ABSTRACT OF THE DISCLOSURE

A lubricating composition for lubricating ductile metals during deformation of the same in contact with a solid deforming member, consisting essentially of ortho and/or condensed phosphates of alkali metals intimately mixed with a metal oxide, which metal oxide is either a trivalent metal oxide or a mixture of bivalent and trivalent metal oxides, wherein the molar proportion of the bivalent metal oxides is at most twice that of the trivalent metal oxides.

BACKGROUND OF THE INVENTION

The present invention relates to high temperature lubricants on a phosphate basis, which may be used during the hot deformation of ductile metals, for instance by rolling, extruding, forging, drawing or stamping. It has long been found that in order to extend the useful life span of the shaping or deforming members which are utilized in the hot deformation of ductile metals, the interposition of a lubricant between the deforming member and the ductile metal is required in order to reduce the friction between the hot ductile metal and the deforming tool. Furthermore, such lubricant will serve as a protective agent against the heat accumulation which occurs at the edges and surfaces of the shaping tool or deforming member which are in contact with the ductile hot metal during deformation of the same.

Generally, up to now, silicon-containing or low alkali metal, phosphorus-containing glasses of certain compositions have been used as lubricants in the deformation of metal at very high temperatures and pressures, for instance for the extrusion of steel.

However, it has been found in the industrial use of these lubricants that lubrication with silicate glasses results in a relatively high degree of wear and tear of the deforming tool and that the surface condition of the deformed ductile metal frequently will be faulty, and that difficulties are involved in the complete removal of residual glass from the surface of the deformed ductile metal. Particularly in the case of hollow profiles, relatively costly etching processes utilizing hydrofluoric acid are required in order to remove such residual glass portions.

Alkali-poor phosphate glasses which were proposed for the extrusion of metal generally contain, expressed in mol-percent, 9 to 33% of alkali metal oxide, 16 to 20% oxides of bivalent metals, 10 to 20% aluminum oxide, and 29 to 61% phosphorus pentoxide. However, such lubricants, as has been found in many industrial test runs, cannot prevent a relatively high degree of wear and tear and a relatively short useful life span of the deforming tools, which is caused by the adherence to the tool surfaces of part of the ductile metal which is to be deformed and by the welding of such ductile metal portions to the surface portions of the deforming tool.

Other high temperature lubricants, such as lubricants consisting essentially of phosphates and borates, sulfates or chlorides, which at relatively low temperatures form eutectic melts, have only a limited applicability, generally only up to temperatures of about 1,000 °C, and thus cannot be used for the deformation of metal at higher temperatures for instance for the extrusion of steel.

SUMMARY OF THE INVENTION

The present invention proposes a high temperature lubricant and a method of deforming ductile metals in contact with shaping tools and the like with the interposition of the high temperature lubricant between the shaping tool and the ductile metal, whereby the lubricant of the present invention will permit shaping of the ductile metal even at very high temperatures so as to obtain a shaped body of the desired surface condition which does not require expensive after-treatment, and without excessive wear and tear of the shaping tool.

This is accomplished, according to the present invention, by providing a high temperature lubricant which consists essentially of a mixture of ortho or condensed phosphates of alkali metals with metal oxides, particularly bivalent and trivalent metal oxides, whereby preferably the major portion of the metal oxides will consist of trivalent metal oxides.

The lubricant according to the present invention will facilitate the deformation of the hot ductile metal without causing adherence of hot metal at the contacting or shaping surfaces of the shaping tool, and without forming on the thus shaped ductile metal difficultly removable lubricant deposits.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The high temperature lubricant according to the present invention consists essentially of a mixture of ortho phosphates and/or condensed phosphates of alkali metals with bivalent or trivalent metal oxides.

The term "condensed phosphates" is meant to denote all phosphates, the anions of which include P—O—P bonds. These include the pyrophosphates, polyphosphates with a chain length of 3 or more, metaphosphates with ring-shaped anions, and cross-linked phosphates.

Preferably, the lubricant of the present invention consists of mixtures of phosphates and metal oxides which contain, expressed in mol-percent, 34 to 49% phosphorus pentoxide, 34 to 49% alali metal oxides, 0 to 25% ferric oxide, and 0 to 25% aluminum oxide, whereby the molar proportion of FeO-Fe2O3 + Al2O3 is not greater than 25%.

Furthermore, part of the trivalent oxides may be replaced by bivalent oxides, and it is also within the scope of the present invention to include in the mixture oxides of bivalent metals in an amount such that the molar relationship between bivalent metal oxides and trivalent metal oxides, i.e., Fe2O3 and/or Al2O3, is at most 2:1, or an even higher proportion of the trivalent oxide.

The bivalent oxides are preferably selected from the group consisting of the oxides of calcium, magnesium, barium, iron, nickel and zinc.

In addition, to the above-mentioned trivalent metal oxides, i.e., Fe2O3 and Al2O3, it is also possible to use chromium oxide (Cr2O3).

It is also possible to incorporate in the lubricant mixture of the present invention oxide phases in which one and the same metal is partly in bivalent and partly in trivalent condition, for instance, magnetite (Fe3O4).
Furthermore, it has been found that potassium phosphates are considerably more effective as the phosphate component than sodium phosphates, since the lubricating film which is formed in the presence of sodium phosphates has lesser heat insulating characteristics and thus will cause a relative increase in the temperature of, for instance, a mandrel inserted in the forming of seamless tubings.

For the same reason, i.e., in order to keep the heat transfer from the hot ductile material to the deforming tool as low as possible, it is preferred to incorporate in the lubricant of the present invention the phosphate component, for instance potassium phosphate, for instance Kurrol's potassium salt (KPO₃), in place of ortho phosphates. For instance, the interior lubrication during the extruding of seamless steel pipes can be achieved in a most effective manner by introducing into the bore of the heated blank a lubricating mixture according to the present invention, which may consist, for instance, of ferric oxide and Kurrol's potassium salt. The high temperature of the blank causes quick melting of the high molecular potassium polyphosphate and reaction of the same with the ferric oxide, whereby the ferric oxide causes a high degree of decomposition or shortening of the initially very long union chains of the polyphosphate so that a mixture of relatively short-chain potassium-iron polyphosphates and ortho phosphates is formed. This reaction proceeds during transportation of the hot blank to the extrusion device and there is a considerable probability that the reaction also continues during the extrusion process. In any event, it is accomplished in this manner that a load-supporting, well adhering lubricant film is formed which, during the extrusion process prevents any direct metal-metal contact between the metal of the hot blank and the metal of the extrusion device and which also prevents the adhesion of metal on the mandrel surface and permits the formation of fault-free inner tubular surfaces.

By utilizing a mixture of Fe₂O₃ and (KPO₃) as the lubricating mixture it is possible to increase the useful life span of the mandrels used for extruding seamless steel tubes and other hollow profiles requiring a high degree of deformation, to a multiple of the useful life span of such mandrels which could be achieved with silicate glass or alkali-poor phosphate glass lubricants.

The lubricating properties of the lubricating mixture are furthermore greatly influenced by the cation: phosphorus ratio in the lubricating mixture, since this ratio determines the median or average chain length of the polyphosphates which are formed by reaction of the initial phosphates with the metal oxides.

Experiments on an industrial scale have shown that the most advantageous lubricating properties are achieved by maintaining a ratio of cation-equivalent phosphorus in the starting mixture which is between 2.60 and 1.50, corresponding to an average chain length of the polyphosphates obtained in the formation of the lubricating film of from n = 1.25 to n = 4.

The lubricating mixture according to the present invention is preferably applied in pulverulent condition directly to the hot metal blank immediately prior to deformation of the latter. However, it is also possible to melt the lubricating mixture by heating and to apply the thus obtained melt in liquid condition, or to cool and solidify the melt and to comminute the same for subsequent application in pulverulent condition to the hot metal blank.

The high temperature lubricant of the present invention is far superior to conventional high temperature lubricants. Utilization of the lubricant of the present invention very considerably reduces the wear and tear of the shaping tools and increases the useful life span of the seamless tubes and other hollow profiles which are inserted during the extrusion with a high degree of deformation, of seamless tubes and other hollow profiles. In fact, the useful life span of these tools is increased in accordance with the present invention, i.e., by applying the lubricant described herein, to a multiple of the conventionally obtainable useful life span, and, at the same time, the heat transfer from the hot ductile metal to the shaping tool is kept relatively low during the deformation process.

It is a particular advantage of the present invention that it is not required when using the lubricant described herein to suppress scale formation during heating of the ductile metal blank by expensive and involved protective gas heating devices, since application of the lubricant of the present invention to all tubes to an appreciable extent dissolves of oxidic scale layers and conversion of the oxides of the scale into materials having lubricating properties.

The following examples are given as illustrative only, without, however, limiting the invention to the specific details of the examples.

**Example I**

More than 1,000 seamless tubes and rectangular hollow profiles of various dimensions and degrees of deformation were extruded in a very successful manner with the help of the following lubricant composition:

A mixture of high molecular potassium polyphosphate (Kurrol's potassium salt) and iron-III-oxide, in the molar ratio of KPO₃ : Fe₂O₃ = 5 : 1, corresponding to 78.71% by weight KPO₃, 21.29% by weight Fe₂O₃, or corresponding to 41.67 mol-percent P₂O₅ : 43 mol-percent Fe₂O₃ and 16.66 mol-percent Fe₂O₃ and a ratio of cation-equivalent: phosphorus of 2.20.

The above described lubricant was used, inter alia, for extruding 38 tubes having an outer diameter of 45 mm., a wall thickness of 5 mm., and a length 11.5 meters each, and for the extrusion of 61 tubes of similar cross-sectional dimensions but a length of 10 meters.

The mandrels which had been inserted into these tubes were thereafter in fully operative substantially unchanged condition and their use could be continued. In a parallel test run, tubes of the same dimensions were extruded with an alkali-poor phosphate glass lubricant having, expressed in mol-percent, the following composition: 27.4% P₂O₅, 6.9% B₂O₃, 18.9% Al₂O₃, 7.2% ZnO, 12.0% MgO, 18.5% Na₂O, and 9.1% K₂O. However, these tests had to be terminated after two extrusions in view of the very extensive heating of the mandrel and the adherence of material thereto, which would have led to a quick destruction of the mandrel.

**Example II**

Similarly good results as were obtained in the production of seamless steel tubes with a lubricant of the composition KPO₃ : Fe₂O₃ = 5 : 1, were also obtained by using a lubricant, consisting of Kurrol's potassium salt and metal oxides and having the following molar compositions:

\[ \text{KPO}_3 : \text{Fe}_2\text{O}_3 = 9:1, 8:1, 7:1, 6:1, 11:2, 9:2, 2:13; \]
\[ \text{KPO}_3 : \text{Al}_2\text{O}_3 = 6:1, 5:1, 4:1; \]
\[ \text{KPO}_3 : \text{Fe}_2\text{O}_3 : \text{Al}_2\text{O}_3 = 12:1:1, 11:1:1, 10:1:1, 9:1:1; \]
\[ \text{KPO}_3 : \text{Fe}_2\text{O}_3 : \text{CaO} = 10:1, 5:1:5:1:5:10; \]
\[ \text{KPO}_3 : \text{Al}_2\text{O}_3 : \text{CaO} = 10:1, 5:1:5:1:5:10; \]
\[ \text{KPO}_3 : \text{Fe}_2\text{O}_3 : \text{CaO} = 10:1, 5:1:5:1:5:10; \]
\[ \text{KPO}_3 : \text{Fe}_2\text{O}_3 : \text{FeO} : \text{Al}_2\text{O}_3 = 10:0.78:0.66:1; \]
\[ 10:0.98:0.83:1.25. \]

The respective, above-described, lubricants were introduced into the bore of the heated blank. After completion of the run the mandrel was still in completely usable and unattacked condition and could be used for further extrusion runs without causing any difficulties. The inner surfaces of the thus extruded seamless steel tubes were faultless.

While the invention has been described primarily with respect to the lubricant being used in connection with the deformation of steel, the invention is not to be considered limited thereto, since the lubricant of the present inven-
tion could be equally well applied to lubricating other ductile metals during hot deformation of the same, for instance titanium and molybdenum.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

We claim:

1. A high temperature lubricant, adapted for use in the hot deformation of metals, consisting essentially of a mixture of (a) at least one substance selected from the group consisting of ortho and condensed phosphates of alkali metals, and (b) at least one metal oxide.

2. A lubricant as defined in claim 1, wherein said mixture contains the equivalents of between 34 and 49 mol percent \( P_2O_5 \), between 34 and 49 mol percent alkali metal oxide, between 0 and 25 mol percent \( Al_2O_3 \) and between 0 and 25 mol percent \( Fe_2O_3 \), and wherein the combined amount of \( Al_2O_3 \) and \( Fe_2O_3 \) is not greater than 25 mol percent.

3. A lubricant as defined in claim 1, wherein said metal oxides include oxides of bivalent and of trivalent metals in a molar ratio such that the amount of bivalent metal oxides is equal to at most twice the amount of trivalent metal oxides, and wherein said mixture contains the equivalents of between 34 and 49 mol percent \( P_2O_5 \), between 34 and 49 mol percent alkali metal phosphate and a combined amount of between 25 and 50 mol percent of oxides of bivalent and trivalent metals.

4. A lubricant as defined in claim 3, wherein said trivalent metal oxides are selected from the group consisting of \( Fe_2O_3 \) and \( Al_2O_3 \).

5. A lubricant as defined in claim 4, wherein said oxides of bivalent metals are selected from the group consisting of \( CaO \), \( MgO \), \( BaO \), \( FeO \), \( NiO \), and \( ZnO \).

6. A lubricant as defined in claim 1, wherein said phosphates are potassium phosphates.

7. A lubricant as defined in claim 2, wherein said alkali metal oxide is potassium oxide.

8. A lubricant as defined in claim 3, and containing the equivalent of between 34 and 49 mol percent \( P_2O_5 \) and between 34 and 49 mol percent potassium oxide.

9. A lubricant as defined in claim 1, wherein said mixture includes Kurrol’s potassium salt.

10. A lubricant as defined in claim 1, wherein said mixture is in the form of a melt.

11. A lubricant as defined in claim 1, wherein said mixture is in the form of a solidified melt.

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