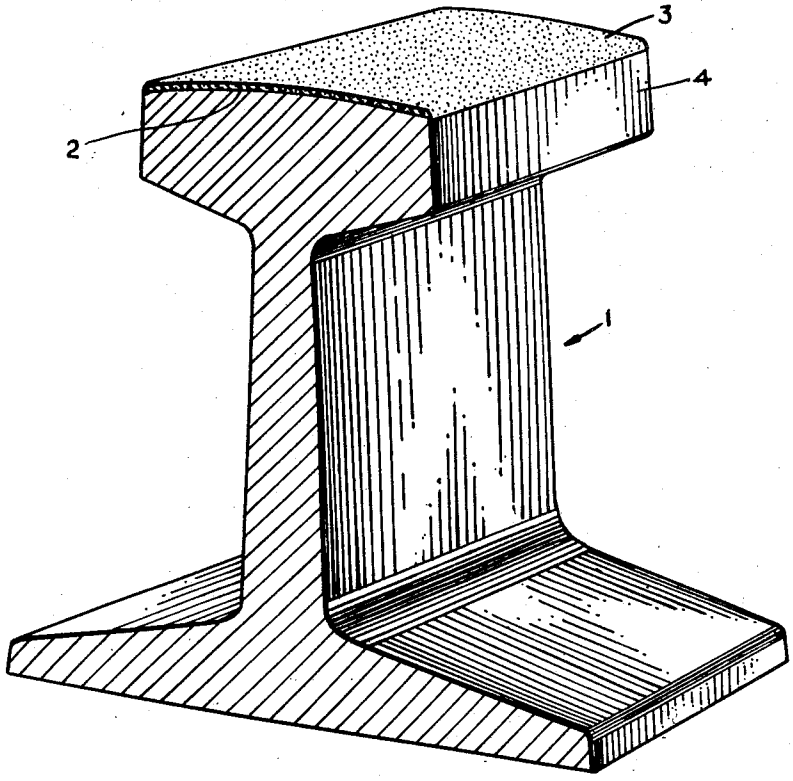
April 9, 1957 T. C. NOHEJL 2,787,967

METHOD OF IMPROVING THE COEFFICIENT OF FRICTION BETWEEN CONTACTING METAL SURFACES AND ARTICLE PRODUCED THEREBY

Filed May 6, 1955



THOMAS C. NOHEJL
INVENTOR.

BY Wigall, Johnston, Cook & Rust

ATT'YS

United States Patent Office 2,787,967 Patented Apr. 9, 1957

2,787,967

METHOD OF IMPROVING THE COEFFICIENT OF FRICTION BETWEEN CONTACTING METAL SURFACES AND ARTICLE PRODUCED THEREBY

Thomas C. Nohejl, Downers Grove, Ill., assignor to National Aluminate Corporation, Chicago, Ill., a corporation of Delaware

Application May 6, 1955, Serial No. 506,487

15 Claims. (Cl. 104—1)

This invention relates to a new and improved adherence treatment for metal surfaces and more particularly to a method and a composition for increasing the coefficient of friction between the contacting surface of a metal wheel and a metal surface on which it operates. The invention is especially concerned with the provision of chemical means for preventing the wheel slippage between locomotive wheels and rails.

The past several decades have produced railway locomotives possessing great power and weight, thus enabling long, heavily-laden trains to be pulled by single engines. With the advent of the extremely heavy locomotive it was felt that driving wheel slip would be eliminated. It was soon discovered, however, that the increased static weight carried on the driving wheels did not solve the problem to any great extent. Track sanding techniques were developed but this only partially alleviated the condition. Wheel slippage has proven to be an erratic condition which has not in all cases been satisfactorily explained.

In one explanation of the problem rail slip is said to result from a tough invisible oil film on the wear band of the rail. Traffic and heat destroy this film and high adhesion results. When a light rain occurs or when the rails reach the dew point, as the result of the relatively high humidity, a water vapor film forms across the wear band where it may contact oil deposits on the edge of a rail with the result that a film of oil creeps through and replaces the water film. The oil deposits on the rail sides act as reservoirs for the formation of new oil films and water acts as the transporting agent. The oil deposits on the rail come from journal box oil leakage by way of the outside face and outer portion of the tread of the car wheels. There are other sources of contamination such as road crossings, rail lubricators and the like.

The importance of solving the problem is strikingly illustrated when it is realized that only 15% of the engine's weight can be utilized as tractive force when the rails are greasy and moist, and 30% when the rails are clean, dry and sanded. Even a small improvement in these figures, as expressed in the terms of increased coefficient of friction, would enable railway locomotives to operate more efficiently and economically as well as providing improved braking for railway locomotives and rolling stock.

It is therefore an object of this invention to provide a method for raising the coefficient of friction between railway car wheels and rails.

Another object is to raise the coefficient of friction between railway car wheels and rails having an oil film thereon.

A further object is to provide a method of decreasing slippage between railway wheels and rails.

Another object is to provide a chemical treatment to prevent locomotive slippage on dry, wet, or oily rails.

Still a further object is to enable railroad locomotives to utilize more of their tractive forces on wet oily rails than has heretofore been considered possible.

An additional object of the invention is to produce a railway rail containing an adherent coating of a material which substantially prevents slippage between the rail and a locomotive or railway car wheel.

Still a further object of the invention is to provide a rail treating adherence producing composition which is relatively easy to prepare and to apply.

Still another object of the invention is to provide a new and improved method for treating the contacting surfaces of railway car wheels and/or tracks in order to increase the coefficient of friction therebetween. Other objects will appear hereinafter.

In accordance with the invention it has been found that the coefficient of friction between a metal surface and another surface in contact therewith can be increased by applying to at least one of the contacting surfaces a suspension of a fine silica in a non-lubricating hydrophilic liquid in an amount sufficient to produce a paste-like product. Only a thin film of the paste-like product applied to a rail or other metal surface is required in order to increase the coefficient of friction between contacting surfaces.

In the drawing a single figure shows a section of a railway rail containing a thin coating of a composition of the invention applied to the bearing surface thereof.

As shown in the drawing, the rail 1 has a bearing surface 2 to which the coating 3 of the anti-slip composition is applied. The coating of the anti-slip composition may also extend over the surface 4 which comes into contact with the wheel flange of the wheels of locomotives and railway cars.

In its practical application, the invention is particularly important where exceptionally high pressures are developed at the contacting surfaces, as is the case, for example, between the steel surfaces of railway car wheels and the tracks upon which railway vehicles operate. In the preferred practice of the invention good results have been obtained by applying to at least one of said contacting surfaces a thin film of a composition consisting essentially of a pasty suspension of at least 2% by weight, preferably 5% to 50% by weight, of a finely divided silica having a surface area of at least 25 square meters per gram in a non-lubricating hydrophilic liquid.

The finely divided silica employed for the purpose of the invention can be any finely divided silica which is capable of forming a homogeneous pasty suspension with a non-lubricating hydrophilic liquid. A silica having a surface area of at least 25 square meters per gram usually has an ultimate particle diameter not greater than about 100 millimicrons. In general, the diameter of the silica particles will be within the range from about 1 to about 100 millimicrons. While the specific surface area of the silica particles is preferably at least 25 square meters per gram, it usually will not exceed 1000 square meters per gram, and a preferred range of specific surface areas is from about 25 $m.^2/g.$ to about 400 $m.^2/g.$

A number of different types of silicas can be prepared by well known methods and many of these are available commercially. The following examples are given to illustrate various types of silicas which can be employed for the purpose of the invention:

1. A silica in the form of very small discrete particles having a gel structure within the particles prepared by reacting sodium silicate and an acid at a pH below 3.0 to give a silica sol, polymerizing the silicic acid in the sol sufficiently to make the sol viscous, mixing an organic hydrogen donor bonding agent, such as tertiary butyl alcohol, with the sol, dissolving salt in the mixture whereby a phase separation occurs giving a hydrogen bonder phase containing the silicic acid and an aqueous brine phase, polymerizing the silicic acid further in the

bonder phase until hydrated silica is precipitated in the form of discrete particles, separating the precipitated silica from the mother liquor and washing free of salt.

2. A hydrated amorphous silica powder consisting of super colloidal aggregates of ultimate units of from 10 to 50 millimicrons in diameter described in Chemical Engineering 54, 177 (1947) having a specific surface area of about 240 square meters per gram and a bulk density of about 0.064 gram per cc. at 3 pounds per square inch gauge.

3. An amorphous silica aerogel having a specific surface area of about 160 $m.^2/g.$, as determined by nitrogen adsorption, and a bulk density of about 0.087 gram per cc. at 3 pounds per square inch gauge (Santocel C).

4. An amorphous silica powder consisting of super colloidal aggregates of ultimate units having an average diameter of about 25 millimicrons, a surface area of about 100 $m.^2/g.$, and containing a small amount of calcium (1% to 2% by weight), known as "Hi-Sil."

5. An amorphous silica powder consisting of super colloidal aggregates having a surface area of about 200 $m.^2/g.$, sold under the name "K–3."

6. A silicate treated with heavy metal salts or hydrous heavy metal oxides to form heavy metal silicates which are water insoluble and usually amorphous as determined by X-ray determination, as, for example, a precipitated hydrated calcium silicate having a molar ratio of SiO_2CaO equal to about 3.25, containing aggregates of ultimate particles of the order of 30 to 50 millimicrons in diameter, described in Chemical and Engineering News 24, 3147 (1946) and marketed as "Silene EF." This product is a calcium silicate having the following analysis:

CaO	19.0% by weight.
SiO_2	67.0% by weight.
Loss on ignition	14.0% by weight.
pH in water suspension	10.1.
Specific gravity	2.10.
Bulk density	15–16 pounds per cubic foot.
Refractive index	1.475.

The metal ion in the aforementioned silicas can be an ion other than calcium, as, for example, barium, strontium, magnesium, zinc, cadmium, lead, tin, iron, cobalt and nickel.

7. Colloidal silicas obtained by hydrolysis of silicon tetrachloride.

8. Estersils obtained by the esterification of an amorphous or crystalline silica as described in Iler, U. S. 2,657,149. The estersils employed for the purpose of the invention are preferably obtained by esterifying any of the silicas described under (1) to (7), inclusive, so as to produce a super colloidal substrate coated with —OR groups, the subtrate having a surface of silica and having a specific surface area of from 25 to 900 square meters per gram, there being at least 100 —OR groups per 100 square millimicrons of substrate surface area, and R being a hydrocarbon radical of from 2 to 18 carbon atoms wherein the carbon attached to oxygen is also attached to hydrogen. For the purpose of the present invention, the estersils employed are hydrophilic and can be both hydrophilic and organophilic.

The invention is not limited to the employment of any particular hydrophilic liquid as the suspending medium for the fine silica provided that it is non-lubricating or at least not lubricating to the extent that the lubricating effect cannot be more than counteracted by the presence of the silica. The preferred hydrophilic liquids are water and hydrophilic aliphatic alcohols, including, for example, lower aliphatic monohydric alcohols such as methanol, ethanol, propanol, isopropanol, butanol and isobutanol, or mixtures thereof; water soluble ether alcohols, such as, for example, the methylether of diethylene glycol or the ethylether of diethylene glycol; and hydrophilic polyhydric alcohols such as, for example, ethylene glycol, diethylene glycol, 1,2-propylene glycol or butylene glycol.

The following tables gives specific examples of silicas which can be employed in the practice of the invention for the preparation of antislip compositions suitable for the purpose of the invention.

TABLE

		Surface Area, $m.^2/g.$	Particle Size, Diameter	Ultimate Particle Size in Millimicrons
Silene EF	A	80	0.030 micron	30.
HiSil 101	B	110	0.030 micron	30.
HiSil X-303	C	160	0.022 micron	22.
HiSil 233	D	150	0.022 micron	22.
Silene JA	E	40	0.07 micron	22.
Dow Corning	F	150–200	10–20 millimicrons.	10–20.
Estersil GT	G	285–335	8–10 millimicrons.	8–10.
DuPont Fine Silica	H	275–325	8–10 millimicrons.	8–10.
Santocel C	I	110–150	3–5 microns	20—approx.
Cab-o-sil	J	175–200	0.015–0.020 micron.	15–20.
Syloid 244	K	292	1.1–7.0 microns	
Santocel 54	L			20—approx.

In the foregoing table silica A is a calcium silicate containing about 19% CaO and 67% SiO_2. Silicas B, C, D, E and F are precipitated silicas. Silicas G and H are incompletely surface esterified silicas of the type described in U. S. 2,657,149. Silica K is a silica derived from a silica gel. Silicas I and L are fine silica aerogels. Silica J is a commercial silica prepared by the hydrolysis of silicon tetrachloride.

Evaluation of the invention

In order to evaluate the various compositions as agents for improving the coefficient of friction between railway car wheels and rails, the following test apparatus was employed. A slotted wooden holder comprising two strips of wood was mounted on a bench. The holder was so constructed as to contain a piece of steel four inches long, one inch wide and one-quarter inch thick, herein referred to as a rail. The steel rail was heat treated and had a tensile strength of 164,200 pounds per square inch, yield point of 159,200 pounds per square inch, a per cent elongation of 17.3%, and decarburization to a depth of 0.008 inch. An analysis of this steel showed it to contain the following:

	Percent by weight
Carbon	.31
Manganese	.58
Phosphorus	.016
Sulfur	.016
Silicon	.29
Chromium	1.000
Molybdenum	.222

A U-shaped member made of heavy strap steel was formed having two perpendicular pieces attached to the tips of the U. A 9/32" diameter hole was bored in the center of the base of the U. A 1⅛" diameter steel ball having a Brinell hardness of 500 was welded to a threaded steel rod. The threaded steel rod was placed in the hole formed in the U-shaped steel member and fastened with a nut so that the steel ball was within the cradle of the U. The perpendicular arms were fitted with small steel boxes capable of holding lead shot or other weighted material. The U-shaped member was placed on the rail so the steel ball rested on the surface. On either side of the inverted U, wires were attached at a point slightly above the rail surface. Next to the other ends of the wire was a short piece of string attached over a fixed pulley, the top of which was approximately

coplanar with the surface of the rail. At the opposite end of the string was a suspended container which could be filled with weights.

In operation, the boxes were filled with lead shot in an amount which, when included with the weight of the cradle and fixtures, were calculated to exert a pressure at point of contact on the rail of 73,900 pounds per square inch. The weight of the U-shaped member and ball was 3,065 grams, which, for the purposes of the experiment may be considered as the operative downward pressure. The suspended container was filled gradually with lead shot until the steel ball just started to slide. This amount of weight is considered as the force necessary to overcome the friction existing between the ball and the rail. By using these two factors, the coefficient of friction may readily be evolved from the following simple equation:

$$\text{Coefficient of friction} = \frac{F}{P}$$

where P equals 3,065 grams and F equals the weight necessary to move the 3,065 grams.

At the start of each series of tests the rail was cleaned with scouring powder, rinsed with distilled water and dried with cellulose tissues. Periodic inspections were made at the contacting surface and when scratches occurred, the ball and rail were polished with emery paper to renew the surface finish.

To simplify the experimental results the forces necessary to overcome the friction of the steel ball and the rail were recorded in grams. The tests were run by simply smearing a light coating of the composition to be tested over the rail and running the tests while the material was still wet unless otherwise indicated.

In order to establish a working basis for comparing the test results obtained, series of tests were run wherein both the rail and the steel ball were perfectly clean. The average of ten such tests showed a force of 1835 grams necessary to move the ball. When a visible film of journal box oil was applied to the rail the average was 620 grams. All of the tests hereinafter described were conducted with a film of journal box oil at all times initially apparent on the surface of the rail. Hence, readings in excess of 620 indicated compositions of enhanced anti-slip properties. The following examples illustrate the results obtained and indicate the utility of the invention.

EXAMPLE I

20% by weight of silica A was slurried into 80% by weight of water and spread on the rail. The average force required to move the ball over the rail in three runs was 2083 grams.

EXAMPLE II

The following composition was prepared:

16.4 grams water
4.4 grams magnesium chloride
5.0 grams silica A

A thin coating of the above composition on the rail in two passes gave an average reading of 1915 grams. This reading was taken before the composition had dried. After drying the average reading on four successive passes was 2125 grams.

EXAMPLE III

The following compositions were tested in accordance with the above described test procedures and all proved to be good anti-slip agents:

Composition A:
30 cc. of 50% by volume water-isopropanol solution
10 grams silica A

Composition B:
60 cc. of 50% by volume water-isopropanol solution
20 grams silica A

Composition C:
15 cc. of a 22% by weight aqueous magnesium chloride solution
4 grams silica A

Composition D:
15 cc. of a 50% by volume water-ethylene glycol solution
4 grams silica A.

EXAMPLE IV

Two grams of silica J were slurried into 20 cc. of a 50% by volume water-isopropanol solution. The force required to move the ball over the surface treated with this composition in three passes was 1334 grams.

EXAMPLE V

The following composition was prepared and passed through a homogenizer to produce a creamy-like paste:

200 grams silica B
375 cc. isopropanol
375 cc. water

The above product gave excellent results when used in the test apparatus.

The compositions illustrated in the examples are only a few of the compositions that can be prepared for the practice of the invention and are intended to illustrate the best modes of practicing the invention. Any of the fine silicas listed in the table can be mixed with any of the hydrophilic liquids previously described in order to prepare compositions suitable for the practice of the invention.

While the preferred amount of silica is at least 5% by weight of the suspension, as little as ½% by weight of fine silica in a hydrophilic liquid, such as water, has been used with fairly good results by allowing the material to dry. The use of such small amounts, however, is generally impractical, particularly where the anti-slip composition has to be transported or stored. Furthermore, the diluted suspensions tend to settle and before use they must be agitated and applied immediately and agitation equipment is not always available in the field. In the more concentrated silica ranges a paste-like product is formed and there is no necessity for such agitation or reslurrying.

The quantity of the anti-slip composition of the present invention required to increase the coefficient of friction between railway car wheels and tracks is subject to some variation but will usually be within the range of 1 to 5 gallons on the track surface per one mile of two-rail track.

The invention is not limited to any particular method or apparatus for applying the anti-slip composition to the surface to be treated. The composition can be applied on operating railway locomotives merely by providing a swabbing or similar type applicating mechanism to apply the material either to the surfaces of the rail or to the wear band of the wheels of the locomotive.

While the invention is primarily designed to be applied to the contacting surfaces of diesel locomotive wheels and the rails upon which they run, it also has equal effectiveness when it is applied to the wheels of other railway car vehicles such as boxcars, passenger cars, and the like. The invention has also equal application in the application to the contacting surfaces of the wheels and rails of such forms of transportation as street-cars and cars used in the operation of various types of mines.

The invention is hereby claimed as follows:

1. The method of improving the coefficient of friction between contacting metal surfaces capable of moving one with respect to the other which comprises applying to at least one of the contacting surfaces a thin coating of a suspension of fine silica in a non-lubricating hydrophilic liquid, said silica having a specific surface area of at least 25 square meters per gram, and bringing said

surfaces into contact with one another with said fine silica therebetween.

2. The method of improving the coefficient of friction between contacting metal surfaces capable of moving one with respect to the other which comprises applying to at least one of the contacting surfaces a thin coating of a suspension of fine silica in a non-lubricating hydrophilic liquid, said silica having a specific surface area of at least 25 square meters per gram, and the concentration of said silica in said liquid being within the range of 2% to 50% by weight, and bringing said surfaces into contact with one another with said fine silica therebetween.

3. The method of improving the coefficient of friction between contacting metal surfaces capable of moving one with respect to the other which comprises applying to at least one of the contacting surfaces a thin coating of a suspension of fine silica in a non-lubricating hydrophilic liquid, said silica having a specific surface area of from 25 to 400 square meters per gram, and bringing said surfaces into contact with one another with said fine silica therebetween.

4. The method of improving the coefficient of friction between contacting metal surfaces capable of moving one with respect to the other which comprises applying to at least one of the contacting surfaces a thin coating of a suspension of fine silica in water, said silica having a specific surface area of at least 25 square meters per gram, and bringing said surfaces into contact with one another with said fine silica therebetween.

5. The method of improving the coefficient of friction between contacting metal surfaces capable of moving one with respect to the other which comprises applying to at least one of the contacting surfaces a thin coating of a suspension of fine silica in a non-lubricating hydrophilic liquid containing a water soluble lower aliphatic alcohol, said silica having a specific surface area of at least 25 square meters per gram, and bringing said surfaces into contact with one another with said fine silica therebetween.

6. The metod of improving the coefficient of friction between railway car wheels and tracks which comprises applying to at least one of the contacting surfaces thereof a coating of a pasty suspension of at least 5% by weight of a hydrophilic finely divided silica having a specific surface area of at least 25 square meters per gram and ultimate particle size of from 1 to 100 millimicrons in a non-lubricating hydrophilic liquid.

7. The method of improving the coefficient of friction between railway car wheels and tracks which comprises applying to at least one of the contacting surfaces thereof a coating of a pasty suspension of at least 5% by weight of a hydrophilic finely divided silica having a specific surface area of at least 25 square meters per gram and ultimate particle size of from 1 to 100 millimicrons in a non-lubricating hydrophilic liquid, said pasty suspension containing from 2 to 50% by weight of water and from 20% to 50% by volume of isopropanol.

8. The method of improving the coefficient of friction between railway car wheels and tracks which comprises

applying to at least one of the contacting surfaces thereof a coating of a pasty suspension of at least 5% by weight of an amorphous finely divided silica having a specific surface area of about 80 square meters per gram and an ultimate particle size of about 30 millimicrons in a non-lubricating hydrophilic liquid.

9. The method of improving the coefficient of friction between railway car wheels and tracks which comprises applying to at least one of the contacting surfaces thereof a coating of a pasty suspension of at least 5% by weight of an amorphous finely divided silica having a specific surface area of about 110 square meters per gram and an ultimate particle size of about 30 millimicrons in a non-lubricating hydrophilic liquid.

10. A railway rail having its wheel bearing surface coated with a coating of a finely divided hydrophilic silica having a specific surface area of at least 25 square meters per gram dispersed in a non-lubricating hydrophilic liquid.

11. A railway rail having its wheel bearing surface coated with a coating of a finely divided hydrophilic silica having a specific surface area of at least 25 square meters per gram dispersed in a non-lubricaitng hydrophilic liquid, said hydrophilic liquid comprising a lower aliphatic alcohol.

12. A railway rail having its wheel bearing surface coated with a pasty suspension of at least 5% by weight of a hydrophilic finely divided silica having a specific surface area of at least 25 square meters per gram and ultimate particle size of from 1 to 100 millimicrons in a non-lubricating hydrophilic liquid, said pasty suspension containing from 2% to 50% by weight of water and from 20% to 50% by volume of isopropanol.

13. A railway rail having its wheel bearing surface coated with a pasty suspension of at least 5% by weight of an amorphous finely divided silica having a specific surface area of about 80 square meters per gram and an ultimate particle size of about 30 millimicrons in a non-lubricating hydrophilic liquid.

14. A railway rail having its wheel bearing surface coated with a coating of a pasty suspension of at least 5% by weight of an amorphous finely divided silica having a specific surface area of about 110 square meters per gram and an ultimate particle size of about 30 millimicrons in a non-lubricating hydrophilic liquid.

15. A structure having two metal surfaces capable of motion one with respect to the other and adapted to engage each other by frictional contact, at least one of said surfaces being coated with a thin coating of a fine silica having a specific surface area of at least 25 square meters per gram dispersed in a non-lubricating hydrophilic liquid.

References Cited in the file of this patent

UNITED STATES PATENTS

1,666,167	Connolly	Apr. 17, 1928
2,408,656	Kirk	Oct. 1, 1946
2,643,048	Wilson	June 23, 1953
2,657,149	Iler	Oct. 27, 1953
2,693,427	Kingsford	Nov. 2, 1954