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HIGH TEMPERATURE LUBRICANT

Gilbert Duane Blake, Overland Park, Kans., Rudolph J. Holzinger, Haddonfield, N.J., and Lawton Eugene Reid, Kansas City, Mo., assignors to Socony Mobil Oil Company, Inc., a corporation of New York

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This invention is directed to an improved lubricant composition for use in lubricating materials which must operate at high temperature for extended periods of time and is particularly directed to an improved lubricant for use on kiln chains.

In the manufacture of many products a final heating or drying step is involved. Giant ovens have been developed for continuously conveying materials therethrough which are generally about 300–1000 ft. in length and which utilize continuous chains travelling over sprocket wheels to convey the articles through the heating zone. These kilns operate at approximately 400–800° F., depending upon the heat treating conditions required. The heat is supplied by heated air or gas which is circulated through the ovens by fans or blowers suitably located to maintain uniform temperature throughout the oven. These ovens are obviously expensive and their continuous operation is essential or extremely desirable to the manufacturing operations.

As a specific example of the problems involved, gypsum wall board contains a substantial amount of moisture which is put into the stucco during the manufacturing operation. These boards must be dried in order to harden the board prior to stacking and shipping. This drying operation is accomplished in an oven or kiln 500 to 700 ft. long. The boards are carried through the kiln on roll conveyors at approximately seven feet per minute. There are six to fourteen conveyors in each kiln stacked one above the other. Each individual roll of the conveyor is of the order of 4 or 5 feet long. The many rolls of the conveyor are mounted in bearings and a sprocket is fixed to one end. A chain engages and moves over the sprocket, rotating the rollers, which in turn slowly propel the wall board through the kiln. Of course, other designs are used, but they have in common operation of moving parts, generally with a drive chain, at the elevated oven temperature, providing an exceedingly difficult lubrication problem.

The chains are continuous and may extend outside the kiln or in some instances be contained completely within the kiln. If they extend outside the kiln, the extension is generally just sufficient to pass the kiln jack at the pull end and far enough on the back end to run over the return adjustment idlers. They are, therefore, about twice the length of the kiln in which they travel and nine-tenths to all of their 600–2000 ft. length is constantly within the kiln and exposed to the high kiln temperatures.

The turbulence created by the circulating hot air in the oven tends to carry in suspension fine particles of dust, dirt, dried stucco, board chips, fibers, and other particles from the product undergoing treatment which tend to deposit on the oil wet chain links, and rollers. The oil used to lubricate the mechanism, which previously has been a hydrocarbon oil containing a small amount of graphite, cracks at the high temperature of the oven producing carbonaceous deposits on the chains. The particles become embedded in the carbonaceous material which acts as a binder and these deposits seriously increase the chain load requiring additional power to move the chain. These deposits can become so serious that they cause the chain to get noisy and may even cause the chain to buckle and break.

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Chain breakage and damage has been a serious problem in the gypsum wall board industry, the fiber glass industry and many other industries using these high temperature ovens or kilns. A variety of lubricants has been tested but none has been found completely satisfactory. It is customary, therefore, to permit the chain power requirement to rise to a critical level and then remove the chain for cleaning and scraping. This increased power requirement is, of course, expensive. The down time of the oven is expensive and inconvenient since it interrupts the normal flow of the product.

It is an object of this invention to provide a lubricant suitable for use on equipment operating at elevated temperatures.

It is a further object of this invention to provide a lubricant suitable for use on equipment operating for sustained periods of time at temperatures of 400–800° F.

It is a further object of this invention to provide a lubricant suitable for use on chains and other members in dusty ovens operating for sustained periods of time at temperatures of 400–800° F.

It is a further object of this invention to provide an improved chain conveyor oven lubricant.

These and further objects of the invention will be more fully disclosed in the following detailed description of the invention.

In accordance with one aspect of this invention a water-in-oil emulsion is formed using an emulsifier suitable for forming such emulsion and using a high-temperature stabilizer to insure stability of the emulsion at high temperatures of the order of 170–200° F. Dispersed in the water-in-oil emulsion is a finely divided solid lubricant, such as graphite, molybdenum disulfide, boron nitride, mica, vermiculite, talcum or tungsten disulfite. The emulsion formed by the emulsifier and stabilizer should have an HLB number of broadly about 2–8 and preferably about 3–7. The emulsifier and stabilizer can be selected from nonionic, anionic or cationic surfacants.

The oil used is a hydrocarbon oil having a viscosity range of broadly 50–1000 SUS at 100° F. The preferred viscosity range, however, is 80–150 SUS at 100° F. The oil generally vaporizes and cracks during the lubrication of the oven conveyor chains and, hence, the Conradson carbon residue should be broadly less than about 0.25% and preferably less than 0.05%. The oil phase of the emulsion, including the emulsifiers may be broadly about 85–30% by weight but is preferably about 70–50% by weight. A particularly good lubricant formulation is obtained when using a white oil with the characteristics given hereinabove.

The emulsifier may be any one of a number of oil-soluble compounds broadly classified as anionic, nonionic or cationic. In order to be effective emulsifying agents, they should be strongly oleophilic, i.e. having an HLB of broadly about 2–6 and preferably 3–5. Surfactants having an HLB below about 2 while very strongly oleophilic tend to be poorer emulsifying agents while those above about 6 tend to form O/W emulsions or so-called mixed emulsions being partly O/W and partly W/O and, therefore, unstable. Compounds of the anionic type having been found particularly useful are oleophilic alkaline earth petroleum sulfonates, oleophilic alkaline earth naphthalene sulfonates, oleophilic alkaline earth C_3–C_{18} alkyl phenates and potassium, sodium, ammonium, calcium, barium, strontium, lithium salts of acid phosphates, said phosphates having been partially neutralized by esterification with about C_8–C_{24} alkyl phenols and ethylene oxide derivatives (2–12 mols ethylene oxide) of said phenols. Compounds of the nonionic type having shown utility are partial esters of polyols and C_{10}–C_{24} fatty acids, or partial esters of polyols and so-called wax acids, the latter produced by the oxidation of a mixture of petroleum hy-

drocarbons having a mean carbon chain length in the range of C_{26}–C_{50}, such mixtures commonly being known as petrolatum or microcrystalline wax. Particularly good results have been obtained with partial esters of sorbitol and its dehydration product such as sorbitan monooleate. These emulsifiers are used at a total concentration of broadly 0.1–5.0 percent by weight and preferably 0.3–3.0 percent by weight.

This lubricant is designed for use on oven conveyor chains and the like operating at very high temperatures, such as 400–800° F. It has been found that a water-in-oil emulsion provides the best lubrication for this purpose in that the water droplets are enclosed in oil and hence are able to remain in liquid form for some time period because of the protective oil cover. Furthermore, oil being the outer phase contacts the hot metal to provide lubrication to the metal. The metal chain is so hot that the water flashes off as steam on contact thereby providing a substantial cooling effect and also a blasting effect which effectively removes the hard layer of carbon on the chain. This carbon layer, unless removed, builds up to form a tight layer preventing the chain from bending easily and increasing the chain load substantially. However, to be effective, the emulsion must be delivered to the hot chain in stable form, with the water particles substantially uniformly dispersed in the oil. In order to produce this result in this very hot environment, an emulsion which is exceedingly stable at elevated temperatures must be provided. The emulsion must remain stable at temperatures as high as 170–200° F. to be at all effective. High-temperature stabilizers must, therefore, be used in the lubricant formulation. Suitable high-temperature stabilizers are surfactants having an HLB of broadly about 8–16 and preferably about 10–15. Among suitable agents of the anionic class, metal soaps of naphthenic acids having molecular weights of about 315–500 formed from the metals sodium, potassium, ammonium, lithium, calcium, strontium and barium have been found especially efficacious. Also useful are calcium C_8–C_{30} alkyl salicylate and C_4–C_{18} alkyl phenols. Likewise useful are soaps of C_{16}–C_{30} and preferably C_{18}–C_{22} fatty acids from the metals calcium, barium, lithium, strontium, sodium, potassium and ammonium. Also useful are salts of so-called wax acids or partial esters of wax acids and polyols, e.g. the ethanolamine salts or soaps of these acids or their partial esters. Useful stabilizers of the nonionic type are ethylene oxide derivatives (3–12 mols ethylene oxide) of C_8–C_{18} alkyl phenols, ethylene oxide condensates (1–5 mols ethylene oxide) of C_{10}–C_{24} fatty or rosin alcohols and ethylene oxide condensates (4–20 mols ethylene oxide) of partial esters of fatty acids and polyols. Likewise useful are ethoxylated fatty acids and amides, such as oleyl or stearyl amides condensed with about 3–8 mols of ethylene oxide, the latter being mildly cationic in character. Cationic stabilizers of merit are fatty amines (C_{12}–C_{36}) derived from oleic, palmitic and stearic acids and modified by condensation with about 2–12 mols of ethylene oxide. Other suitable agents are copolymers of C_{10}–C_{40} α olefines and vinyl alcohol having a molecular weight of 4000–50,000 water soluble polyacrylamide having a molecular weight of 35,000–50,000 and water soluble polyvinyl pyrollidone having a molecular weight of 35,000–50,000. The stabilizers are used at a total concentration 0.1–5.0 percent by weight and preferably 0.3–3.0 percent by weight.

The amount of high temperature stabilizer needed is based in part upon the operating condition. For chains operating at the lower end of the temperature range and where the length of time in the oven is minimum, less stabilizer need be used. This is also influenced in part by the method of application of the lubricant to the chain. It is essential that the lubricant reach the chain in the form of a uniform emulsion so that the oil phase will provide lubrication and the water droplets will provide the blasting effect desired. Some of the emulsifiers listed above show some mild stabilizing effect. Under the milder operating conditions these emulsifiers may also be used as the stabilizer. Under severe operating conditions, of course, this is impossible. In any event, even under mild conditions, when using the one material as both emulsifier and stabilizer, the material must be used in substantial amount. The maximum amount is suggested, such as 6–10 percent by weight.

The preferred emulsifiers are the oil-soluble sulfonates. The preferred materials for making oil-soluble sulfonates are those obtained by sulfonation of mineral lubricating oil fractions which may be prepared by any of the well known and accepted methods in this art. Calcium petroleum sulfonate may be used as the emulsifier and may be present in the blend in the amount of 0.1–5.0 percent by weight of the total blend but preferably about 0.3–3.0 percent by weight can be used to provide entirely satisfactory results. The calcium petroleum sulfonate, while primarily an emulsifying agent, supplies a certain amount of anti-corrosive action and anti-wear protection. It is preferable that the calcium petroleum sulfonate have a molecular weight of at least about 900. When the calcium petroleum sulfonate has a molecular weight of about 1000 the emulsification is excellent. Particularly useful calcium sulfonates are Calcium Petronate HMW or Basic Calcium Petronate HMW supplied by Sonneborn and Sons, Inc.

It is found that the emulsion will rapidly deteriorate, especially under the influence of heat, when the calcium petroleum sulfonate is used alone and hence the mixture of calcium petroleum sulfonate and oil alone as the oil phase of the lubricant for high temperature use is generally not satisfactory. As previously indicated, it is found necessary to add a stabilizer to the emulsion which will act to hold the emulsion together at elevated temperatures. Unusually stable emulsions are found to occur when naphthenic acid soaps of sodium, potassium, ammonium, lithium, calcium, barium or strontium are used as the stabilizing medium. The molecular weight of the naphthenic acid is found to be critical, naphthenic acids of molecular weight less than 275 being found to possess little or no stabilizing action. Particularly useful are naphthenic acids of about 275–1000 molecular weight. Outstandingly stable emulsions are obtained when using naphthenic acids identified as Sunaptic Acid "B" and Sunaptic Acid "C," using sodium, potassium or lithium as the soap forming ingredient. The "B" acid has a molecular weight of 325, whereas the "C" acid has a molecular weight of 415. The "C" acid is somewhat better than the "B" acid, although both provide excellent results. Naphthenic acid identified as Sunaptic Acid "A" having a molecular weight of 295, on the other hand, was found to provide fair but still usable stabilization of the emulsion. This lighter acid salt reached optimum stability at a lower concentration but this stability was inferior to the stability obtained with the heavier acid salt and was more critical than that obtained with the heavier acid salt. Salts of a naphthenic acid of molecular weight about 250, designated "D" however, were found to provide little or no benefit regardless of concentration, and regardless of whether the sodium, potassium, ammonium, lithium, calcium, strontium or barium salts were used. The preferred naphthenic acids are those having molecular weights of about 315–500. The concentration of the stabilizing agent in the finished blend may vary from about 0.1–5.0 percent by weight but preferably should be from about 0.3–3.0 percent by weight.

In order to insure adequate lubrication of the chain and related parts in the hot oven and yet obtain the full cleaning effect of the gasification of the water, the water content in the emulsion must be between about 15–70 percent of the water-in-oil emulsion. A preferred water content is about 30–50 percent by weight of the water-in-oil emulsion. The water content in the emulsion has a

blasting effect upon chain deposits, particularly when the chain is operated at the higher temperatures. As the emulsion hits the hot chain the water flashes to a gas, causing a rupture and flaking away of the carbonaceous deposits on the chain. This keeps the chain free and able to flex without strain. Since the water particles are surrounded by oil, however, the oil provides lubrication to the chain and its moving parts and protects the chain from detrimental contact with water at elevated temperature.

It is essential for proper lubrication of these hot oven chains to have dispersed in the emulsion lubricant a solid lubricant such as graphite or molybdenum disulfide or tungsten disulfide or boron nitride or mica or vermiculite or talcum which is dispersed in the oil phase and remains on the chain after the intense heat has altered or driven off the remainder of the lubricant. Of the solid lubricants mentioned, the preferred solid lubricants are graphite, molybdenum disulfide and tungsten disulfide, with the most preferred solid lubricant being graphite. The solid lubricant can be dispersed in an oil or distillate hydrocarbon in concentrated form for admixture with the emulsion or it can be distributed directly with the oil by well known procedures. The graphite or other solid lubricant may or may not be mixed with a satisfactory graphite dispersant, depending upon mixing procedure, type of emulsion selected viz concentrated or dilute, and the decision to use a graphite dispersant may also depend in part upon the conditions under which the water-in-oil emulsion will be used and the oven operating conditions. Skill in blending and using graphite containing water-in-oil emulsions can be rapidly acquired, bearing in mind that a deposit of the graphite must be laid down on the hot chain to insure adequate lubrication and the graphite dispersant must be compatible with the emulsifier system. The dispersed solid lubricant, such as graphite, should be added in the amount of broadly 0.05–5% and preferably 0.1–2% by weight of the final composition. The graphite may be supplied first as a 1 part in ten dispersion in light oil or naphtha. This dispersion can then be readily mixed with the remainder of the emulsion lubricant to provide the finished blend. The particle size of the solid lubricant should be broadly 0.25 to 50 microns but preferably 0.5 to 5 microns.

Example 1

A conventional prior art oven conveyor lubricant was used consisting of 37.9% by volume of a paraffin oil having a viscosity of 60 SUS at 100° F., 56.7% by volume of a naphthenic oil having a viscosity of 100–110 SUS at 100° F. and 5.2% by volume of a colloidal graphite dispersion containing 1 part of graphite in 9 parts of mineral spirits (particle size about 2 microns). This lubricant, when used on oven conveyor chains operating at temperatures over about 400° F., used in the manufacture of fiber glass, produced a very hard carbon formation on the chain which ultimately caused the links of the chain to freeze. Some of the links would then wear excessively so that flat spots occurred in the chain. Furthermore power consumption greatly increased after the hard carbon formation occurred making it necessary to remove the chains for cleaning and replacement of worn links. This is an extremely expensive proposition amounting to as much as $10,000 per year per chain.

Example 2

A fine stable water-in-oil emulsion lubricant for oven conveyor chains can be formed by mixing 1 percent by weight of oil-soluble calcium petroleum sulfonate as the basic emulsifier, 41.5 percent by weight of water, 0.8 percent by weight potassium naphthenate (using naphthenic acid of 325 M.W.) as the stabilizer, 0.5 percent by weight colloidal graphite and the balance paraffin oil having a viscosity of about 100 SUS at 100° F. The mixture is emulsified by a well known method and is then ready for

use. As a test of stability, a sample of this emulsion was placed in a tall 4 oz. oil sample bottle up to a level of 130 mm. and subjected to a seven day storage test at 170° F. The water separated was nil and the oil separated was about 7 mm. This lubricant, when applied to high temperature oven conveyor chains, does a superior lubricating job when compared to the prior art lubricant of Example 1.

Example 3

Another fine stable water-in-oil emulsion lubricant for oven conveyor chains was formed in the following manner:

Two-thirds of the total amount of oil to be used, i.e. 52.05% by weight, was charged to a steam heated kettle equipped with mechanical agitation. The oil used was a medicinal white oil having a viscosity of about 110 SUS at 100° F. To this oil were added 0.19% by weight of naphthenic acid (M.W. 295), 0.19% by weight of naphthenic acid (M.W. 415), and 0.10% by weight of hydrogenated marine oil fatty acids. The mixture was heated to 140° F. to 150° F. and 0.10% by weight of glacial acetic acid was added, followed by 0.39% by weight of caustic potash solution (45% by weight active material), the blend was stirred for an additional 15 minutes whereupon the temperature was raised to 190° F. At this point 2.37% by weight of basic calcium petroleum sulfonate (970–1000 M.W.; 40–45% active) was added and the temperature raised to 260° F. This temperature was maintained for 5–10 minutes and the batch quenched with the remaining one-third of the mineral oil. While adjusting the batch temperature to 175–185° F., 0.48% by weight of a mixture of octylated diphenyl amines was added. 39.83% by weight of water was heated in a separate kettle and added to the oil phase over a period of 15–30 minutes and vigorous agitation. After homogenizing to insure small particle size of the water droplets, the emulsion was cooled and 4.30% by weight of colloidal graphite dispersion (1 part graphite in 9 parts of mineral spirits) was added. The resultant preparation had excellent stability at temperatures of about 170–200° F.

Example 4

A portion of the lubricant of Example 3 was supplied to a commercial oven chain used in the curing of fiber glass. This oven measured approximately 85 feet in length, 10 feet in width, and 10 feet in height. The oven contained two conveyor flights—upper and lower—extending almost the full length of the oven. The lower flight was fixed but the upper flight was adjustable in height to provide a means of controlling the thickness of the mat. The sprockets were located within the oven and at each end of the oven. The sprockets measured about 3 ft. in diameter and were about 90 ft. apart, giving a total chain length of about 200 ft. Since four chains were located in this oven the total chain length measured about 800 ft. The oven conveyors were driven by an Oilgear hydraulic unit, the hydraulic pressure varying from 400–1200 p.s.i. (gauge) according to the load factors. Given a set operating condition, the only variable was the effectiveness of the lubrication or the carbon build-up on the chain. The 400 p.s.i. is roughly equivalent to 60 horsepower whereas the 1200 p.s.i. is roughly equivalent to 120 horsepower requirement. The oven was maintained at about 400–600° F. during the test operation.

The test lubricant was pumped intermittently and discharged under pressure onto the link of the chain in an amount to supply sufficient lubricant. Before the test lubricant was applied the chains had been lubricated with the oil of Example 1 and a heavy deposit of carbonaceous material mixed with fiber glass had built up on the chain. When the test lubricant was substituted the deposits on the chain commenced to decrease. The hydraulic pressure of the drive unit gradually reduced from over 1000 p.s.i., to about 700–800 p.s.i. at the same general operating conditions.

Example 5

In two other installations using a convention prior lubricant similar to the lubricant of Example 1, hydraulic pressure had built up gradually until it reached relief pressure over about 1100 p.s.i. (gauge), and the unit automatically shut down. Upon changing to the lubricant shown in Example 3, this pressure was reduced to about 500 p.s.i. (gauge) over a period of less than two weeks and subsequently decreased to 400 p.s.i. (gauge), indicating that horsepower requirements were reduced by almost fifty percent.

Example 6

A test of the lubricant of Example 1 without the graphite was made on the oven chains described in Example 3. The lubrication of the chain was found to be inferior and the chain commenced to squeal from inadequate lubrication. This test had to be discontinued to prevent damage to the equipment from lack of lubrication.

It had been estimated that the use of the water-in-oil lubricant of this invention will prolong the active life of these high temperature oven conveyor chains from about one year to about two years. Since the chains are expensive and down time is expensive, the economic advantage of using this lubricant is measured in many thousands of dollars in saving to the user.

Example 7

A suitable oven conveyor lubricant is obtained by mixing 0.5% by weight basic calcium salicylate, 0.5% by weight basic calcium petroleum sulfonate, about 35% by weight water, 0.5% by weight dibenzyl disulfide, 0.5% by weight glycerol mono-oleate, 0.5% by weight colloidal graphite and 62.5% by weight of a naphthenic petroleum oil having a viscosity of about 200 SUS at 100° F. The materials are mixed and emulsified by methods known in the art and a satisfactory stable emulsion is formed which remains stable at elevated temperatures.

Example 8

A suitable oven conveyor lubricant for high temperature operation is obtained by mixing 1.5 percent by weight lithium naphthenate (using a naphthenic acid having a molecular weight of 415), 0.5% by weight of calcium petroleum sulfonate (about 1000 molecular weight), 70% by weight of petroleum white oil, 5% by weight of colloidal graphite in naphtha (1/10 or 0.5 percent by weight graphite), and 33 percent by weight of water. The ingredients are emulsified by procedures well known in this art to yield a high stable water-in-oil emulsion lubricant suitable for high temperature duty and oven conveyor chains.

Example 9

An oil-in-water emulsion lubricant containing about 1 part oil and 3 parts water (using a conventional oil-in-water emulsifier system) was combined with about 0.5% by weight of the final formulation of colloidal graphite and tested on the commercial oven disclosed in Example 3. It was soon noted that the power requirement increased, indicating inadequate lubrication and the formation of hard carbon on the chains. The chains began to squeal noticeably. After several days operation the power requirement had increased to such an extent that the test was discontinued to prevent damage to the chains. Reuse of the lubricant of Example 2 stopped the squealing of the chain and brought the power requirement back to the level prevailing before this test was commenced.

Example 10

An oil-in-water emulsion lubricant containing about equal parts of oil and water (using a conventional oil-in-water emulsifier system) was combined with about 0.5% by weight of the final formulation of colloidal graphite and tested on the commercial oven disclosed in Example 3. The results were very similar to those disclosed in Example 9.

Example 11

A fine stable water-in-oil emulsion lubricant was formed by mixing 2.36% by weight of basic calcium petroleum sulfonate (970–1000 M.W.; 40–45% active), 0.95% by weight of naphthenic acid (M.W. 415), and 0.58% by weight of caustic potash solution (20% active) with approximately one-third of a total of 51.77% by weight of solvent refined paraffin (about 100 SUS at 100° F.). This mixture was heated to about 150° F. and the remaining two thirds of the base oil was added. Subsequently, 0.42% by weight of a mixture of octylated diphenyl amines and 4.72% by weight of colloidal graphite dispersion (one part graphite in nine parts mineral spirits) were blended into the mixture. Finally 39.20% by weight of water previously heated to about 150° F. was added with rapid agitation. A sample of the resulting fine particle emulsion was stored at 170° F. Examination after five days showed no water separation and only 2.5% of free oil. The same sample after eleven days still showed no separation of water and only 5.0% of supernatant oil. It will be appreciated that in water-in-oil emulsions separation of oil is a minor deficiency since it can easily be mixed with the remaining emulsion by mild agitation inasmuch as the oil constitutes the continuous or outer phase. Another sample of the above described oven conveyor lubricant was stored at a temperature close to the boiling point of water, i.e. at 200° F. This sample, which was stored under such severe conditions, was examined at similar time intervals (5 days; 11 days) and after five days still exhibited no free water and only 3% of free oil; after a total of eleven days of exposure water separation amount to about 1.5% and oil separation to about 8%. The outstanding heat stability of this material makes it of particular utility for use as a high-temperature, oven-conveyor lubricant.

Example 12

A fine stable high-temperature oven-conveyor lubricant is formed by mixing 1.8% by weight of sorbitan mono-oleate, 1.2% by weight of polyoxyethylene sorbitan tri-oleate (20 mols of ethylene oxide), 52.0% by weight of solvent refined naphthenic petroleum oil of a viscosity of 100 SUS at 100° F., 3–4 p.p.m. of a defoamant (Dow Corning Fluid 200–12,500 centipoises) and 5% by weight of colloidal graphite (one part graphite to nine parts mineral spirits). This lubricant was stored for 40 hours at 170° F. and showed no water separation and only 2% oil separation. This lubricant is an excellent lubricant for hot oven conveyor chains (operating at 400–800° F.).

Example 13

Another fine stable high-temperature oven-conveyor lubricant was formed by mixing 2.5% by weight of sorbitan mono-oleate, 0.5% by weight of the condensation product of oleyl amide and 5 mols of ethylene oxide, 47% by weight of a solvent-refined naphthenic petroleum oil having a viscosity of 100 SUS at 100° F., 0.1% by weight of a defoamant (Dow Corning 200 Fluid, 1000 centipoises, 10% solution in kerosine), 49% by weight of water and 1% by weight of molybdenum disulfide (96% of total number of particles below 2 microns in size). This lubricant was stored at 170° F. for 24 hours and showed no water separation and only 3% oil separation. This formulation is an excellent conveyor chain lubricant for chains operating at temperatures in the range of 400–800° F.

The test program conducted has demonstrated that oven conveyor chains operating at temperatures over 300° F. and more particularly at temperatures of 400–800° F. require for maximum performance a water-in-oil emulsion in which a stabilizer is used with the base emulsifier to provide a stable emulsion at temperatures as high as

170° F.–200° F. This program has shown that a solid lubricant, such as colloidal graphite, molybdenum disulfide, tungsten disulfide, boron nitride, or the like, must be dispersed in the emulsion to provide adequate lubrication of the chains. The lubricant, for most efficient lubrication, should be provided either intermittently, or continuously to the chain without a long dwell period in the oven.

The examples given hereinabove were presented only to illustrate the invention and are not intended to limit the scope of the invention. The only limitations are contained in the following claims.

We claim:

1. A lubricant for use at elevated temperatures on oven conveyor chains and the like in the form of a water-in-oil emulsion which comprises about 0.1–5 percent by weight, sufficient to emulsify the water and oil, of an oleophilic anionic emulsifier possessing an HLB number of about 2–6, about 0.1–5 percent by weight of a high-temperature ionic stabilizer for said emulsion possessing an HLB number of about 8–16, the combined emulsifier and stabilizer having an HLB number of about 2–8, the oil portion of said emulsion being a hydrocarbon oil possessing a Conradson carbon residue less than about 0.25% and of from about 50–1000 SUS viscosity at 100° F. in the amount of about 85–30 percent by weight, the water content of said emulsion being about 15–70 percent by weight, and about .05–5 percent by weight of a solid lubricant in finely divided form having a particle size from about 0.25 to 25 microns said lubricant being dispersed in the water-in-oil emulsion and normally adapted to become deposited on the said oven conveyor chains at elevated temperatures.

2. A lubricant for use at elevated temperatures on oven conveyor chains and the like in the form of a water-in-oil emulsion which compries about 0.3–3 percent by weight, sufficient to emulsify the water and oil, of an anionic emulsifier possessing an HLB number of about 2–6, about 0.3–3 percent by weight of a high-temperature anionic stabilizer for said emulsion possessing an HLB number of about 8–16, the combined emulsifier and stabilizer having an HLB number of about 3–7, the oil portion of said emulsion being a hydrocarbon oil possessing a Conradson carbon residue less than about 0.25% and of from about 80–150 SUS viscosity at 100° F. in the amount of about 70–50 percent by weight, the water content of said emulsion being about 30–50 percent by weight, and about 0.1–2 percent by weight of a solid lubricant in finely divided form having a particle size from about 0.25 to 25 microns said lubricant selected from the group consisting of graphite, molybdenum disulfide, boron nitride, mica, vermiculite, talcum and tungsten disulfide.

3. A lubricant for use at elevated temperatures on oven conveyor chains and the like in the form of a water-in-oil emulsion which comprises about 0.1–5 percent by weight, sufficient to emulsify the water and oil, of an emulsifier possessing an HLB number of about 2–6 and selected from the group consisting of oleophilic alkaline earth petroleum sulfonates, oleophilic alkaline earth naphthalene sulfonates and oleophilic alkaline earth C_3–C_{18} alkyl phenates, about 0.1–5 percent by weight of a high-temperature stabilizer for said emulsion possessing an HLB number of about 8–16 and selected from the group consisting of metal soaps of naphthenic acids having molecular weights of about 315–500 formed from the metals sodium, potassium, ammonium, lithium, calcium, strontium and barium, calcium C_8–C_{30} alkyl salicylate, C_4–C_{18} alkyl phenol, copolymers of C_{10}–C_{40} α-olefines and vinyl alcohol having a molecular weight of 4000–50,000, water-soluble polyacrylamide having a molecular weight of 35,000–50,000, water-soluble polyvinyl pyrrolidone having a molecular weight of 35,000–50,000, oil-soluble partial esters of polyhydric alcohol and C_8–C_{32} fatty acid, soaps of C_{16}–C_{30} fatty acids formed from the metals potassium, sodium, ammonium, lithium, calcium, strontium and barium in the amount of about 85–30 percent by weight, the water content of said emulsion being about 15–70 percent by weight, and about .05–5 percent by weight of a solid lubricant in finely divided form having a particle size about from 0.25 to about 25 microns said lubricant being dispersed in the water-in-oil emulsion and normally adapted to become deposited on the said oven conveyor chains at elevated temperatures.

4. The composition of claim **3** further characterized in that the solid lubricant is selected from the group consisting of graphite, molybdenum disulfide, boron nitride, mica, vermiculite, talcum and tungsten disulfide.

5. A lubricant for use at elevated temperatures on oven conveyor chains and the like in the form of a water-in-oil emulsion which comprises about 0.1–5 percent by weight, sufficient to emulsify the water and oil, of an emulsifier possessing an HLB number of about 2–6 and selected from the group consisting of potassium, sodium, ammonium, calcium, strontium, barium, lithium salts of acid phosphates, said phosphates having been partially neutralized by esterification with C_8–C_{24} alkyl phenols and ethylene oxide derivatives containing 2–12 mols ethylene oxide of said phenols, about 0.1–5 percent by weight of a stabilizer for said emulsion possessing an HLB number from about 8–16 and selected from the group consisting of ethylene oxide condensates containing 1–5 mols of ethylene oxide of C_{10}–C_{24} fatty and rosin alcohols, in the amount of about 85–30 percent by weight, the water content of said emulsion being about 15–70 percent by weight and about .05–5 percent by weight of a solid lubricant in finely divided form having a particle size from about 0.25 to about 25 microns said lubricant being dispersed in the water-in-oil emulsion and normally adapted to become deposited on the said oven conveyor chains at elevated temperatures.

6. The composition of claim **5** further characterized in that the solid lubricant is selected from the group consisting of graphite, molybdenum disulfide, boron nitride, mica, vermiculite, talcum and tungsten disulfide.

7. A lubricant for use at elevated temperatures on oven conveyor chains and the like which comprises a water-in-oil emulsion containing about 25–45 percent by weight water, about 0.25–2.00 percent by weight of oil-soluble calcium petroleum sulfonate as an emulsifying agent, about 0.25–3.0 percent by weight of metal soaps of naphthenic acids having molecular weights of about 315–500 as a stabilizer, the metal being selected from the group consisting of sodium, potassium, ammonium, lithium, calcium, strontium, and barium, the oil portion of said emulsion being a hydrocarbon oil possessing a Conradson carbon residue of less than about 0.25% of from about 50–400 SUS viscosity at 100° F., the ratio between the oil-soluble calcium petroleum sulfonate and the metal naphthenate being from 5/95 to 95/5 by weight, and about 0.5 percent by weight of colloidal graphite.

8. The composition of claim **7** further characterized in that the metal salt is potassium naphthenate.

9. The composition of claim **7** further characterized in that the oil is a white oil.

10. A lubricant for use at elevated temperatures on oven conveyor chains and the like which comprises a water-in-oil emulsion containing about 25–45 percent by weight water, about 0.1–5.0 percent by weight of sorbitan mono-oleate, about 0.1–5.0 percent by weight of a partial ester of a polyhydric alcohol and a C_{10}–C_{24} fatty acid, said ester being condensed with about 4–20 mols of ethylene oxide, 0.5 percent by weight of a solid lubricant selected from the group consisting of graphite, molybdenum disulfide and tungsten disulfide having a particle size from about 0.25 to 50 microns, the balance being a petroleum hydrocarbon oil having a viscosity of about 100 SUS at 100° F. and a Conradson carbon residue less than about 0.05 percent.

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DANIEL E. WYMAN, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,213,024 October 19, 1965

Gilbert Duane Blake et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 34, for "disulfite" read -- disulfide --; column 6, line 35, for "and" read -- with --; line 45, for "85" read -- 95 --; column 7, line 20, for "had" read -- has --; column 8, line 35, for "amount" read -- amounted --.

Signed and sealed this 14th day of June 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents