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Water-based lubricants

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Bezeichnung: SCHMIERSTOFFE AUF WASSERBASIS

Abstract: The present invention relates to water-based lubricants. In particular, the invention relates to the use of the water-based lubricants for the lubrication of frictional partners in drive elements, and the use thereof.

Zusammenfassung: Die vorliegende Erfindung betrifft Schmierstoffe auf Wasserbasis. Insbesondere betrifft die Erfindung die Verwendung der Schmierstoffe auf Wasserbasis für die Schmierung von Reibungspartnern in Antriebskomponenten, sowie deren Verwendung.

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This invention relates to water-based lubricants. In particular, the invention relates to the use of water-based lubricants for the lubrication of frictional partners in drive elements, as well as their use.

The development of new lubricants must go along with the general further development of technology, which imposes new and more stringent requirements on the lubricant compositions, this in particular also with respect to environmental protection and the ejection of carbon dioxide. The known lubricants based on mineral oil or synthetic oil no longer measure up to these requirements.

Lubricants are used in particular in drive elements, such as, e.g., chains, gears, roller bearings, and plain bearings or seals on rotating shafts. These lubricants are based on mineral oil or synthetic hydrocarbons. In particular in roller bearings and plain bearings, the lubricants provide for a separating, load-transferring lubricating film to be built up between the parts that slide or roll on one another. It is thus achieved that the metal surfaces do not touch and thus also no friction occurs. The lubrication means must therefore satisfy high requirements with respect to:

- Cooling of the friction site,
- Extreme operating conditions, such as very high and very low speeds,
- High temperatures that are caused by high speeds and loads and associated internal or external heating,
- Very low temperatures in a cold environment,
- Special user requirements as regards the running features, e.g., low friction, noise attenuation,
- Extremely long running times without interim relubrication,
- Biodegradability.

A ready-to-use gear, an operating fluid for such a gear, and a method for its start-up are known from WO 2007/098523 A2. The operating fluid consists of a mixture of water and an aliphatic hydrocarbon, in which graphite particles are suspended as solid lubricant. This solid lubricant is in the form of flocculent graphite particles, which have a grain size of less than 50 μm. Other components of these lubricating and cooling means are dispersing additives, foam inhibitors, and corrosion inhibitors. In this operating fluid, the graphite particles that are present in solid or flocculent form and that, on the one hand, settle out of the suspension and thus can adhere to the working parts to be lubricated are disadvantageous. Another drawback is the persistent fouling of components that come into contact with graphite-containing lubricants. If a filtration of the lubricating oil during operation is necessary, the graphite can result in a clogging of the filter pores. In addition, the operating fluid has a very low viscosity, which in the case of high loads can result in a failure of the lubricating film.

The object of this invention was therefore to prepare a water-based lubricant that corresponds to the above-mentioned requirements, in particular is biodegradable, and that contributes to significantly reducing the production of carbon dioxide.

This problem is achieved according to the invention in that a lubricant that consists of water, water-soluble polyalkylene glycols, water-soluble emulsifiers, and additives conventionally used in lubricants is used. The water-soluble polyalkylene glycols are selected from the group of statistically distributed polyoxyethylene units and
polyoxypropylene units and/or other polyoxyalkylene components with one or more hydroxyl end groups and from a block polymer that consists of polyoxyethylene units and/or polyoxypropylene units, and/or other polyoxyalkylene components. As emulsifiers, anionic surfactants, e.g., sulfonates, non-ionic surfactants, e.g., fatty alcohol ethoxylates, or NPE or cationic surfactants, e.g., quaternary ammonium compounds, water-soluble or water-emulsifiable carboxylic acid esters are used.

It was found, surprisingly enough, that certain water-based formulations (water content > 10%) exceed the lubrication output of conventional lubricants and significantly reduce friction coefficients. Because of this and owing to the good intrinsic cooling action, reduced temperature development occurs in the tribo system. Such water-based lubricants are readily biodegradable and are environmentally compatible in an aquatic environment. In addition, they are distinguished by good compatibility with rubber-elastic materials.

Depending on the application, for example, the low-temperature behavior of water-based lubricants can be considerably improved by, for example, addition of anti-icing additives, e.g., low-molecular glycols, glycerol, salts, or ionic liquids.

In addition, additives can be added to influence the properties of the lubricant in a targeted manner. The latter can be present in soluble, or dispersed, colloidal or nanoscale form.

If desired, water-based lubricants can also be formulated in a foaming manner. The application as spray foam is of special interest in this connection, since as a result, a visual monitoring of the lubricant application is made possible. In the case of a contamination of textiles or machine parts with water-based lubricating fluids, the latter are easy to clean.
To dye lubricants based on mineral oil or synthetic oil, in most cases harmful and/or ecotoxicological dyes are necessary. In the case of water-based lubricants, a number of toxicologically harmless water-soluble dyes up to food coloring can be used.

The "base oil" according to the invention can also be transformed by mixing with soap or urea powders, sheet silicates or other current lubricant thickeners to form a lubrication fat or a lubrication paste.

A preferred embodiment of the water-based lubricant according to the invention contains:

5 to 80% by weight of water-soluble polyalkylene glycol that is selected from the group that consists of statistically distributed polyoxyethylene units and/or polyoxypropylene units and/or other polyoxyalkylene components, a block polymer that consists of polyoxyethylene units and/or polyoxypropylene units and/or other polyoxyalkylene components,

0.5 to 20% by weight of foaming or non-foaming emulsifiers from the class of anionic surfactants (e.g., sulfonates), non-ionic surfactants (e.g., fatty alcohol ethoxylates or else NPE) or cationic surfactants (e.g., quaternary ammonium compounds), or water-soluble or water-emulsifiable carboxylic acid esters,

0.5 to 50% by weight of anti-icing additives, selected from the group that consists of alkylene glycol, glycerol, salts or ionic liquids,

0.05 to 10% by weight of corrosion additives, such as alkanolamines, boric acid or carboxylic acid derivatives,

0.001 to 1% by weight of additives for preventing the formation of foam, e.g., polydimethylsiloxanes or acrylate polymers, and

0.05 to 5% by weight of friction-reducing agents
added to make 100% water by weight.

In addition, the lubricant composition can contain the following components:

0.001 to 0.5% by weight of pesticides, e.g., sorbic acid and/or
0.05 to 5% by weight of nanoparticles.

Thus, according to an aspect of the present invention there is provided a water-based lubricant that contains

5 to 80% by weight of water-soluble polyalkylene glycol that is selected from the group that consists of statistically distributed polyoxyethylene units and/or polyoxypropylene units and/or other polyoxyalkylene components, a block polymer that consists of polyoxyethylene units and/or polyoxypropylene units and/or other polyoxyalkylene components,

0.5 to 20% by weight of foaming or non-foaming emulsifiers from the class of anionic, non-ionic, or cationic surfactants, water-soluble or water-emulsifiable carboxylic acid esters,

0.5 to 50% by weight of anti-icing additives, selected from the group that consists of alkylene glycol, glycerol, salts or ionic liquids,

0.05 to 10% by weight of corrosion additives,

0.001 to 1% by weight of additives for preventing the formation of foam, and

0.05 to 5% by weight of friction-reducing agents

0.001 to 0.5% by weight of pesticides, and

0.05 to 5% by weight of nanoparticles,

added to make 100% water by weight.

In addition, the lubricant composition can contain

0.5 to 40% by weight of lubricant thickener, selected from the group that consists of metal soaps that consist of monocarboxylic acids and/or dicarboxylic acids, ureas, sheet silicates, solid lubricants, and aerosil.
Examples

Example 1

For the production of a gear oil, the following components are mixed:

- Distilled water 45.0% by weight
- Propylene glycol 20.0% by weight
- High-molecular polyethylene glycol 25.0% by weight
- Alcohol polyglycol ether 5.0% by weight
- Alkanolamine and boric acid derivative 2.0% by weight
- Sulfurized fatty acid 3.0% by weight

This is a virtually colorless, limpid solution of ISO VG 32 with little foaming tendency. The lubricant remains liquid up to temperatures of -35°C.

The friction level that is drastically reduced in comparison to conventional lubricants results in considerably improved energy efficiency and a lower noise level as well as extended service life during operation. Because of the replacement of mineral oil or a base oil that corresponds thereto by water, the advantage lies in the durability of this lubricant.
In particular because of the solid lubricant-free design, such a composite lubricant is suitable for applications in which the lubricant is filtered continuously, such as, e.g., gears in wind power plants.

In Table 1, properties of sample formulation 1 are cited in comparison to a mineral-oil-based product.

**Table 1**

<table>
<thead>
<tr>
<th></th>
<th>Example 1</th>
<th>Mineral Oil Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity Situation at 40°C</td>
<td>ISO VG 32</td>
<td>ISO VG 32</td>
</tr>
<tr>
<td>Pour Point</td>
<td>-35°C</td>
<td>-10°C</td>
</tr>
<tr>
<td>Friction Coefficient, SRV Test</td>
<td>0.058</td>
<td>0.100</td>
</tr>
<tr>
<td>Hazen Color Unit</td>
<td>35</td>
<td>140</td>
</tr>
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</table>

**Example 2**

For the production of a heavy-duty gear oil, the following components are mixed with one another:

- Distilled water 38.0% by weight
- Propylene glycol 20.0% by weight
- High-molecular polyethylene glycol 24.644% by weight
- Alcohol polyglycol ether 5.0% by weight
- Carboxylic acid derivative M-528, Cortec 10.0% by weight
- Sulfurized fatty acid 2.3% by weight
- Cerium oxide nanoparticles 0.05% by weight
- Sorbic acid 0.003% by weight
Acrylic copolymer 0.003% by weight

The advantages of the lubricant that are already described in Example 1 are also present here. By the addition of nanoparticles, further improved protection against wear is ensured.

In Table 2, properties of sample formulation 2 are cited in comparison to a mineral-oil-based product. Despite considerably lower viscosity, the aqueous formulation has a significantly improved protection against wear (higher achievable surface pressing) according to Reichert.

<table>
<thead>
<tr>
<th>Table 2</th>
</tr>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Viscosity Situation at 40°C</td>
</tr>
<tr>
<td>110 mm²/s</td>
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<tr>
<td>460 mm²/s</td>
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<tr>
<td>Pour Point</td>
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<tr>
<td>-35°C</td>
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<tr>
<td>-10°C</td>
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<tr>
<td>Surface Pressing According to Reichert Wear Scale</td>
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<tr>
<td>According to VKIS [Industrial Lubricants Users Group] Worksheet</td>
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<tr>
<td>3,500 N/cm²</td>
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<td>2,800 N/cm²</td>
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<td>Hazen Color Unit</td>
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<tr>
<td>130</td>
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<tr>
<td>230</td>
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</tbody>
</table>

Example 3

An oil foam consists of:

Distilled water 50.0% by weight
Propylene glycol 15.0% by weight
High-molecular polyethylene glycol 25.0% by weight
Foaming fatty alcohol ethoxylate 5.0% by weight
Alkanolamine and boric acid derivative 2.0% by weight
Sulfurized fatty acid 3.0% by weight

The advantages of the lubricant that are already described in Example 1 are also present here; the pour point of the formulation is approximately -20°C.

This composition has a high foam formation, which makes possible the application by means of spray/pump spray as a foam.

Such an application has the advantage that the lubricant on the surface can be easily detected visually, even with a minimal amount of lubrication immediately after application, e.g., with the focus on quality assurance. Another advantage of the application as a foam is the improved wetting of the entire surface of the tribo system, which makes possible a shortened intake time and an improved intake behavior.

Figure 1 shows a considerably lower torque of a roller bearing that is provided with foamed (not water-based) lubricant within the first 120 minutes of running time.

**Fig. 1:** Current uptake of a roller bearing lubricated with lubricant A.

Gray curve: Standard application.
Black curve: Application as foam.

**Example 4**

Production of a water-based fat with low-temperature suitability containing:

Distilled water 32.0% by weight
Propylene glycol 15.0% by weight
High-molecular polyethylene glycol 15.0% by weight
Li-Hydroxystearate 35.0% by weight
Na-Sebacate 3.0% by weight
In Table 2, properties of sample formulation 4 are cited.

**Table 3**

<table>
<thead>
<tr>
<th>Worked Penetration DIN ISO 2137</th>
<th>NLGI 2</th>
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<tr>
<td>Base Oil Viscosity, DIN 51562</td>
<td>90 cst</td>
</tr>
<tr>
<td>Flow Pressure at -30°C, DIN 51805</td>
<td>&lt; 1,400 mbar</td>
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</table>

**Example 5**

Lubricant consisting of:

- Distilled water 27.5% by weight
- High-molecular polyalkylene glycol 50.0% by weight
- Alkylene glycol 10.0% by weight
- Carboxylic acid derivative M-528, Cortec 2.0% by weight
- Water-soluble carboxylic acid ester 10.0% by weight
- Acryl copolymer 0.5% by weight

This lubricant is suitable for lubrication of seals on rotating shafts and, in contrast to the known lubricating agents that consist of mineral oils or synthetic hydrocarbons, it is readily biodegradable and therefore can be disposed of in an environmentally compatible way. It is distinguished by a low friction, good cooling action, good compatibility with rubber-elastic materials, and it has a low potential of water contamination. Advantageously, in the case of dilution with water, it changes the viscosity only slightly and therefore makes possible the formation of an active lubricating film.

The water-based lubricant according to the invention can be used for lubrication of drive elements in chains, gears, roller bearings and plain bearings or for lubrication of seals on rotating shafts in the form of a foam, spray or emulsion, which is applied by means of
spray or pump spray systems with the focus of better surface wetting and better detectability of thin lubricating films.
CLAIMS

1. A water-based lubricant that contains

5 to 80% by weight of water-soluble polyalkylene glycol that is selected from the

group that consists of statistically distributed polyoxyethylene units and/or polyoxypropylene

units and/or other polyoxyalkylene components, a block polymer that consists of

polyoxyethylene units and/or polyoxypropylene units and/or other polyoxyalkylene

components,

0.5 to 20% by weight of foaming or non-foaming emulsifiers from the class of

anionic, non-ionic, or cationic surfactants, water-soluble or water-emulsifiable carboxylic

acid esters,

0.5 to 50% by weight of anti-icing additives, selected from the group that consists of

alkylene glycol, glycerol, salts or ionic liquids,

0.05 to 10% by weight of corrosion additives,

0.001 to 1% by weight of additives for preventing the formation of foam, and

0.05 to 5% by weight of friction-reducing agents

0.001 to 0.5% by weight of pesticides, and

0.05 to 5% by weight of nanoparticles,

added to make 100% water by weight.

2. The lubricant according to Claim 1 that contains in addition:

0.5 to 40% by weight of lubricant thickener, selected from the group that consists of

metal soaps that consist of monocarboxylic acids and/or dicarboxylic acids, ureas, sheet

silicates, solid lubricants, and aerosil.

3. A water-based lubricant as defined in claim 1 and substantially as herein
described with reference to the Examples.
4. Use of the water-based lubricant according to any one of Claims 1 to 3 for lubrication of drive elements in chains, gears, roller bearings and plain bearings or for lubrication of seals on rotating shafts.

5. Use of the water-based lubricant according to any one of Claims 1 to 3 in the form of a foam, spray or emulsion, which is applied by means of spray or pump spray systems with the focus of better surface wetting and better detectability of thin lubricating films.

Klüber Lubrication München KG

Patent Attorneys for the Applicant/Nominated Person
SPRUSON & FERGUSON
Fig. 1

[Key:]
Drehmoment = Torque
Fett = Fat
Schaum = Foam
Zeit [min] = Time [min]