C_{16-24} alcohol and the emulsifier.

In a further embodiment of the invention, it can however be provided also that the lubricant composition contains in addition from 0.05 to 5 wt.%, relative to
 30 the total weight of the composition, fatty acid alkanolamide or alkoxyated fatty

acid alkanolamide of the formula (III)



wherein R^3 is an aliphatic, linear or branched, C_{5-23} alkyl or alkenyl residue and R' , R'' independent from each other are hydrogen or an aliphatic, linear
5 or branched, substituted or unsubstituted alkyl or alkenyl residue. x and y can be each selected from 0 to 10 so that, as above, purely ethoxylated, purely propoxylated, and mixed ethoxylated and propoxylated compounds are encompassed, wherein here the sum $x + y$ can be from 0 (non-alkoxylated) to 10. The addition of a fatty acid alkanolamide or alkoxylated fatty acid
10 alkanolamide contributes to an improved corrosion protection action of the lubricant composition and can positively affect the cleaning action of the workpiece or of the machine as a result of the emulsifying properties.

Moreover, a lubricant composition according to the invention can additionally
15 comprise at least one performance additive that can be selected from a group that encompasses

- a) sulfurized compounds such as sulfurized olefins, sulfurized esters, sulfurized triglycerides, and sulfurized natural ester oils,
- b) C_{12-24} fatty acids,
- 20 c) ethoxylated natural oil,
- d) KOH-saponified rapeseed oil,
- e) ethoxylated acidic phosphoric acid ester.

In the following, examples are disclosed that explicitly are not to be
25 understood as limiting:

Non-limiting examples for

- a) sulfurized compounds comprise
 - sulfurized olefins such as di-*tert*-dodecyl polysulfides (EC No. 270-335-7), e.g., di-*tert*-dodecyl trisulfide or di-*tert*-dodecyl
30 pentasulfide,
 - sulfurized esters such as fatty acids, vegetable oil, methyl ester, sulfurized (EC No. 276-337-4),

- sulfurized triglycerides / sulfurized natural ester oils such as e.g. sulfurized rapeseed oil, sulfurized lard oil, sulfurized castor oil etc.,
- b) pure fatty acids such as e.g. oleic acid or similar ones with chain lengths in the range of C₁₂₋₂₄,
- 5 c) ethoxylated natural oils such as e.g. castor ethoxylate with 1 to 10 ethylene oxide units,
- d) KOH-saponified rapeseed oil,
- e) acidic phosphoric acid ester ethoxylated, such as e.g. oleyl alcohol ethoxylated phosphate (CAS No. 39464-69-2).

10

In this context, a proportion of each performance additive relative to the total weight of the composition amounts to maximally 15 wt.%, wherein the proportion of the sum of the performance additives relative to the total weight of the composition does not surpass 30 wt.%.

15

A lubricant composition according to the invention can thus be used for minimum quantity lubrication in metalworking wherein residues of the lubricant composition remaining on surfaces of workpiece and tool can be washed off with water.

20

CLAIMS

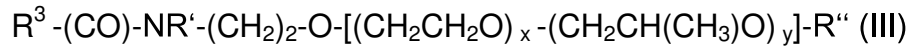
1. Lubricant composition for minimum quantity lubrication in metalworking,
5 characterized in that
the composition comprises
0.05 to 5 wt.% of emulsifier, relative to the total weight of the composition, and
a proportion of an aliphatic C₁₆₋₂₄ alcohol supplementing the
10 composition to 100%,
wherein the emulsifier is a glycolic acid alkoxylate alkyl ether, or a mixture thereof with a fatty alcohol polyalkylene glycol ether, wherein the glycolic acid alkoxylate alkyl ether has the formula (II)
$$R^2-O-[(CH_2CH_2O)_x-(CH_2CH(CH_3)O)_y]-CH_2-COOH \text{ (II)}$$

15 wherein R² is an aliphatic, branched or linear C₆₋₂₀ alkyl or alkylene residue, wherein x = 0 to 10, y = 0 to 10, and x + y = 1 to 10.
2. Lubricant composition according to claim 1,
characterized in that
20 the fatty alcohol polyalkylene glycol ether has the formula (I)
$$R^*-[(CH_2CH_2O)_x-(CH_2CH(CH_3)O)_y]-R^1 \text{ (I)}$$

wherein R¹ is an aliphatic, branched or linear C₁₆₋₁₈ alkyl or alkylene residue and R* is a hydroxyl residue, wherein x = 0 to 10, y = 0 to 10, and x + y = 1 to 10.
25
3. Lubricant composition according to claim 1 or 2,
characterized in that
the aliphatic C₁₆₋₂₄ alcohol is a branched alcohol, preferably a Guerbet
30 alcohol, particularly preferred a C₂₀ alcohol.
4. Lubricant composition according to at least one of the claims 1 to 3,
characterized in that

the composition contains additionally

0.05 to 5 wt.%, relative to the total weight of the composition, fatty acid alkanolamide or alkoxylated fatty acid alkanolamide of the formula (III)



5 wherein

R^3 is an aliphatic, linear or branched C_{5-23} alkyl or alkylene residue, R' , R'' independent of each other is hydrogen or an aliphatic, linear or branched, substituted or unsubstituted alkyl or alkenyl residue, and wherein $x = 0$ to 10, $y = 0$ to 10, and $x + y = 0$ to 10.

10

5. Lubricant composition according to at least one of the claims 1 to 4, characterized in that the composition comprises additionally at least one performance additive of the group that encompasses

15

- a) sulfurized compounds comprising sulfurized olefins, sulfurized esters, sulfurized triglycerides, and sulfurized natural ester oils,
- b) C_{12-24} fatty acids,
- c) ethoxylated natural oil,
- d) KOH-saponified rapeseed oil,
- 20 e) ethoxylated acidic phosphoric acid ester.

20

6. Lubricant composition according to claim 5, characterized in that a proportion of each performance additive relative to the total weight of the composition amounts to 15 wt.% relative to the total weight of the composition and a proportion of the sum of the performance additives relative to the total weight of the composition amounts to 30 wt.%.

25

- 30 7. Use of a lubricant composition according to at least one of the claims 1 to 6 for minimum quantity lubrication in metalworking, wherein residues of the lubricant composition remaining on surfaces of workpiece and tool can be washed off with water.