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(54) **A STEEL WIRE ROPE FOR USE IN A DRIVE SYSTEM**

STAHLDRAHTSEIL ZUR VERWENDUNG IN EINEM ANTRIEBSSYSTEM

CABLE EN FILS D'ACIER POUR UTILISATION DANS UN SYSTEME D'ENTRAINEMENT

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Description

Field of the invention.

[0001] The invention relates to the field of steel wire ropes more in particular to steel wire ropes that have to withstand corrosive circumstances during operation. Such steel wire ropes can be found in many drive systems such as a window elevator in a car door, or a drive system for a sliding door, or a canvas roof drive, or a garage door opener drive system, or a hoisting rope to name just a few. The invention offers a more corrosion resistant kind of rope while maintaining good fatigue properties and improved friction properties.

Background of the invention.

[0002] Steel wire ropes are in many cases the preferred means to convey force and displacement (i.e. work) over a distance between meters and kilometres at a low cost. The ropes can be made very flexible - so that the rope can accommodate small bending pulleys - by using fine wire diameters. When assembled out of cold formed, hard drawn steel wires the strength of the rope can be increased thus enabling the transmittal of higher forces. In addition the modulus of elasticity is close to that of steel and the elongation of the cord can be minimised thus eliminating slack out of the drive system. The ropes can be designed to withstand the repeated bending, torsion or stretch movements that occur in such drive systems. Indeed, steel wire ropes are reliable because the fatigue limit can be accurately predicted by means of tests that simulate the real live usage of the ropes. Finally, the steel wire ropes show a favourable friction coefficient with respect to wear pieces, a property that in many cases allows the replacement of bending pulleys with fixed rope guides with considerable cost savings in the drive system as a consequence.

[0003] Unfortunately most steels tend to rust when subjected to conditions that enhance corrosion (such as outdoor usage, but also in the inside of an elevator shaft, or the inside of an automobile door). Corrosion is in that respect detrimental that it can reduce the predicted fatigue level dramatically leading to premature, fatal fractures. Such a mechanism is known in the field as 'corrosion fatigue' i.e. the fatigue phenomena that occur when dynamic loading of the cord is performed in a corrosive environment. A few standard solutions are known to the skilled person to reduce this corrosion:

- one could use stainless steels that are less prone to corrosion (such as AISI 306, AISI 314). Unfortunately, such steels often only perform well in static corrosive applications, i.e. when no dynamics is involved. When ropes are repeatedly bent over pulleys, the oxide skin that forms on the stainless steel is continually abraded away leading to excessive fretting of the filaments and inferior fatigue life.
- perhaps the oldest solution is to use wires that are individually coated with a protective coating. In order not to adversely influence the other properties of the wire rope, such a coating is by preference metallic. Most preferred in this respect are zinc or zinc alloy coatings that are applied through a hot dipping process onto the steel wire. Intermediate alloy layers are formed in the hot dipping ensuring a good adhesion of the coating to the steel wire. Such coatings provide a sacrificial corrosion protection to the steel.
- encapsulation of the cord in a polymer is also a known technique. Such an encapsulation must withstand the dynamics of the drive system to prevent that the corrosive atmosphere reaches the steel surface. WO 03/044267 describes such a rope. The solution provides excellent corrosion protection in combination with excellent fatigue properties, but is somewhat stiffer, has not so good friction properties and is more expensive.
- the application of corrosion inhibitive oils, greases, slurries or gels. Such gels must enable a number of properties into the steel wire rope and are in many cases a compromise between different properties (cost, environmental, fatigue performance etc...). An example can be found in US 6106741.

[0004] The current state of the art for drive system ropes is therefore dominated by zinc or zinc alloy coated wire ropes that are immersed with a lubricant. The thickness of the zinc or zinc alloy coating is chosen to withstand a certain number of hours in a corrosive environment. Such corrosion tests are widely known in the field as the ISO 9227 standard (national equivalents are ASTM B117 or DIN 50021). In this test samples as obtained from the steel wire rope manufacturer are hung in a closed chamber filled with a nebula maintained at a 100% relative humidity at a temperature of 35°C. The atmosphere in the chamber is saturated by means of a circulating spray of water containing 5% by weight of NaCl. So far to what is described in the ISO 9227 standard.

[0005] The corrosion progress is regularly (e.g. every 24 hours) visually monitored and graded into a number of classes ('dots of light brown rust', 'spots of light brown rust', 'dots of dark brown rust', 'spots of dark brown rust' and '5% surface coverage with dark brown rust'). In what follows the number of hours salt spray withstood in this test is until 'spots of dark brown rust' appear on the sample. Currently wire ropes must withstand a minimum of 72 hours of salt spray before being accepted in the automobile industry.

[0006] The lubricant is chosen in order to optimise the fatigue life. Estimates for the fatigue life can be obtained through dedicated test procedures that simulate the real life usage of the rope in the drive system. Hence, there are a number of proprietary test benches available to determine this fatigue life. A publicly available test is the MIL-W-83420 standard that was (and is) still widely used to test 'aircraft cable'.

[0007] In the industry there is a constant drive to use thinner wire ropes of equal or higher strength in order to reduce the size of the drive systems while increasing corrosion protection as well as fatigue life. With known zinc or zinc-alloy coatings one runs into a strength versus corrosion protection conflict. As the corrosion protection of the coating is roughly proportional to the thickness of the coating a minimum coating thickness must be maintained in order to meet the corrosion requirements. However, when using finer and finer wires, the coating takes up an increasing amount of wire cross sectional area. As the coating does not add to the strength of the wire, thinner ropes compared with their thicker counterparts relatively lose strength due to this.

[0008] WO-A-03/048403 discloses a process for improving the corrosion resistance of substrates, such as galvanised steel wires substrates, comprising coating the galvanised steel substrates with a solution containing nano particles of oxides.

[0009] DE-A1-4202625 discloses a metallic product coated with a layer of zinc having a thickness of 1-30 microm. A more resistant coated metallic product is obtained by adding MgO to the zinc coating in an amount of 10-5000mg/m2.

[0010] EP-A1-1508479 discloses a steel product coated with a layer of zinc having a weight amount of 10-100 g/m2. A more corrosion resistant steel product is obtained by adding MgO to the zinc coating in an amount of 10-100g/m2.

Summary of the invention.

[0011] It is therefore a first object of the invention to provide a steel wire rope that overcomes the problems of the past. More in particular it is an object of the invention to provide a steel wire rope that combines a good corrosion resistance without giving in on strength. It is a further object to provide a wire rope with improved frictional properties. The inventors have searched for a particularly simple corrosion inhibitor adapted to the specific use of wire ropes in drive systems that is effective, cheap, environmentally friendly and easy to apply: another object of their invention.

[0012] According a first aspect of the invention a metallic wire rope is provided that is intended for use in a drive system. Such wire ropes have a diameter smaller than 5 mm, although sizes below 3 mm are more preferred while nowadays sizes of 2 mm and 1.5 mm are most popular. The inventors believe that the trend towards smaller diameter wire ropes will continue and foresee that 1 mm diameter ropes will become possible in the foreseeable future.

[0013] The metallic wire rope is assembled out of zinc or zinc alloy coated steel wires. The steel used to produce these wires is - as high strength is needed - a high carbon steel. Such steels have compositions according following lines: a carbon content between 0.35 and 1.15 wt. %, preferably between 0.60 and 1.00 wt.% carbon, a manganese content between 0.30 and 0.70 wt. %, a silicon content between 0.10 and 0.60 wt.%, a maximum sulphur content of 0.05 wt. %, a maximum phosphorus content of 0.05 wt.%. Micro-alloying with particular elements such a chromium, nickel, vanadium, boron, cobalt, copper, molybdenum are not excluded for amounts ranging from 0.01 to 0.08 wt.% as this alloying may help to reach higher strength levels.

[0014] Particularly popular coatings for these steel wires are:

- a coating of technically pure zinc whereby the unavoidable impurities are also included
- an intentionally alloyed zinc coating of which the following are particularly envisaged:
  - zinc-aluminium alloys such as those comprising 2 to 12 wt.% Al and a mischmetal such as cerium or lanthanum, the remainder being zinc. These are particularly preferred for their anti-corrosive properties (see e.g. EP 0 550 005 B1)
  - zinc-iron alloys such as those comprising 0.3 to 1.5 wt.% of Fe or those comprising 15 to 25 wt. of Fe, the remainder being zinc. The iron can originate from the steel substrate itself.
  - a zinc-tin alloy This is a coating to which favourable friction properties are attributed (see e.g. DE 195 12 180 A1)
  - Zinc-nickel alloys such as those comprising 20 to 30 wt. % nickel, the remainder being zinc.

[0015] Note that the coating of the wire is usually done on an intermediate diameter steel wire that is subsequently drawn to finer diameters through a series of dies. During drawing the tensile strength of the wire gradually increases, an increase that is outspoken for steel wires with a high carbon content such as the ones envisaged in this application. Typically, the steel wires have tensile strengths in excess of 1750 N/mm^2, typically above 2500 N/mm^2, or more preferred in excess of 2750 N/mm^2, or even in excess of 3000 N/mm^2. Such higher tensile strengths are necessary to be able to further reduce the wire rope diameter. The diameters of the wires for this kind of rope are rarely above 0.25 mm and by preference below 0.22, even more preferred below 0.15 mm. Using many, fine diameter wires results in a wire rope that is better fatigue resistant than a rope with less wires that have a larger diameter.

[0016] The wires are assembled into strands that may or may not be further assembled into wire ropes. Typical configurations that are common in the field are 7x7, 7x19, 19+8x7, 19W+8x7, 7x8, 8x7, 8x8 19+9x7, 1x3+5x7 to name just a few. For example the formula 7x8 designates a rope consisting of 7 strands that each consist of 8 wires. A strand consists of a core wire around which 7 outer wires are helically twisted with a certain pitch. Six of said strands are twisted around a central core strand, again with a defined pitch. The diameters of the outer wires are by preference chosen such that they easily fit around the core wire. Likewise the diameter of the core strand can be so chosen as to be adapted to the diameter of the outer strands. The strands can be produced layer by layer by twisting wires around intermediate strands leading to an exemplary configuration of a core wire surrounded by six wires again surrounded by twelve wires giving a 1+6+12 configuration that is shortened to a 19 wire strand. A special case is where the wire diameters are so chosen as to fit nicely together as in a Warrington configuration (as in the core of the 19W+8x7 construction). All 19 wires are then assembled together with the same pitch. Sometimes strands are compacted prior to cabling or even complete cables are compacted. Sometimes a fibre replaces the core wire. The inventive idea of this application is equally well applicable to all these variations.

[0017] Typically the amount of coating on the wire is expressed in grams of coating per square meter of wire surface. As the coating does not add to the strength of the cord, it must be as thin as possible without jeopardising the corrosion resistance. Conventional coating amounts are - the number between brackets refers to the average thickness for a corresponding zinc coating having a density of 7.14 kg/dm^3 - minimum 30 g/m^2 (4.2 μm). However, lower amounts such as lower than 25 g/m^2 (3.5 μm), or lower than 20 g/m^2 (2.8 μm) or even lower as 15 g/m^2 (2.1 μm) are more preferred for this inventive wire rope. The inventors think that acceptable corrosion results could even be obtained with zinc coatings targeting 5 g/m^2 (0.7 μm) of zinc.

[0018] Although in principle there is no limitation on the type of process used to coat these steel wires, hot-dip processes are preferred as they provide a solid coating welded to the steel. Due to the hot dip, an alloy layer will form between the steel and the coating that entails additional protection to the steel. Particularly preferred from the viewpoint of strength and fatigue is the coating as described in EP 1 280 958 B1. There a zinc coating with a reduced thickness of below 2 micrometer (14.3 g zinc per m^2 of wire) inclusive the zinc-iron alloy layer is described together with the associated process to coat the wires. Such a wire has a reduced thickness of zinc, which is favourable to obtain a higher breaking load of the cord. In addition, the roughness of the zinc to steel transition layer is much reduced what results in an improved fatigue. Unfortunately, the coating on itself does not protect sufficiently against corrosion.

[0019] However; the inventors have found that the reduced corrosion resistance can be compensated by the use of corrosion inhibitor applied by means of a liquid carrier. Much to their surprise they found that a very simple compound namely magnesium oxide (MgO) was best fitted to this end. The magnesium oxide (MgO) must be finely dispersed in the carrier. The carrier only serves to distribute the magnesium oxide evenly over the surface of the wire: the particles must come in close contact with the coating of the wire. The liquid carrier can remain in place or may evaporate: it has been found that the positive, corrosive inhibitive effects remain. The magnesium oxide makes it possible to use thinner zinc coatings, entailing the advantages of higher strength and better fatigue, while maintaining and even improving the corrosion resistance. Mutatis mutandis the magnesium oxide gives more certainty against corrosion when used on wires with the currently used zinc coatings.

[0020] Magnesium oxide (MgO) is a very common product that can be obtained through a number of process routes. A first route is through heating of magnesite (magnesium carbonate, a natural mineral deposit) in the presence of oxygen. A second route uses brine containing $MgCl_2$ that is first converted to $Mg(OH)_2$ for purification through wet precipitation followed by calcination to drive out the water. The latter route is more preferred. The resultant magnesium oxide (MgO) can be classified in different grades:

1. 'Fused magnesium oxide' is calcinated MgO that has been melted in an electric arc furnace at temperatures in excess of 2750°C. It is the most stable and strongest of all types of magnesia.
2. 'Dead burned magnesium oxide' has been calcinated at temperatures between 1500°C and 2000°C and has a surface area of less than 0.1 m^2 per gram.
3. 'Hard burned magnesium oxide' has been calcinated at temperatures between 1000°C to 1500°C and has a surface area of 0.1 to 1.0 m^2 per gram.
4. 'Light burned or caustic magnesium oxide' has been heated at 700 to 1000°C and has a surface area of 1.0 to 250 m^2 per gram.

[0021] The 'light burned' grade is most preferred, while the 'hard burned' grade is less preferred. The 'dead burned' grade is hard to disperse and hence least preferred. The 'fused magnesium oxide' is too inert to be useful.

[0022] As a carrier, an aliphatic mineral oil is most preferred. Aliphatic mineral oils are normally used to enhance the fatigue life of the wire rope by reducing the friction between the wires as they are bent over a pulley or a wear piece. As they are to be applied on the wire rope anyhow, they can conveniently be used as a carrier for the magnesium oxide dispersion. Other possible liquid carriers are paraphenes and more in particular isoparaphenes that are known to easily evaporate.

[0023] The effect of the corrosion protection of magnesium oxide (MgO) is already apparent when only minute quantities are applied on the zinc or zinc alloy coated surface. Indeed, at a minimum of 100 milligram of MgO per square meter of wire surface, already positive effects on the number of hours survived in the salt spray test can be identified. Compared to the amount of the zinc coating (present in an amount of typically 15 000 to 30 000 mg/m^2) this is remarkable. The effects increase linear with the amount of MgO applied on the zinc or zinc alloy coating. An amount of 200 mg $/m^2$ MgO is therefore more preferred. Higher quantities of 1 000 mg/m^2 or 2 000 mg/m^2 or even 4 000 mg/m^2 MgO still lead to improved results. At present, no levelling off of the positive effects has been detected. One of the inventors hypothesises that - without being bound by this theory - the presence of MgO on the zinc coating suppresses the cathodic reaction (i.e. the electron consuming reaction) in the corrosion process. Due to this the MgO is converted to a product that enhances the passivation behaviour of the zinc coating. Consequently corrosion will only start at MgO free spots . This would make MgO a cathodic inhibitor, of which the effectiveness increases with the amount of magnesium oxide present.

[0024] It has therefore been found important that the magnesium oxide is finely spread over the wire surface in order to obtain a uniform spread of the magnesium oxide flocs. This is best obtained by using a finely ground magnesium oxide with an average particle size of between 1 and 100 micrometer, most preferred being 5 to 75 micrometer. The magnesium oxide must be in physical contact with the zinc or zinc coating layer, otherwise the corrosion protection is less effective or non-existent.

[0025] In order to improve this contact even further, the inventors added abrasive particles of about the same size (5 to 50 micrometer average particle size) as the magnesium oxide particles into the liquid carrier. The idea was that by adding this abrasive, the surface of the zinc coating is ground thus embedding better the magnesium oxide particles. Much to their surprise they found that adding such an abrasive reduced the wear of polymer guiding pieces in the drive system. Such guiding pieces are usually made of hard polymers such as polyoxymethylene (POM) or polyamide (Nylon 6). For a description of the test reference is made to EP 0 550 005 B1, page 14 and FIGURES 13, 14 and 15. Applicant presumes - without being bound by this hypothesis - that the abrasive particles not only activate the zinc coating, but also polish the surface of the wire making it smoother. As an abrasive, silicon carbide (SiC) is most preferred as it is cheap and easily available in all grain sizes. Other abrasives (quartz, cubic boron nitride, diamond and many others) could probably function as well. Remarkable is also that these abrasive particles do not have a negative influence on the fatigue behaviour of the steel wire rope. It has been found that between 0.1 and 10, preferably between 0.1 and 2 grams of SiC per kilogram of wire rope more than suffices to obtain the positive effects.

[0026] It will be clear from the above that the inventors have searched for particular simple chemicals and additives. Many of the commercial available corrosion inhibitors are for general-purpose use and are not specifically oriented towards wire ropes for drive systems. As such they contain more than five ingredients, many of these ingredients being complex and not readily available. The inventors intentionally searched for a simple solution that is above all effective, cheap, environmentally friendly and easy to implement. The number of constituents remains below five namely: a liquid carrier (that may or may not disappear after application), magnesium oxide (MgO), silicon carbide (SiC) and maybe some kind of dispersant or floatant that might be added.

[0027] According a second aspect of the invention, a metallic wire product is defined that comprises at least one zinc or zinc alloy coated steel wire. Special about this steel wire is that a corrosion inhibitor is embedded in the zinc or zinc alloy coating as a finely dispersed solid. By preference this corrosion inhibitor is present in the outer surface of the coating. Even more preferred is that the solid corrosion inhibitor is embossed, pressed into the outer surface of said coating. Preferably this corrosion inhibitor is magnesium oxide (MgO) .

[0028] According a third aspect of the invention a method is disclosed to protect a metallic wire product. The method starts from a steel wire of intermediate diameter provided with a zinc or zinc alloy coating. The steel and coating compositions are in line with the compositions described in the first aspect of the invention. On a wire drawing bench, preferably a wet wire drawing bench, the wire is sequentially drawn through progressively smaller dies, a technique common in the art. Particular about the method is that the wire drags a finely dispersed corrosion inhibitor into one of the drawing dies. The corrosion inhibitor gets impressed into to the outer surface of the coating by the compressive action of the die on the wire. The corrosion inhibitor can be applied on the wire at one die e.g. the entrance (i.e. the largest) die or at the exit (i.e. the smallest) die. Or the inhibitor can be fed to the wire at two or more dies, or at every die of the whole die series.

[0029] The corrosion inhibitor is provided in a powder form. In that case the corrosion inhibitor can be mixed into powder soaps that are common in the art of steel wire dry drawing as solid lubricants. Such a powder mixture can be fed together with the wire into the die by guiding the wire through a soap box at the entrance of the die. Or the corrosion inhibitor can be mixed into a liquid carrier that is dragged by the wire into the die entrance. Important is that the corrosion inhibitor comes in intimate, electrical contact with the zinc or zinc alloy coating. The corrosion inhibitor therefore should not be isolated from the zinc or zinc alloy coating by drawing soap residues.

[0030] By preference the corrosion inhibitor is magnesium oxide (MgO). Preferred is that the magnesium oxide powder has been finely ground so as to pass a 74 micrometer mesh.

Description of the preferred embodiments of the invention.

[0031] In the following a series of tests on lab scale and in a production environment are described that have been performed on a zinc coated steel wire rope of type 19+8x7 of diameter 1.5 mm for use in a window elevator system. The cord is of the following make:

$$\{[(0.15+6\times0.14)_{3.5\,s}+12\times0.14]_{8.5\,s}+8\times(0.14++6x0.14)_{4.8\,z}\}_{12\,S}$$

the different bracket levels indicating single operations, the subscripts indicating lay lengths and lay directions. The cord has a linear mass of 9.78 g/m and a wire surface of 33.56 m^2/km of cord. If not indicated to the contrary, the rope wires have obtained a hot dip galvanised, technically pure zinc coating of about 100 g per kg of coated steel wire rope (i.e. 28 g/m^2 or an average thickness of 3.9 μm).

[0032] In a first series of tests, a number of substances have been evaluated in the laboratory. Clean cord samples were coated with mixtures of compounds with the standard aliphatic mineral oil as used on the standard production cords. Six samples of each were hung in the salt spray test chamber and visually inspected on a daily basis. The day on which the first dark brown spots became visible was noted. The result mentioned in TABLE 1 is the average (hSS AVG), the minimum (hSS min) and the maximum (hSS MAX) of the six samples. The compounds were present in the mixture according the indicated weight percentages on the total mixture. Based on these findings MgO was selected for further investigation.

TABLE 1

Nr.	*Mixture*	*hSS Avg*	*hSS min*	*hSS MAX*
1	Lubricant	84	72	96
2	Lubricant + 5% Benzimidazole	116	96	144
3	Lubricant + 10% Magnesium oxide	324	312	336
4	Lubricant + 10% Zinc oxide	108	96	120
5	Lubricant + 10% Zinc carbonate hydroxide	116	96	144
6	Lubricant + 10% Magnesium carbonate hydroxide	180	168	192
7	Lubricant + 10% Hydrated zinc phosphate	84	72	96
8	Lubricant + 10% Aluminium oxide	84	72	96
9	Lubricant + 10% Hydrated magnesium silicate	84	72	96
10	Lubricant + 5% Magnesium oxide + 5% hydrated magnesium silicate	156	144	168
11	Lubricant + 10% Magnesiumhydroxide	156	144	168
12	Lubricant + 10% Magnesium stearaat	132	120	144
13	Lubricant + 10% Magnesium hydrogen phosphate	100	72	120

[0033] In a second series of lab experiments the influence of the MgO was ascertained by applying mixtures on the bare and degreased cable with increasing amounts of magnesium oxide in them. Again the samples were tested in the salt spray chamber, the results of which are summarised in TABLE 2.

TABLE 2

Nr.	*Mixture*	*hSS Avg*	*hSS min*	*hSS MAX*
14	Lubricant	108	96	120
15	Lubricant + 15% MgO	556	432	648
16	Lubricant + 20% MgO	716	672	792
17	Lubricant + 25% MgO	884	816	1005
18	Lubricant + 30% MgO	828	816	840
19	Lubricant + 40% MgO	1140	1032	1248

[0034] In a third series of experiments, a series of mixtures was tested on an industrial scale. Wire ropes with two levels of zinc coating amount were tested: one with the standard coating of 28.0 g/m^2 of wire surface and one with a reduced coating of 24.3 g/m[2]. Also a different kind of liquid carrier was used namely a liquid isoparaphine wax. Isoparaphines with low molecular weight easily evaporate. In this case the paraphine merely acts as a distributor for the magnesium oxide over the wire surface of the cable. From the result it can be deduced that the positive effects of the MgO remain.

TABLE 3

Nr	*Liquid carrier*	*Zn (gr/m²)*	*mg/m² MgO*	*hSS Avg*
20	Lubricant	24.3	0	65
21			459	120
22			885	136
23			989	168
24			1138	256
25		28.0	0	85
26			72	144
27			272	248
28			504	248
29			1362	248
30	Paraphine	28.0	180	280

[0035] In a fourth series of experiments, an amount of silicon carbide (grain size between 8 and 32 micron) was added to the lubricant in an attempt to activate the surface of the zinc coating for the action of the magnesium oxide by slight abrasion of the surface. Although the corrosion resistance as measured in the salt spray chamber did not deteriorate nor improve by the action of the silicon carbide, another positive effect was surprisingly found. It was found that the cutting wear of fixed guiding pieces that are sometimes used to replace pulleys virtually disappeared: if the normal level of wear was 100, the influence of the SiC reduced this to 40 and even to 25. The test was performed with a load of 120 N and a rope vs. guiding piece speed of 7.5 m/minute. The radius of curvature of the POM guiding piece was 15 mm while the rope covers 180° of the piece. The wear is evaluated after 5 000 back and forth cycles (i.e. 10 000 passages) in which the same 430 mm of rope glides over the guiding piece. No lubricant is added prior to the testing.

[0036] The inventors want to stress that the invention is equally well applicable to all kinds of configurations of steel wire ropes and that their use is not limited to window elevator systems but to all kinds of drive systems (sliding doors, sliding rooftops, garage doors, curtain drives, brake cables, clutch cable, door latch system, a non-exhaustive list).

Claims

1. A steel wire rope for use in a drive system comprising zinc or zinc alloy coated steel wires with an amount of zinc or zinc alloy coating that is lower than 15 g/m[2], said steel wires having a diameter finer than 0.25 mm and a tensile strength in excess of 1750 N/mm[2], said steel wires further comprising a liquid carrier coating comprising a corrosion inhibitor **characterised in that** said corrosion inhibitor is magnesium oxide, said magnesium oxide being finely dispersed in said liquid carrier.

2. The steel wire rope of claim 1 wherein said liquid carrier is one out of the group consisting of an aliphatic mineral oil, paraphenes, and iso-paraphenes.

3. The steel wire rope of claim 1 or 2 whereon at least 100 milligrams of magnesium oxide per square meter of wire surface of said metallic wire rope is present.

4. The steel wire rope of claim 1 or 2 whereon at least 200 milligrams of magnesium oxide per square meter of wire surface of said metallic wire rope is present.

5. The steel wire rope of claim 1 or 4 wherein the average particle size of said finely dispersed magnesium oxide is between 1 and 100 micrometer.

6. The steel wire rope according any one of claims 1 to 5 wherein said liquid carrier further comprises an abrasive powder with a particle size between 5 and 50 micron.

7. The steel wire rope according claim 6 wherein said abrasive powder is silicon carbide.

8. The steel wire rope according claim 7 whereon between 0.1 and 10 grams of silicon carbide per kilogram of said metallic wire rope is present.

9. A method to protect a steel wire product from corrosion comprising the steps of:

> Providing a steel wire coated with zinc or zinc alloy
> Sequentially drawing said zinc or zinc alloy coated steel wire
through successively smaller dies
characterised in that at the entrance of at least one of said dies, a finely dispersed magnesium oxide corrosion inhibitor carried by a liquid carrier is dragged by said steel wire into said at least one die and subsequently impressed into said zinc or zinc alloy.

10. A method to protect a steel wire product from corrosion comprising the steps of:

> Providing a steel wire coated with zinc or zinc alloy
> Sequentially drawing said zinc or zinc alloy coated steel wire
through successively smaller dies
characterised in that a finely dispersed magnesium oxide corrosion inhibitor mixed with a powder soap resulting in a powder mixture, said mixture being fed at the entrance of at least one of said dies and dragged by said steel wire into said at least one die and subsequently impressed into said zinc or zinc alloy.

11. The method of claim 9 or 10 wherein said magnesium oxide has passed a 74 micrometer mesh.

Patentansprüche

1. Stahldrahtseil zur Verwendung in einem Antriebssystem, umfassend mit Zink oder Zinklegierung beschichtete Stahldrähte mit einer Menge von Zink- oder Zinklegierungsbeschichtung, die geringer als 15 g/m^2 ist, wobei die Stahldrähte einen Durchmesser von weniger als 0,25 mm und eine Zugfestigkeit von mehr al 1750 N/mm^2 aufweisen, wobei die Stahldrähte weiter eine flüssige Trägerbeschichtung umfassen, umfassend einen Korrosionsschutz, **dadurch gekennzeichnet, dass** der Korrosionsschutz Magnesiumoxid ist, wobei das Magnesiumoxid in dem flüssigen Träger fein dispergiert ist.

2. Stahldrahtseil nach Anspruch 1, wobei der flüssige Träger einer aus einer Gruppe umfassend ein aliphatisches Mineralöl, Paraphene und Isoparaphene ist.

3. Stahldrahtseil nach Anspruch 1 oder 2, wobei mindestens 100 Milligramm Magnesiumoxid pro Quadratmeter Drahtoberfläche des metallischen Drahtseils vorhanden ist,

4. Stahldrahtseil nach Anspruch 1 oder 2, wobei mindestens 200 Milligramm Magnesiumoxid pro Quadratmeter Drahtoberfläche des metallischen Drahtseils vorhanden ist.

5. Stahldrahtseil nach Anspruch 1 oder 4, wobei die durchschnittliche Partikelgröße des fein dispergierten Magnesiumoxids zwischen 1 und 100 Mikrometer liegt,

6. Stahldrahtseil nach einem der Ansprüche 1 bis 5, wobei der flüssige Träger weiter ein Schleifpulver mit einer Partikelgröße zwischen 5 und 50 Mikron umfasst.

7. Stahldrahtseil nach Anspruch 6, wobei das Schleifpulver Siliziumkarbid ist.

8. Stahldrahtseil nach Anspruch 7, wobei zwischen 0,1 und 10 Gramm Siliziumkarbid pro Kilogramm des metallischen Drahtseils vorhanden ist.

9. Verfahren zum Schutz eines Stahldrahtproduktes vor Korrosion, umfassend die folgenden Schritte:

> Bereitstellen eines Stahldrahtes, beschichtet mit Zink oder Zinklegierung

> danach Ziehen des mit Zink oder Zinklegierung beschichteten Stahldrahts durch aufeinander folgend kleinere Formen
dadurch gekennzeichnet, dass am Eingang mindestens einer der Formen ein fein dispergierter Magnesiumoxid-Korrosionsschutz, getragen von einem flüssigen Träger, von dem Stahldraht in die mindestens eine Form gezogen wird und dann in das Zink oder die Zinklegierung eingeprägt wird.

10. Verfahren zum Schutz eines Stahldrahtproduktes vor Korrosion, umfassend die folgenden Schritte:

> Bereitstellen eines Stahldrahtes, beschichtet mit Zink oder Zinklegierung
> danach Ziehen des mit Zink oder Zinklegierung beschichteten Stahldrahts durch aufeinander folgend kleinere Formen
dadurch gekennzeichnet, dass ein fein dispergierter Magnesiumoxid-Korrosionsschutz, gemischt mit einem Seifenpulver eine Pulvermischung ergibt, wobei die Mischung am Eingang mindestens einer der Formen eingeführt wird und von dem Stahldraht in die mindestens eine Form gezogen wird und dann in das Zink oder die Zinklegierung eingeprägt wird.

11. Verfahren nach Anspruch 9 oder 10, wobei das Magnesiumoxid durch eine 74 Mikrometer-Siebmasche passiert ist.

Revendications

1. Câble en fil d'acier pour usage dans un système d'entraînement comprenant des fils d'acier revêtus de zinc ou d'alliage de zinc avec une quantité de revêtement de zinc ou d'alliage de zinc qui est inférieure à 15 g/m^2, lesdits fils d'acier ayant un diamètre plus fin que 0,25 mm et une résistance à la traction de plus de 1750 N/mm^2, lesdits fils d'acier comprenant en outre un revêtement de véhicule liquide comprenant un inhibiteur de corrosion, **caractérisé en ce que** ledit inhibiteur de corrosion est l'oxyde de magnésium, ledit oxyde de magnésium étant finement dispersé dans ledit véhicule liquide.

2. Câble en fil d'acier selon la revendication 1, dans lequel ledit véhicule liquide est un véhicule du groupe constitué d'une huile minérale aliphatique, de paraphènes et d'iso-paraphènes.

3. Câble en fil d'acier selon la revendication 1 ou 2, dans lequel il y a au moins 100 milligrammes d'oxyde de magnésium par mètre carré de surface de fil dudit câble en fil métallique,

4. Câble en fil d'acier selon la revendication 1 ou 2, dans lequel il y a au moins 200 milligrammes d'oxyde de magnésium par mètre carré de surface de fil dudit câble de fil métallique.

5. Câble en fil d'acier selon la revendication 1 ou 4, dans lequel la taille particulaire moyenne dudit oxyde de magnésium finement dispersé est de 1 à 100 micromètres.

6. Câble en fil d'acier selon l'une quelconque des revendications 1 à 5, dans lequel ledit véhicule liquide comprend en outre une poudre abrasive d'une taille particulaire de 5 à 50 micromètres.

7. Câble en fil d'acier selon la revendication 6, dans lequel ladite poudre abrasive est le carbure de silicium.

8. Câble en fil d'acier selon la revendication 7, dans lequel il y a 0,1 à 10 grammes de carbure de silicium par kilogramme dudit câble en fil d'acier,

9. Procédé de protection d'un produit en fil d'acier contre la corrosion, comprenant les étapes consistant à :

> mettre en oeuvre un fil d'acier revêtu de zinc ou d'alliage de zinc ;
> étirer de manière séquentielle ledit fil d'acier revêtu de zinc ou d'alliage de zinc à travers des filières de plus en plus petites ;
caractérisé en ce que, à l'entrée d'au moins l'une
desdites filières, un inhibiteur de corrosion d'oxyde de magnésium finement dispersé transporté par un véhicule liquide est étiré par ledit fil d'acier dans ladite au moins une filière et ensuite imprimé dans ledit zinc ou alliage de zinc.

10. Procédé de protection d'un produit en fil d'acier contre la corrosion, comprenant les étapes consistant à :

> mettre en oeuvre un fil d'acier revêtu de zinc ou d'alliage de zinc ;
> étirer de manière séquentielle ledit fil d'acier revêtu de zinc ou d'alliage de zinc à travers des filières de plus en plus petites ;
caractérisé en ce qu'un inhibiteur de corrosion
d'oxyde de magnésium finement dispersé mélangé à un savon en poudre forme un mélange pulvérulent, ledit mélange étant chargé à l'entrée d'au moins l'une desdites filières et étiré par ledit fil d'acier dans ladite au moins une filière et imprimé ensuite dans ledit zinc ou alliage de zinc.

11. Procédé selon la revendication 9 ou 10, dans lequel ledit oxyde de magnésium passe à travers des mailles de 74 micromètres.

REFERENCES CITED IN THE DESCRIPTION

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