

LUBRICANT FILM FOR PREVENTING GALLING OF
SLIDING METAL SURFACES

This invention relates to a novel lubricant film
5 to be formed on the surfaces of sliding metal parts
under high surface pressure for preventing galling thereof.

Galling occurs to metal surfaces which are in
sliding contact under high surface pressure, particularly
where the metal has a low thermal conductivity and a
10 large thermal expansion coefficient, such as stainless
steel, often giving rise to problems in various industrial
machines.

For example, if the phenomenon of galling occurs
when connecting threaded ends of oil well pipes, the
15 connecting and breaking operation has to be interrupted
to lift up the pipe for cutting off the defective pipe
end and tapping a fresh screw thread on the pipe end,
wasting considerable time and labour. In addition to oil
well pipes, the same applies to metallic sliding parts
20 which are subjected to a high surface pressure.

Hitherto, various lubricants have been proposed
for preventing galling of metallic sliding parts. In
most cases these lubricants contain a solid lubricant,
a lubricant additive and/or an organic resin. For
25 example, a lubricant comprising an MoS_2 -resin system is
proposed in U.S. Patent Nos. 3,051,586, 4,303,537,
3,146,142 and 4,206,060 and Japanese Patent Publication

No. 51-43558, a lubricant comprising an MoS_2 - Sb_2O_3 -resin system is disclosed in U.S. Patent Nos. 3,314,885 and 3,882,030, and Kirk-Othmer Encyclopedia of Chemical Technology, and a lubricant comprising a graphite-resin system is described in U.S. Patent No. 2,335,958.

In order to make the most of the functions of the component of a lubricant and to maintain satisfactory lubricative properties in severe conditions under a high surface pressure, the kinds and blending ratios based on the correlations of the respective ingredients are important factors which should be taken into consideration in this connection. The lubricants of the above-mentioned systems or compositions are not necessarily satisfactory as a lubricant for sliding metal parts under high surface pressure and cannot be expected to have a sufficient effect on the prevention of galling.

We have sought to eliminate the above-mentioned problem, and more particularly to provide a lubricant film which is capable of effectively preventing galling of sliding metallic parts under high surface pressures.

According to one aspect of the invention, there is provided a lubricant film containing: a solid lubricant containing 60-80 wt % of MoS_2 or MoS_2 + graphite; a lubricant additive consisting of at least one component selected from 10-30 wt % of Sb_2O_3 , Fe powder, Zn powder and Ag powder; and an organic binder consisting of more than 3 wt % and less than 15 wt % of at least one

component selected from epoxy-ester resin, acrylic resin and urea resin.

Reference is now made to the accompanying drawings, in which:

5 FIGURE 1 is a graphic representation of the sliding time up to the occurrence of initial galling versus the Sb_2O_3 content;

FIGURES 2 to 4 are schematic views of a plate-rider friction test apparatus; and

10 FIGURE 5 is a diagram of the number of the sliding time versus the friction coefficient for various lubricants.

The lubricant film according to the present invention is constituted by a solid lubricant, an additive and an
15 organic resin binder. The solid lubricant is selected

from MoS_2 and MoS_2 + graphite, the lubricant additive is selected from Sb_2O_3 , Fe powder, Zn powder, Ag powder and any mixture thereof, and the
20 organic resin is selected from an epoxy-ester resin, an acrylic resin, a urea resin and any mixture thereof.

With regard to the solid lubricant, the lubricant film according to the present invention contains MoS_2 or MoS_2 + graphite, as mentioned hereinbefore, in an amount
25 of 60-80 wt %. The solid lubricant which plays the main role in lubrication lowers the friction coefficient and therefore reduces the amount of frictional heat in the

sliding metal portions under high surface pressure to prevent galling, so that it should be contained in the range of 60-80 wt %.

Solid lubricants such as WS_2 , $(CF)_n$ (carbon fluoride) PTFE (polytetrafluoroethylene) and the like have inadequate lubricating properties, so that the solid lubricant component in the present invention is restricted to MoS_2 or MoS_2 + graphite in the above defined range. A solid lubricant content of less than 60 wt % results in a deterioration in durability and a high friction coefficient, and the deterioration in durability will occur even with a solid lubricant content in excess of 80 wt %. Thus, the content of the solid lubricant should be in the range of 60 to 80 wt %.

With regard to the lubricant additive which improves the thermal stability of the solid lubricant containing film, Sb_2O_3 , Fe powder, Zn powder, Ag powder or any mixture thereof is added in an amount of 10-30 wt %. This lubricant additive serves to suppress the oxidation of MoS_2 of the solid lubricant (MoS_2 being oxidized to MoO_3 which has lower lubricating properties). The content of the lubricant additive should be in the range of 10-30 wt % since the above-mentioned effect cannot be expected if its content is less than 10 wt % and the lubricating property of the solid lubricant containing film is instead lowered if its content is greater than 30 wt %.

FIGURE 1 shows the results of sliding tests of lubricant films containing an epoxy-ester resin and MoS_2 + Sb_2O_3 in a constant weight ratio of 8:92 but with variations in the content of Sb_2O_3 . As is clear there-
5 from, the durability of the lubricant film is improved conspicuously when the Sb_2O_3 content is in the range of 10-30 wt %, enduring more than 500 cycles of sliding motions before initiation of galling.

Examples of other lubricant additives include
10 PbO , $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$, As_2O_3 and the like. However, it will be clear from Table 1 below that, except in the case of the lubricant additives according to the invention, galling occurs at a relatively early time due to an unsatisfactory effect of the lubricant additive.

15 With regard to the organic binder, it consists of an epoxy ester resin, an acrylic resin, a urea resin or a mixture thereof and is added in the range of more than 3 wt % and less than 15 wt %. More particularly, the organic binder, which plays an important role in binding the particles of the solid
20 lubricant powder and the lubricant additive powder to each other as well as to the base metal surface, should be present in an amount of more than 3 wt % in order to secure that effect in a sufficient degree but its content should not exceed 15 % in view of the low lubricating
25 property of the binder itself under high surface pressure, a preferred range being 3.5 to 12 wt. %.

TABLE 1

Sample No.	Solid Lubric't	Organic Lubric't	Lubric't Additive	Sliding Time (A)	Sliding Time (B)
1	MoS ₂	Epoxy-ester resin	ZnSO ₄ ·7H ₂ O	153	387
2	"	"	Fe ₂ O ₃	160	>500
3	"	"	MnCl ₂ ·4H ₂ O	370	>500
4	"	"	NaHCO ₃	320	405
5	"	"	As ₂ O ₃	201	305
6	"	"	Bi ₂ O ₃	280	>500
7	"	"	SiO ₂	305	>500
8	"	"	PbO	380	420
9	"	"	TiO ₂	345	>500
10	"	"	Cu powder	374	>500
11	"	"	Pb powder	374	>500
12	"	"	CaO	418	>500
13	"	"	Ag powder	500	>500
14	"	"	Zn powder	≥500	>500
15	"	"	Fe powder	>500	>500
16	"	"	Sb ₂ O ₃	>500	>500

Note: The sliding times A and B represent an average number of sliding motions before initiation of galling and an average number of sliding motions up to a time when an abrupt increase in friction coefficient occurs, respectively, in a sliding test which was repeated three times under the same conditions.

In consideration of the above-mentioned function of the resin binder, its nature is regarded as an important factor which governs the durability of the lubricant film. The organic binders which are generally known in the art include phenol resins, epoxy resins + phenol resins or alkyd resins, urethane resins and the like. In this regard, the present invention restricts the binder to epoxy ester resins, acrylic resins urea resins and mixtures thereof for the following reasons.

Table 2 below shows the sliding time up to the time point at which galling initially takes place, with regard to lubricant films of an MoS_2 - Sb_2O_3 -organic resin system formed on sliding metal portions under high surface pressure and containing different kinds of organic binders. It will be understood therefrom that acrylic resins, epoxy ester resins and urea resins which are employed in the present invention have excellent properties with regard to the durability of the lubricant film as compared with other organic binders.

Examples of acrylic resins, epoxy ester resins and urea resins useful in the present invention include, but are not limited to, acrylic resins such as copolymers of methyl methacrylate, ethyl methacrylate, propyl methacrylate and the like, epoxy ester resins such as epichlorohydrin-bisphenol A-type epoxy resins esterified with an unsaturated fatty acid of, for instance, linseed oil, castor oil and the like, and urea resins such as condensation polymers

of urea and formaldehyde.

Table 2

Sample No.	Solid Lubric't	Lubric't Additive	Organic Resin	Sliding Time (1)	Sliding Time (2)
1	MoS ₂	Sb ₂ O ₃	Urethane resin	190	>500
2	"	"	Epoxy-ester resin + phenol resin	195	310
3	"	"	Phenol resin	250	90
4	"	"	Alkyd resin	325	470
5	"	"	Silicon resin	210	320
6	"	"	Epoxy resin	450	>500
7	"	"	Acrylic resin	>500	>500
8	"	"	Epoxy-ester resin	>500	>500
9	"	"	Urea resin	>500	>500

15 The lubricant film according to the present invention is formed on sliding metallic parts in the following manner.

In the first place, the respective components of the lubricant film are blended in the above-defined proportions and then mixed with an organic liquid such as toluene or the like. The resulting suspension is applied uniformly and thinly, for example, on threaded joint portions of stainless steel pipes by a brush or a sprayer, and then the organic liquid is removed by air seasoning to form a film of the above-mentioned constituents. Although natural seasoning is sufficient, it is preferred that the film which has been formed

in this manner be thermally treated for a time period of several minutes to 5 hrs in a temperature range of 200-300°C.

5 The above-described lubricant film according to the present invention exhibits good durability when applied to sliding metal parts under high surface pressure, eliminating the problem of galling which occurs with conventional lubricants.

10 The lubricant film of the present invention can be applied to various sliding metal parts which are subjected to a high surface pressure for diverse purposes, for example, to stainless steel pipes to be used as oil well pipes. Although grease (thread compounds) is usually applied to the threaded ends of such pipes before
15 joining them end to end, some parts of the threaded end portions are subjected upon tightening to a surface pressure close to the yield stress of stainless steel (e.g. 70 kg/mm²) with the problem of galling as mentioned hereinbefore. However, tightening and breaking of the
20 threaded joint portions with the lubricant film of the present invention can be effected smoothly and without galling problems. Furthermore, the above-mentioned grease which is applied to the threaded joint portions of stainless pipes in the conventional pipe joining operations
25 may possibly become contaminated with muddy water or sea water depending upon the environment in which it is to be used. The lubricant film of the present invention

can maintain good lubricant properties and exhibits high durability even in such severe environments.

The invention is now illustrated more particularly by way of an example.

5 Example

There were prepared lubricant compositions containing MoS_2 , Sb_2O_3 and an epoxy-ester resin in the ratios of 52 wt %: 13 wt %: 35 wt % (No. 1), 72 wt %: 18 wt %: 10 wt % (No. 2) respectively, and after mixing with an
10 organic liquid, each suspension was applied on plate 1 of the testing apparatus as shown in Figures 2 to 4. After natural seasoning, the resulting film was subjected to the plate-rider friction tests, in which an apparent contact load of 100 kg/mm^2 was imposed on the plate 1, a
15 test piece of SUS 410, by a rider 2.

In the test shown in FIGURE 2, the sliding duration was measured by counting the number of one-way sliding movements of the plate 1 in the leftward or rightward direction from one to the other end (over a distance
20 of 60 mm) at a sliding speed of 30 mm/sec.

As seen in FIGURE 5 which shows the test results, the lubricant film No. 1, outside the range of the present invention, endured only about 30 sliding motions before initiation of galling, showing an abrupt increase
25 in friction coefficient thereafter. On the other hand, the test pieces with the lubricant film No. 2 according to the present invention were completely free of galling

-11-

even after 500 sliding motions, proving good durability of the films.



CLAIMS:

1. A lubricant comprising:

60-80 wt % of a solid lubricant which is MoS_2 or

5 MoS_2 + graphite;

10-30 wt % of a lubricant additive selected from

Sb_2O_3 , Fe powder, Zn powder and Ag powder, and mixtures thereof; and

more than 3 wt % and less than 15 wt % of an organic binder selected

10 from epoxy-ester resin, acrylic resin and urea resin, and mixtures thereof.

2. A lubricant as claimed in claim 1, wherein said organic binder is contained in an amount of 3.5 - 12 wt %.

15 3. A lubricant as claimed in claim 1 or 2, in the form of a film for preventing galling of sliding metal parts under high surface pressure.

20 4. A lubricant as claimed in claim 1, substantially as hereinbefore described with reference to the Example and/or the accompanying drawings.

5. A method for preventing galling of a sliding metal
25 part under high surface pressure, said method comprising the steps of:

preparing a suspension by mixing with an organic



DL

liquid a lubricant film composition containing 60-80 wt %
of a solid lubricant consisting of MoS_2 or MoS_2 + graphite,
10-30 wt % of a lubricant additive consisting of at least
one component selected from Sb_2O_3 , Fe powder, Zn powder, Ag
5 powder and mixtures thereof, and more than 3 wt % and less than 15
wt % of an organic binder consisting of at least one
component selected from epoxy-ester resins, acrylic resins,
urea resins and mixtures thereof;

applying said suspension on the surface of said
10 sliding metal part; and

drying the applied suspension to remove said organic
liquid and to form a lubricant film on said sliding metal
part.

15 6. A method as claimed in claim 5, wherein the
suspension is dried by natural seasoning.

7. A method as claimed in claim 5, wherein said
lubricant film formed on said sliding metal part is thermally
20 treated for a time period of several minutes to 5 hrs.
in a temperature range of 200-350°C.

8. A method as claimed in claim 5, substantially
as hereinbefore described with reference to the Example
25 and/or the accompanying drawings.

9. A stainless steel oil well pipe having threaded



joint portions thereof coated with a lubricant film constituted by 60-80 wt % of solid lubricant consisting of MoS_2 or MoS_2 + graphite, 10-30 wt % of a lubricant additive consisting of Sb_2O_3 , Fe powder, Zn powder,

- 5 Ag powder or a mixture thereof, and more than 3 wt % and less than 15 wt % of an organic binder consisting of an epoxy-ester resin, an urea resin, an acrylic resin or a mixture thereof.