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WORKING OF NON-FERROUS METALS

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ABSTRACT OF THE DISCLOSURE

The use of a lubricant comprising a polyglycol when working one metal which is in movable contact with a second metal.

BACKGROUND OF THE INVENTION

When working a metal wherein two metal surfaces which may be dissimilar in nature are in movable contact with each other, a lubricant is required to serve as an anti-wear and anti-seize agent, as well as being required as a coolant. The requirements for said lubricant in the working of ferrous metals are not as severe as the requirements in the case of non-ferrous metals. Accordingly, the prior art is replete with numerous lubricants for use with ferrous metals, these lubricants include oil, fat, grease, soaps, detergents, emulsions, etc. However, these lubricants generally are not satisfactory for use in the working of non-ferrous metals, particularly zirconium, titanium and alloys thereof. In particular, zirconium does not possess the property of being able to react with lubricants as do other metals such as iron, tin, lead, etc. As will be hereinafter shown in greater detail, it has now been discovered that certain compounds may be utilized neat as lubricants when working non-ferrous metals.

DESCRIPTION OF THE INVENTION

This invention relates to the use of certain compounds as lubricants for non-ferrous metals. More particularly, the invention is concerned with the use of certain polyglycols as a lubricant and/or coolant for the working of non-ferrous metals.

It is therefore an object of this invention to provide a novel lubricant for the working of metals.

A further object of this invention is to provide a lubricating material when working metals wherein one metal is in movable contact with a second metal, the first metal being non-ferrous in nature.

In one aspect an embodiment of this invention is found in a process for the working of a metal, wherein one metal is in movable contact with a second metal and with a lubricant, said lubricant comprising a polyglycol.

A specific embodiment of this invention is found in a process for the tube reduction of zirconium alloy in which said zirconium alloy tube is in movable contact with a mandrel and a lubricant, said lubricant comprising polypropylene glycol.

Other objects and embodiments will be found in the following further detailed description of the present invention.

As hereinbefore set forth the present invention is concerned with a lubricant which is utilized when working metals. While the lubricants of the type hereinafter set forth in greater detail are particularly advantageous for use in the working of non-ferrous metals, it is to be understood that said lubricants may be utilized to advantage in the working of ferrous metals. The working of the metal may take various forms such as drawing, rolling, extruding, cutting, drilling, broaching, tapping, threading, etc. As will be hereinafter shown in greater detail, the lubricant of the present invention is of especial advantage for use in reducing the diameter of tubes or similar operations.

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In addition to serving as an anti-wear and anti-seizure agent, the lubricant must survive the chemical and thermal environment at the interface in order to avoid formation of wear debris which is difficult to remove from the finished article. The lubricant must also avoid corrosion of the metal, staining and in addition, must not excessively alter the surface structure of the metal. This latter requirement is of particular importance in the case of zirconium and titanium because of the desirability to prevent formation of an open-grain structure. Therefore, in order to be of efficient use, the lubricant must result, after working of the metal, in a low debris content, a low wear area, and a low surface roughness, that is to say a smaller amount of surface defects which result in the aforesaid open-grain structure.

As was hereinbefore set forth, the use of certain lubricants is known in the art. In addition, it is known to use glycols for lubricants. However, these glycols are not used neat nor are these used for non-ferrous metals such as zirconium. The glycols which are used in the working of other metals such as ferrous metals are actually used as carriers for other additives, these additives being the actual lubricating agents. In constradistinction to this, the polyglycols which are utilized in the present invention are the effective lubricating agents and may be used neat or in combination with a friction modifier. By utilizing polyglycols of the type hereinafter set forth in greater detail, it is possible to overcome certain inherent undesirable properties which are present in other lubricants. For example, mono- or diglycols such as propylene glycol, dipropylene glycol, etc. are hygroscopic in nature and therefore will pick up any moisture which may be present, either in the air or on the surface of the metal to be worked, thereby altering the lubricating properties of the lubricant. As opposed to these compounds, the polyglycols of the present invention may fall within a wide range of molecular weights, the criterion for the polyglycol of low molecular weight being that it must not be hygroscopic in nature and the criterion for the highest molecular weight polyglycol which may be used being that it must be liquid in form and possess some water-solubility. By utilizing a polyglycol which is water-soluble, it is possible to effect an ease of cleaning after the metal has been worked by subjecting the worked piece to a cleaning stream of water or water plus a detergent system. Another advantage in utilizing the polyglycols of the present invention is that said polyglycols are non-toxic in nature as opposed to monohydric compounds such as alcohols which possess a certain degree of toxicity.

While the method or process of the present invention is particularly applicable for the working of zirconium, titanium, or alloys thereof, it is to be understood that the lubricants of the present invention may also be utilized to advantage in the working of other non-ferrous metals including, but not limited to, aluminum, copper, brass, bronze, magnesium, etc.

Examples of polyglycols which may be utilized as the lubricant in the process of this invention will include polyethylene glycols and polypropylene glycols possessing a molecular weight in the range of from about 400 up to about 2,000 or more, the lower molecular weight polyglycols or higher molecular weight polyglycols possessing one of the criteria hereinbefore set forth, glycerine, or the sorbitol type polyols, etc. Some specific examples of the type of polyglycols which may be employed will include those sold by Union Carbide Company under the trade name PPG-424 and PPG-1025 as well as polypropylene glycols sold by the Dow Chemical Company under the trade name P-400, P-1200, and P-2000, in each of these trade names the number designates the moleculare weight of the particular polyglycol.

It is also contemplated within the scope of this invention that the polyglycols may be utilized in admixture with other ingredients such as friction modifiers. These friction modifiers will include the various soaps, detergents comprising polyoxyethylated materials, acids such as saturated fatty acids, including formic acid, acetic acid, propionic acid, butyric acid, valeric acid, caproic acid, enanthylic acid, caprylic acid, pelargonic acid, capric acid, lauric acid, palmitic acid, stearic acid, behenic acid, etc.; unsaturated fatty acids such as acrylic acid, crotonic acid, isocrotonic acid, tiglic acid, angelic acid, senecioic acid, hexenic acid, decylenic acid, dodecylenic acid, palmitoleic acid, ricinoleic acid, oleic acid, linoleic acid, linolenic acid, vaccenic acid, eleostearic acid, licanic acid, parinaric acid, gadoleic acid, cetoleic acid, selacholeic acid, etc.; salts of these acids including sodium acetate, potassium acetate, sodium propionate, potassium butyrate, potassium oleate, sodium oleate, etc.; amines such as ethyl amine, propyl amine, isopropyl amine, butyl amine, amyl amine, hexyl amine, heptyl amine, octyl amine, nonyl amine, decyl amine, dimethyl amine, diethyl amine, dipropyl amine, dibutyl amine, diamyl amine, dihexyl amine, diheptyl amine, etc. In the preferred embodiment of the invention, the aforementioned friction modifiers may be present in an amount in the range of from about 0.1 to about 2% by weight of the polyglycol. It is to be understood that the aforementioned examples of polyglycols and friction modifiers are only representative of the class of compounds which may be used, and that the present invention is not necessarily limited thereto.

It is contemplated that the friction modifiers may be used in solution with the polyglycols of the type hereinbefore set forth. However, if the friction modifier does not form a solution with the polyglycol the composition may then be utilized as an emulsion either with or without water. The lubricant of the present invention may be utilized in any conventional manner, said manner being dependent upon the particular procedure which is employed in the working of the metal. However, in any event, the lubricant must be applied in such a manner so as to insure its presence at the points of contact of the metals which are in moving relationship to each other. Also, the amount of lubricant which is used will be that which is sufficient to accomplish effective lubrication, this amount also being dependent upon the particular working procedure which is employed.

The following examples are given to illustrate the process of the present invention which, however, are not intended to limit the generally broad scope of the present invention in strict accordance therewith.

Example I

The lubricants were evaluated in a modified Bowden-Leben pin and disc machine. The Bowden-Leben method is described in "The Friction and Lubrication of Solids," 1954, page 74, by Bowden and Tabor. This method is also discussed in the article by E. Rabinowicz, entitled "The Boundary Friction of Very Well Lubricated Surfaces," which was presented at the A.S.L.E. Ninth Annual Meeting in Cincinnati on Apr. 5, 1954, and published in the July-August 1954 issue of "Lubricating Engineering." In the modification used for the runs reported herein, a polished A-8 steel disc rotates in contact with an upwardly extended rounded Zircaloy pin. Zircaloy No. 2, for example, is an alloy comprising 98.3% by weight zirconium, 1.5% by weight tin, 0.20% by weight iron and 0.10% by weight chromium.

A total of about 2 grams of lubricant is utilized. About 1.8 grams of lubricant is applied to the disc and about 0.2 grams of lubricant is applied to the pin. The equipment is enclosed in a housing which is heated for varying the temperature of the run which, in these evaluations, can be within the range of from 72° to 212° F. The speed is fixed at 6 r.p.m. In each run an original load of 100 grams is increased in units of 100 grams at intervals of 1.67 minutes to a maximum load of 1300 grams. A strain

gage circuit is used as sensing element in converting the frictional effects into equivalent electrical responses, which then are recorded on a continuous chart recorder. The coefficient of friction is determined for each time interval. In addition, the diameter of the wear spot on the pin is measured. The pin and disc are visually inspected immediately after the test to determine the amount of debris.

The lubricants which were utilized for these tests were high molecular weight polypropylene glycols sold by the Dow Chemical Company under the trade names P–400 and P–1200 respectively, said runs being made at 22° C. The effect of these tests are set forth in Table I below:

TABLE I

		Lubricant	
		Dow P–400	Dow P–1200
	Time, min.	Coefficient of friction	
Load, g.:			
100	1.67	0.154	0.112
200	3.34	0.140	0.119
300	5.01	0.121	0.126
400	6.68	0.112	0.126
500	8.35	0.109	0.126
600	10.02	0.107	0.124
700	11.69	0.106	0.124
800	13.36	0.107	0.123
900	15.03	0.107	0.123
1,000	16.70	0.106	0.122
1,100	18.37	0.108	0.122
1,200	20.04	0.106	0.120
1,300	22.00	0.105	0.119
1,300	37.00	0.103	0.119
1,300	52.00	0.103	0.116
1,300	67.00	0.105	0.116
1,300	82.00	0.105	0.118
1,300	97.00	0.103	0.118
1,300	112.00	0.105	0.118
1,300	127.00	0.105	0.118
1,300	142.00	0.105	0.118
1,300	157.00	0.107	0.118
1,300	172.00	0.107	0.119
1,300	187.00	0.107	0.118
1,300	202.00	0.108	0.119
200		0.126	0.126
DPH, original		194.6	192.4
DPH, final		206.6	207.0
Wear area, mm.²		0.0803	0.0706
Debris		Light	Light

From the data in the above table it will be noted that the coefficient of friction was satisfactory, the wear area was relatively small and the debris was light.

Example II

To illustrate the contrast between the polyglycols of the present invention and a monoglycol two more runs were made utilizing propylene glycol and dipropylene glycol as the lubricant. The results of these runs are set forth in Table II below:

TABLE II

		Lubricant	
		Propylene glycol	Dipropylene glycol
	Time, min.	Coefficient of friction	
Load, g.:			
100	1.67	0.192	0.154
200	3.34	0.171	0.147
300	5.01	0.161	0.154
400	6.68	0.161	0.151
500	8.35	0.155	0.154
600	10.02	0.156	0.156
700	11.69	0.157	0.154
800	13.36	0.156	0.141
900	15.03	0.158	0.129
1,000	16.70	0.146	0.126
1,100	18.37	0.158	0.124
1,200	20.04	0.164	0.122
1,300	22.00	0.159	0.115
1,300	37.00	0.132	0.086
1,300	52.00	0.127	0.081
1,300	67.00	0.115	0.078
1,300	82.00	0.118	0.088
1,300	97.00	0.121	0.096
1,300	112.00	0.118	0.102
1,300	127.00	0.119	0.102
1,300	142.00	0.119	0.108
1,300	157.00	0.124	0.105
1,300	172.00	0.122	0.102
1,300	187.00	0.125	0.102
1,300	202.00	0.128	0.107
200		0.147	0.140
DPH, original		196.6	193.8
DPH, final		213.4	203.6
Wear area, mm.²		0.694	0.528
Debris		Heavy	(1)

1 Light to moderate.

It is noted that the wear area was almost 10 times greater than the wear area when utilizing a polyglycol and in addition the debris was heavy or light to moderate. This comparison graphically illustrates the advantage of utilizing a polyglycol as a lubricant when working a zirconium alloy using a disc of a different metal, namely, steel.

Example III

In this test the lubricant which was evaluated in the same manner as that set forth in Examples I and II above comprised a mixture of 99% P–400 and 1% potassium oleate. As in the above examples, the load in grams ranged from 100 to 1300 for a period of 202 minutes. The coefficient of friction decreased from 0.168 to 0.126 during this period. The wear area at the end of this time was 0.0907 mm.^{2} and the debris was light to moderate.

Example IV

The lubricant which was evaluated in this example comprised a mixture of 99% P–400 and 1% oleic acid. The coefficient of friction was reduced from 0.140 to 0.112 during a period of 202 minutes, the wear area was 0.212 and the debris was moderate.

Example V

A Zircaloy tubing was again subjected to a test similar to that set forth in Example I above utilizing, as a lubricant therefor in the working, a mixture of 99% P–1200 and 1% oleic acid. The test was run at a temperature of 22° C. for a period of 202 minutes, the coefficient of friction being reduced from 0.142 to 0.108. The amount of debris was light and the wear area was 0.0803 mm.^{2}.

Example VI

The lubricant which was used in this example comprised a mixture of 99% polyglycol P–15–200 and 1% oleic acid. The coefficient of friction decreased from 0.117 to 0.087 during a period of 202 minutes, the debris was light to moderate and the wear area was 0.166 mm.^{2}.

Example VII

The lubricant which was evaluated in this example comprised a mixture of 99% polyglycol P–400 and 1% stearic acid. After a period of 202 minutes the coefficient of friction was reduced from 0.140 to 0.119 while the amount

of debris was light to moderate. Likewise when the lubricant comprised a mixture of 99% polyglycol P–400 and 1% potassium naphthanate, the coefficient of friction was reduced from 0.175 to 0.121 during a period of 202 minutes and the amount of debris was again light to moderate.

I claim as my invention:

1. In the working of zirconium or a zirconium alloy which is predominantly zirconium in movable contact with another metal, the improvement which comprises lubricating the contacting surfaces of said zirconium or alloy and metal with lubricating amounts of a water-soluble polyglycol having a molecular weight of at least about 400.

2. The process as set forth in Claim **1** in which said polyglycol contains a friction modifier in an amount in the range of from about 0.1 to about 2% by weight.

3. The process as set forth in Claim **1** in which said polyglycol is a polyethylene glycol.

4. The process as set forth in Claim **1** in which said polyglycol is a polypropylene glycol.

5. The process as set forth in Claim **2** in which said friction modifier is oleic acid.

6. The process as set forth in Claim **1** in which said working of the zirconium alloy is a tube reducing operation.

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