



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
18.07.2018 Bulletin 2018/29

(51) Int Cl.:
E01D 19/16^(2006.01) D07B 1/10^(2006.01)

(21) Application number: **16898333.6**

(86) International application number:
PCT/CN2016/083894

(22) Date of filing: **30.05.2016**

(87) International publication number:
WO 2017/177518 (19.10.2017 Gazette 2017/42)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

- **WU, Qiong**
Wuxi
Jiangsu 214445 (CN)
- **QIANG, Qiang**
Wuxi
Jiangsu 214445 (CN)
- **HUANG, Kebin**
Wuxi
Jiangsu 214445 (CN)
- **ZHU, Xiaoxiong**
Wuxi
Jiangsu 214445 (CN)
- **SHU, Weihong**
Wuxi
Jiangsu 214445 (CN)
- **WANG, Jin**
Wuxi
Jiangsu 214445 (CN)
- **LIANG, Zhongmei**
Wuxi
Jiangsu 214445 (CN)
- **ZHAI, Pengcheng**
Wuxi
Jiangsu 214445 (CN)

(30) Priority: **13.04.2016 CN 201610229109**

(71) Applicant: **Jiangsu Fasten Steel Cable Co., Ltd.**
Jiangyin, Jiangsu 214445 (CN)

- (72) Inventors:
- **ZHAO, Jun**
Wuxi
Jiangsu 214445 (CN)
 - **NING, Shiwei**
Wuxi
Jiangsu 214445 (CN)
 - **XUE, Huajuan**
Wuxi
Jiangsu 214445 (CN)
 - **ZHOU, Zhubing**
Wuxi
Jiangsu 214445 (CN)

(74) Representative: **Hryszkiewicz, Danuta**
Matthias Scholl, Inc.
Friedrichstrasse 123
10117 Berlin (DE)

(54) **METHOD FOR MANUFACTURING HOT EXTRUDED POLYETHYLENE ZINC-ALUMINIUM ALLOY-PLATED STEEL WIRE HAULING CABLE**

(57) Provided is a method for manufacturing a hot extruded polyethylene zinc-aluminium alloy-plated steel wire hauling cable. The method involves: in accordance with arrangement rules for steel wires at the cross section of a hauling cable (4), the length of the hauling cable is controlled through a central standard wire, zinc-aluminium alloy-plated steel wires are bundled at a twisting angle of 2°-4°, a high-strength polyester belt is wound externally on the steel wire bundle, a double-layer high-density polyethylene protection layer is hot-extruded through a double-cavity co-extrusion one-time moulding process,

anti-wind- and rain-induced vibration embossments are arranged on the outer layer of a polyethylene protection jacket according to design requirements of the hauling cable (4) regarding wind- and rain-induced vibration, and the hauling cable is coiled and stored after both ends of the hauling cable (4) are anchored. Finally, the hauling cable is transported to an erection site according to delivery requirements, and erected one by one. The process for manufacturing the hauling cable (4) is not limited by a construction site, is less affected by climate factors, is convenient to control due to industrialised production

management, and can satisfy the service requirements of long length, high accuracy, and durability for stay ca-

bles in super-long-span bridges in a marine environment.

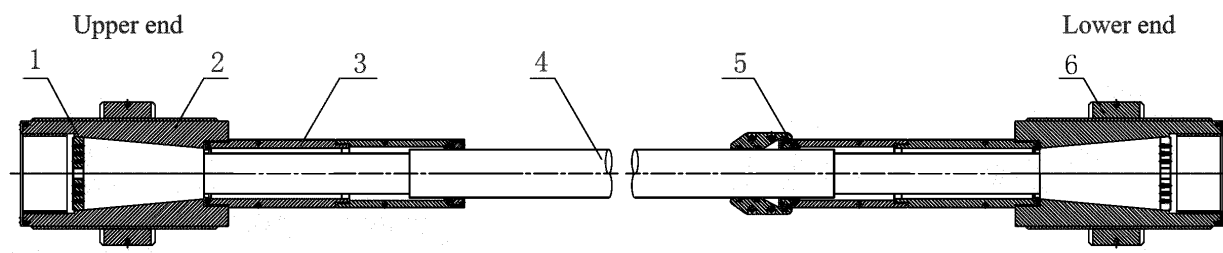


FIG. 1

Description

[0001] The invention belongs to the technical field of bridge cable, and relates to a method for fabricating a steel wire cable comprising an extruded polyethylene and a zinc-aluminum alloy plating.

[0002] A cable-stayed bridge has one or more towers, from which cables support the bridge deck. The cable-stayed bridge features light structure and strong applicability, and is able to form different systems by varying the combination of bridge deck, cables, and towers according to different geologic environment and terrains. Due to the addition of the stay cables, a bending moment of a main girder is significantly decreased. Compared with large-span bridges of other systems, the uses of the steel and the concrete of the main girder in the cable-stayed bridge are relatively saved. Under the action of the pretension of the cable-stayed bridge, an internal force of the main girder can be adjusted to make the distribution thereof uniform and therefore acquire better economic effect. In addition, the main girder can be manufactured as a uniform girder, thus being convenient for manufacture and installation. A horizontal component force of the stay cable is equivalent to a pre-pressure applied to the main girder, which further improves the crack resistance of the girder (especially the concrete girder) and fully presents the performances of the materials.

[0003] The concept of cable-stayed bridge was originated from 17th century but not well developed due to condition restrictions at that time. In 1784, a German named CJLoscher built a 32 m-span wooden cable-stayed bridge in Friborg. The bridge adopts a support system formed by wooden tension rods connected to wooden towers and is the first truly cable-stayed bridge. After World War II, with the rebuild of the Europe and the developments in the modern mechanics theory and technologies, in order to seek the both economic and convenient bridge, the cable-stayed bridge attracted the attention of the public and was recognized to possess great advantages in a certain span range. The world's first modern cable-stayed bridge was the Stromsund Bridge built in 1955 in Sweden, and was a steel cable-stayed bridge having a span of 182.6 m across the Strom Strait, marking the beginning of modern cable-stayed bridges. In 1962, the world's first concrete cable-stayed bridge was built in Venezuela (with a main span of 135 meters). At that time, the cable-stayed bridge had gained rapid development. By the end of the twentieth century, the Norman Bridge, with a main span of 856 meters, had been built in France, and the Duo Luo Bridge, with a main span of 890 meters, had been built in Japan. Cables of all these bridges adopts hot galvanized stranded wire or steel wire.

[0004] With the quick development of the modern bridge, many sea-crossing bridges with ultra-long span will be built in the future, the stay cable of which is required to have long length, high accuracy, and long designed service life. However, the conventional galvanized steel

wire cable is unable to meet the endurance requirement for the ultra-long span sea-crossing bridge.

[0005] In view of the above-described problems, it is one objective of the invention to provide a method for fabricating a steel wire cable comprising an extruded polyethylene and a zinc-aluminum alloy plating. In which, steel wires are arranged according to an arrangement rule at a cross section of the steel wire cable; a length of the overall cable is controlled by a length of a central standard wire; a bunch of the steel wires comprising a zinc-aluminum alloy plating are twisted with a torsion angle of between 2° and 4°; the steel wire bunch is then wrapped with a polyester wrapping bandage and covered with a double-layered protective polyethylene sheath by using double-cavity co-extrusion process for one-step formation, and an outer surface of the polyethylene sheath is provided with embossments for rain-wind induced vibration resistance; the two ends of the steel wire cable are fixed by anchors using fillers, coiled, and stored. And the coils of the steel wire cables are then transported to and respectively laid on a construction field.

[0006] Technical scheme of the invention is as follows: a method for fabricating a steel wire cable comprising an extruded polyethylene and a zinc-aluminum alloy plating, the method comprises the following steps:

1) Fabricating a steel wire comprising a zinc-aluminum alloy plating

[0007] The steel wire comprising the zinc-aluminum alloy plating is adopted because the zinc-aluminum alloy plating possesses much stronger anti-corrosive property, principle of which is as follows: a) as aluminum has very active chemical property, a dense layer of alumina is formed on a surface of the steel wire after hot dip of aluminum, and therefore the surface of the steel wire is easily inactivated to form a protective layer in corrosive environment. In a corrosive medium, a zinc-enriched surface layer, functioning as a positive electrode, is firstly eroded, the aluminum content continuously increases to make the alumina content increase, thus making the plating layer possessing stronger capability of preventing external toxic substances. In the meanwhile, the addition of the aluminum also inhibits the formation of a zinc-aluminum transitional layer which has weaker anti-corrosion performance and loosen tissue, thus being helpful for improving the overall anti-corrosion performance of the plating layer. b) When the zinc-aluminum alloy plating is destructed and the steel is exposed, the plating functions as a positive electrode of an iron-zinc aluminum battery and is dissolved, and a steel substrate is therefore protected. A corrosion potential of the zinc-aluminum alloy is slightly lower than a pure zinc layer and is approximately -0.87, but the corrosion current of the zinc-aluminum alloy is only 1/5 of the hot dipped pure zinc. Under the protection of sacrificing the positive electrode, the consumption time of the zinc-aluminum alloy plating of the same amount is five folds of that of the hot dipped

zinc layer. Thus, the zinc-aluminum alloy plating is able to provide much longer sacrificial protection time and possesses better endurance. The zinc-aluminum alloy plating includes two types, Zn95Al5 having an aluminum content of between 4.2 and 7.2 wt. %, and Zn90Al10 having the aluminum content of between 9.2 and 12.2 wt. %. A plating weight is equal to or larger than 300 g/m². A homogeneity indicator of the plating satisfies a time of copper sulfate of equal to or larger than 4 with each time lasting 60 s.

2) Fabricating a steel wire having a standard length

[0008] As each layer of steel wires in the stay cable exists with a certain torsion angle, it is unable to directly control the length of the steel wire cable by using the outer layers of steel wires. Only the central wire of the stay cable always remains straight without being twisted during the whole fabrication process, therefore, the central wire is utilized as the standard wire to control the overall length of the steel wire cable.

[0009] The length of the standard wire is determined by baseline measurement, and specific operation includes: applying a certain tension force to two ends of a steel wire to straighten the steel wire a performing stress correction and temperature correction using the following equation:

$$L=L_0 \times [(1 + F/EA) + \alpha (T-20)]$$

in which, L represents a length (m) of the steel wire in a stressed state, L₀ represents a designed length, m, of the steel wire in an unstressed state, F represents a tensioning force, N, E represents an elastic module, MPa, of the steel wire, and fabrication of the standard wire adopts a measured value, A represents an area of a cross section, m², of the steel wire, and fabrication of the standard wire adopts the measured value, α represents an expansion coefficient of the steel wire, and T represents a temperature, °C, of the environment.

[0010] A steel wire having a standard length is prepared. Certain markers for cutting are made at two ends of the steel wire. Thereafter, the steel wire having the standard length is utilized as a reference, and the overall length of the steel wire cable is controlled by a transfer method. By using the above measurements, the length error of the stay cable can be greatly reduced. The fabrication precision of the standard wire exceeds 1/30000, and the fabrication precision of the finished product of the steel wire cable is improved from the China's national standard of 1/5000 to 1/20000.

3) Twisting a steel wire bunch

[0011] The steel wire cable is formed by multiple layers of steel wires. When relaxing the steel wires, the standard

wire is positioned at a center position of a cross section of the steel wire cable.

[0012] A steel wire bunch is twisted to the left with a torsion angle of between 2° and 4°. The twisted steel wire bunch is wrapped to the right by a wrapping bandage to yield a naked steel wire cable as a semi-product. As lengths of the multiple layers of the steel wires exist with differences, a relaxed length L' of other layers of steel wires surrounding the standard wire considering the length of the standard wire is calculated according to the following equation:

$$L_0 = L' \times \cos \alpha + K$$

in which, α represents the torsion angle ranging from 2° to 4°; K represents a fabrication allowance, m, which is selected according to specifications and operations; L' represents the relaxed length, m, of other layers of the steel wires surrounding the standard wire; and L₀ represents the length, m, of the standard wire at the center position;

[0013] An outer diameter of the steel wire bunch, i. e., the naked steel wire cable, after being twisted is measured. Because the cross section of the steel wire bunch is in a shape of hexagon or hexagon with missing angles, a circumscribed circle of the selected cross section of the steel wire bunch is directly the diameter of the naked steel wire cable.

[0014] The wrapping bandage is preferably a bandage made from a polyester fiber. The wrapping bandage has a width of between 40 and 60 mm and a tensile strength of equal to or high than 500 N/25 mm².

4) Extruding

[0015] A double-layered protective polyethylene is prepared outside the naked steel wire cable, in which, the double-layered protective polyethylene has a density of between 0.942 and 0.978 g/cm³, environmental stress crack resistance property of ≥ 5000 F₀/h, and a melt index of ≤ 0.45 g/10 min. Specific operation is as follows:

[0016] before extruding, a die aperture of an extruder and an extrusion velocity are preset according to an outer diameter of the naked steel wire cable and thicknesses of two layers of polyethylene. The double-cavity co-extrusion for one-step formation is adopted. The two layers of the polyethylene plastics simultaneously cover the naked steel wire cable during the requirements of anti-corrosion. According to the requirement of resistance of the rain-wind induced vibration, after the extrusion, an outer surface of the double-layered protective polyethylene is provided with helical lines or embossments. When reaching the effect of the steel wire cable in effectively inhibiting the rain-wind induced vibration, a drag coefficient is equal to or smaller than 0.8.

5) Accurate cutting

[0017] Original cutting positions of the steel wire cable are determined, the double-layered protective polyethylene is locally stripped, and the markers for cutting at two ends of the standard wire at the center position of the steel wire cable are found. Then, the steel wire cable is cut by using a non-liquid cutting machine and end faces of the steel wire cable are ensured perpendicular to an axis of the steel wire cable. The double-layered protective polyethylene is stripped according to a preset length to expose the steel wires, during which, the plating of the steel wires is prevented from being destructed.

6) Casting anchor

[0018] The anchor is a main connecting structure to transmit a tension of the steel wire cable to a tower and a girder. The steel wire cable adopts anchor structures including nut-screwing type anchor, anchor plate gap adjusting type anchor, or a fork-ear pin joint type anchor at two ends. The anchor is performed with hot galvanizing or paints coating for corrosion resistance. A thickness of the hot galvanizing is equal to or larger than 90 μm , and a thickness of the paints coating is determined according to specifications and design requirements of a steel structure. The types of the structures of the anchor is as follows:

a) Nut-screwing type anchor

[0019] The nut screwing type anchor comprises: an anchor cup, a screw nut, an anchor plate, and a sealing assembly of a connecting cylinder. Such steel wire cable utilizes the end face of the nut to support the pressure and to transmit the load. The nut and the anchor cup are in rotary joint via a trapezoidal thread having high strength to realize the continuous adjustment of the length of the steel wire cable. The anchor cup is provided with tensional inner threads. In installation of the steel wire cable on the construction site, an installation force is applied on the steel wire cable by drawing the anchor. The anchor plate primarily functions in dispersing the steel wires, steel wire holes are distributed on the anchor plate, and the steel wires pass through corresponding steel wire holes and are headed. An external cone boss can be tightly attached to an internal conical cavity.

b) End face-supporting type anchor

[0020] The end face-supporting type anchor comprises: an anchor cup, an anchor plate, and a sealing assembly of a connecting cylinder. End faces of such steel wire cable are directly supported on anchor plate, and different gap adjusting plates are utilized to regulate the length of the steel wire cable. The gap adjusting plates have different thicknesses to satisfy the requirement of the construction site. The anchor cup is provided with

tensional inner threads. In installation of the steel wire cable on the construction site, an installation force is applied on the steel wire cable by drawing the anchor. Such kind of anchor does not necessitate nuts, and the anchor cup is not provided with external threads. The anchor plate functions in dispersing the steel wires, the steel wire holes are distributed on the anchor plate, and the steel wires pass through corresponding steel wire holes and are headed. An external cone boss can be tightly attached to an internal conical cavity.

c) Fork-ear pin joint type anchor at one end and nut-screwing type anchor at the other end

[0021] The fork-ear pin joint type anchor comprises: a fork ear, a pin shaft, an anchor cup, a nut, and a sealing assembly of a connecting cylinder. One end of such steel wire cable is connected to the steel structure of the tower or the girder via the fork ear and the pin shaft, and the other end of the steel wire cable adopts an end face of a nut to bear pressure and to transmit the load, thus realizing the continuous adjustment of the length of the steel wire cable. the anchor cup is provided with tensional inner threads. In installation of the steel wire cable on the construction site, an installation force is applied on the steel wire cable by drawing the anchor. The anchor plate functions in dispersing the steel wires, the steel wire holes are distributed on the anchor plate, and the steel wires pass through corresponding steel wire holes and are headed. An external cone boss can be tightly attached to an internal conical cavity.

[0022] The sealing assembly of the connecting cylinder in the above three structures all adopts the new type of cable end sealing technology, in which, an outer part of the connecting cylinder is firstly sealed by a sealing cover, and an inner wall of the connecting cylinder in the vicinity of a port is sealed again by an elastic sealing ring and a sealing press ring. The two sealing measurements finally realizes the sealing of the two ends of the steel wire cable, that is, the sealing between the anchors and the interfaces of the polyethylene steel wire cable. The sealing assembly has stronger strength, thus being difficult to be destructed, much longer service life, and much durable sealing structure.

[0023] The sealing structure at the ends of the steel wire cable is a reliable mechanical sealing structure, configured to prevent the corrosion resulting from the water penetration into the PE cable. In the meanwhile, the sealing structure, as a substitute of a heat shrink sleeve, is utilized for sealing, thus overcoming the problem of damage of the heat shrink sleeve.

[0024] The technical solution to solve the above described technical problem is as follows: an durable sealing structure at an end of the steel wire cable. The sealing structure fits together with the connecting cylinder of the anchor and comprises: the elastic sealing ring, a sealing press ring, and a sealing cover. The sealing press ring is disposed in the port of the connecting cylinder and

an outer end of the sealing press ring is exposed outside the connecting cylinder. A press surface is formed on the inner wall of the connecting cylinder relative to the inner end face of the sealing press ring. The elastic sealing ring is disposed between the inner end face of the sealing press ring and the press surface. Under the press of the press surface, the elastic sealing ring is deformed and attached to the outer wall of the steel wire cable. The sealing cover is disposed on a front end of the connecting cylinder and possesses a Harvard structure. A front part of the sealing cover contacts and fits with the outer wall of the steel wire cable and a corresponding contact surface is provided with a sealing ring. A rear part of the sealing cover contacts and fits with the sealing press ring or the connecting cylinder and a corresponding contact surface is provided with a sealing strip.

[0025] The casting of the anchor is carried out by chill casting of heading anchor or by hot casting of anchor, operations of which are as follows:

A. Chill casting of heading anchor

[0026]

a. Ends of the steel wires are fixed in anchor cups on a casting platform, oil stains and rusts are removed from portions of the steel wires inside the anchor cups, and inner walls of the anchor cups are synchronously washed.

b. The ends of the steel wires are uniformly dispersed corresponding to holes of anchor plates, and each steel wire is headed by using a heading machine. Heading dimensions are as follows: heading diameter $\geq 14 D$, heading height $\geq 1.0 D$, and D represents a diameter of the steel wires.

c. A chilled filler comprising steel balls, a stone dust, an epoxy resin, a curing agent, di-n-butyl, and a diluent is provided and uniformly mixed. A mixture of the chilled filler is poured into the anchor cups while vibrating by using a vibration pump to fully fill gaps among the anchor cup and steel wires with the mixture of the chilled filler.

d. A compression strength of the casting body of the chilled filler is ≥ 147 MPa.

B. Hot casting of anchor

[0027] The hot casting anchor adopts a zinc alloy for casting, and a zinc-copper alloy and a zinc-copper-aluminum alloy are the common two alloys.

[0028] The zinc-copper alloy comprises 98 ± 0.2 wt. % of zinc and 2 ± 0.2 wt. % of copper, and the zinc-copper-aluminum alloy comprises 4 - 7 wt. % of aluminum, 1 - 2 wt. % of copper, and 91 - 95 wt. % of zinc. The casting is performed as follows:

a. Ends of the steel wires are perpendicularly fixed in anchor cups on the casting platform, steel wires comprising a zinc-aluminum alloy plating are dispersed inside the anchor cups in the form of concentric circles. Oil stains and rusts are then removed from surfaces of the steel wires, and the inner walls of the anchor cups are simultaneously washed.

b. The center of the steel wire cable is kept coincide with centers of the anchor cups, and steel wires are prevented from contacting the anchor cups.

c. Bottom openings of the anchor cups are sealed to prevent the alloy from leaking via the bottom openings. The anchor cups are preheated.

d. The zinc-copper alloy or the zinc-copper-aluminum alloy is poured into the anchor cups for one-step casting while avoiding any vibration or disruption.

7) Performing tension detection or top pressure detection

[0029] The tension detection or the top pressure detection are important means to detect the quality of the steel wire cable. According to fillers for the casting of the anchor, the tension detection is performed on the steel wire cable with chilled-casted anchor or the top pressure detection is performed on the steel wire cable with hot-casted anchor before leaving a plant, which is specifically as follows:

[0030] For the steel wire cable with the chilled-casted anchor, the steel wire cable is stretched by an overstretching force which is set to be between 1.1 and 1.5 folds of a designed tension of the steel wire cable and satisfies that a retraction value of a casting body inside the anchor cup after stretching is equal to or less than 6 mm.

[0031] The overstretching force is then unloaded to be 20% of the original overstretching force or to be the designed tension of the steel wire cable after the stretching. A length of the steel wire cable is measured at a constant temperature in the dark, and a stressless length of the steel wire cable is calculated at a reference temperature according to the following equation:

$$L_{CO} = \frac{L_{CP}}{1 + \frac{P_{20}}{EA} + \alpha(t - t_0)}$$

in which, L_{CO} represents the stressless length, m , of the steel wire cable at the reference temperature; L_{CP} represents a length, m , of the steel wire cable loaded with a tension force of P_{20} ; P_{20} represents 20% of the overstretching force, N ; A represents a nominal area, mm^2 , of the steel wire bunch of the steel wire cable; E represents an elastic modulus, MPa ; α represents a coefficient

of linear expansion of a stay cable which is equal to $0.000012/^{\circ}\text{C}$; t represents the constant temperature, $^{\circ}\text{C}$, when measuring a length of the stay cable; and t_0 represents a designed reference temperature, $^{\circ}\text{C}$, of the stay cable.

[0032] For the steel wire cable with hot-casted anchor, A top pressure is applied to the steel wire cable. The top pressure is 1.25 folds of the designed tension of the steel wire cable and satisfies that a retraction value of the casting body inside the anchor cup after the top pressure detection is equal to or less than 6 mm.

8) Coiling

[0033] The steel wire cable is coiled by a coil frame. Before the coiling, an outer surface of the steel wire cable is packed, and layers of the steel wire cables are successively coiled by using the coil frame. An inner diameter of a resulting coil is equal to or larger than 20 folds of an outer diameter of the steel wire cable and is equal to or larger than 1.6 m.

9) Storing

[0034] Finished product of the steel wire cable adopts indoor storage or outdoor storage. When the indoor storage is adopted, an oilcloth is used to cover the steel wire cable. A storage site is equipped with ventilation and fire-proof facilities to ensure the quality and the safety of the stored steel wire cables.

[0035] Compared with the prior art, the method for fabricating the steel wire cable comprising the extruded polyethylene and the zinc-aluminum alloy plating has the following advantages: the steel wires are arranged according to the arrangement rule at the cross section of the steel wire cable. The length of the overall cable is controlled by the length of the central standard wire. The bunch of the steel wires comprising the zinc-aluminum alloy plating are twisted with the torsion angle of between 2° and 4° . The steel wire bunch is then wrapped with the polyester wrapping bandage and covered with the double-layered protective polyethylene sheath by using double-cavity co-extrusion process for one-step formation, and the outer surface of the polyethylene sheath is provided with embossments for rain-wind induced vibration resistance. The two ends of the steel wire cable are fixed by anchors using fillers, coiled, and stored. And the coils of the steel wire cables are then transported to and respectively laid on the construction field. The fabrication of the steel wire cable of the invention is not restricted by the construction site, and hardly affected by the climate factors. And the management of the industrialized production is easily controllable. All these satisfy the use requirements of long length, high accuracy, and endurance of the stay cable for the large-span bridge used in the marine environment.

FIG. 1 is a structure diagram illustrating two nut-

screwing type anchors at two ends of a steel wire cable;

FIG. 2 is a structure diagram illustrating two anchor plate gap adjusting type anchors at two ends of a steel wire cable;

FIG. 3 is a structure diagram illustrating a fork-ear pin joint type anchor at one end of a steel wire cable and a nut-screwing type anchor at the other end of the steel wire cable; and

FIG. 4 is a side view of FIG. 3.

[0036] In the drawings, the following numbers are utilized: 1. Anchor plate; 2. Anchor cup; 3. Sealing assembly of a connecting cylinder; 4. Steel wire cable; 5. Sealing structure at an end of a steel wire cable; 6. Nut; 7. Gap adjusting plate; 8. Pin shaft; and 9. Fork ear.

[0037] For further illustrating the invention, experiments detailing a method for fabricating a steel wire cable comprising an extruded polyethylene and a zinc-aluminum alloy plating are described below. It should be noted that the following examples are intended to describe and not to limit the invention.

[0038] In the method of the invention, steel wires comprising a zinc-aluminum alloy plating are twisted together to form a naked steel wire cable, an outer layer of the naked steel wire cable is covered by a double-layered protective polyethylene by extrusion. Two ends of a resulting steel wire cable are then anchored by casting, coiled, transported to the construction site and laid respectively.

1) fabricating a steel wire comprising a zinc-aluminum alloy plating

[0039] The steel wire comprising the zinc-aluminum alloy plating is adopted because the zinc-aluminum alloy plating possesses much stronger anti-corrosive property. The zinc-aluminum alloy plating includes two types, Zn95Al5 5 having an aluminum content of between 4.2 and 7.2 wt. %, and Zn90Al10 having the aluminum content of between 9.2 and 12.2 wt. %. A plating weight is equal to or larger than 300 g/m^2 .

2) fabricating a steel wire having a standard length

[0040] As each layer of steel wires in the stay cable exists with a certain torsion angle, it is unable to directly control the length of the steel wire cable by using the outer layers of steel wires. Only the central wire of the stay cable always remains straight without being twisted during the whole fabrication process, therefore, the central wire is utilized as the standard wire to control the overall length of the steel wire cable.

[0041] The length of the standard wire is determined by baseline measurement, and specific operation in-

cludes: applying a certain tension force to two ends of a steel wire to straighten the steel wire a performing stress correction and temperature correction using the following equation:

$$L=L_0 \times [(1 + F/EA) + \alpha (T-20)]$$

in which, L represents a length (m) of the steel wire in a stressed state, L_0 represents a designed length, m, of the steel wire in an unstressed state, F represents a tensioning force, N , E represents an elastic module, MPa , of the steel wire, and fabrication of the standard wire adopts a measured value, A represents an area of a cross section, m^2 , of the steel wire, and fabrication of the standard wire adopts the measured value, α represents an expansion coefficient of the steel wire, and T represents a temperature, $^{\circ}C$, of the environment.

[0042] A steel wire having a standard length is prepared. Certain markers for cutting are made at two ends of the steel wire. Thereafter, the steel wire having the standard length is utilized as a reference, and the overall length of the steel wire cable is controlled by a transfer method.

3) twisting a steel wire bunch

[0043] The steel wire cable is formed by multiple layers of steel wires. When relaxing the steel wires, the standard wire is positioned at a center position of a cross section of the steel wire cable.

[0044] A steel wire bunch is twisted to the left with a torsion angle of between 2° and 4° . The twisted steel wire bunch is wrapped to the right by a wrapping bandage to yield a naked steel wire cable as a semi-product. As lengths of the multiple layers of the steel wires exist with differences, a relaxed length L' of other layers of steel wires surrounding the standard wire considering the length of the standard wire is calculated according to the following equation:

$$L_0 = L' \times \cos \alpha + K$$

in which, α represents the torsion angle ranging from 2° to 4° ; K represents a fabrication allowance, m , which is selected according to specifications and operations; L' represents the relaxed length, m , of other layers of the steel wires surrounding the standard wire; and L_0 represents the length, m , of the standard wire at the center position;

[0045] An outer diameter of the steel wire bunch, i. e., the naked steel wire cable, after being twisted is measured. Because the cross section of the steel wire bunch is in a shape of hexagon, a circumscribed circle of the selected cross section of the steel wire bunch is directly the diameter of the naked steel wire cable.

4) extruding

[0046] A double-layered protective polyethylene is prepared outside the naked steel wire cable. before extruding, a die aperture of an extruder and an extrusion velocity are preset according to an outer diameter of the naked steel wire cable and thicknesses of two layers of polyethylene. The double-cavity co-extrusion for one-step formation is adopted. The two layers of the polyethylene plastics simultaneously cover the naked steel wire cable during the requirements of anti-corrosion.

[0047] According to the requirement of resistance of the rain-wind induced vibration, after the extrusion, an outer surface of the double-layered protective polyethylene is provided with helical lines or embossments. When reaching the effect of the steel wire cable in effectively inhibiting the rain-wind induced vibration, a drag coefficient is equal to or smaller than 0.8.

5) accurate cutting

[0048] Original cutting positions of the steel wire cable are determined, the double-layered protective polyethylene is locally stripped, and the markers for cutting at two ends of the standard wire at the center position of the steel wire cable are found. Then, the steel wire cable is cut by using a non-liquid cutting machine and end faces of the steel wire cable are ensured perpendicular to an axis of the steel wire cable. The double-layered protective polyethylene is stripped according to a preset length to expose the steel wires, during which, the plating of the steel wires is prevented from being destructed.

6) casting anchor

[0049] The anchor is a main connecting structure to transmit a tension of the steel wire cable to a tower and a girder. Anchor structures of the steel wire cable are as follows: two nut-screwing type anchors disposed at two ends of the steel wire cable, as shown in FIG. 1, two anchor plate gap adjusting type anchors at two ends of the steel wire cable, as shown in FIG. 2, and a fork-ear pin joint type anchor at one end of the steel wire cable and a nut-screwing type anchor at the other end of the steel wire cable, as shown in FIGS. 3-4.

a) Nut-screwing type anchor

[0050] The nut screwing type anchor comprises: an anchor cup, a screw nut, an anchor plate, and a sealing assembly of a connecting cylinder. Such steel wire cable utilizes the end face of the nut to support the pressure and to transmit the load. The nut and the anchor cup are in rotary joint via a trapezoidal thread having high strength to realize the continuous adjustment of the length of the steel wire cable. The anchor cup is provided with tensional inner threads. In installation of the steel wire cable on the construction site, an installation force is applied

on the steel wire cable by drawing the anchor. The anchor plate primarily functions in dispersing the steel wires, steel wire holes are distributed on the anchor plate, and the steel wires pass through corresponding steel wire holes and are headed. An external cone boss can be tightly attached to an internal conical cavity.

b) End face-supporting type anchor

[0051] The end face-supporting type anchor comprises: an anchor cup, an anchor plate, and a sealing assembly of a connecting cylinder. End faces of such steel wire cable are directly supported on anchor plate, and different gap adjusting plates are utilized to regulate the length of the steel wire cable. The gap adjusting plates have different thicknesses to satisfy the requirement of the construction site. The anchor cup is provided with tensional inner threads. In installation of the steel wire cable on the construction site, an installation force is applied on the steel wire cable by drawing the anchor. Such kind of anchor does not necessitate nuts, and the anchor cup is not provided with external threads. The anchor plate functions in dispersing the steel wires, the steel wire holes are distributed on the anchor plate, and the steel wires pass through corresponding steel wire holes and are headed. An external cone boss can be tightly attached to an internal conical cavity.

c) Fork-ear pin joint type anchor at one end and nut-screwing type anchor at the other end

[0052] The fork-ear pin joint type anchor comprises: a fork ear, a pin shaft, an anchor cup, a nut, and a sealing assembly of a connecting cylinder. One end of such steel wire cable is connected to the steel structure of the tower or the girder via the fork ear and the pin shaft, and the other end of the steel wire cable adopts an end face of a nut to bear pressure and to transmit the load, thus realizing the continuous adjustment of the length of the steel wire cable. the anchor cup is provided with tensional inner threads. In installation of the steel wire cable on the construction site, an installation force is applied on the steel wire cable by drawing the anchor. The anchor plate functions in dispersing the steel wires, the steel wire holes are distributed on the anchor plate, and the steel wires pass through corresponding steel wire holes and are headed. An external cone boss can be tightly attached to an internal conical cavity.

[0053] The sealing assembly of the connecting cylinder in the above three structures all adopts the new type of cable end sealing technology, in which, an outer part of the connecting cylinder is firstly sealed by a sealing cover, and an inner wall of the connecting cylinder in the vicinity of a port is sealed again by an elastic sealing ring and a sealing press ring. The two sealing measurements finally realizes the sealing of the two ends of the steel wire cable, that is, the sealing between the anchors and the interfaces of the polyethylene steel wire cable. The

sealing assembly has stronger strength, thus being difficult to be destructed, much longer service life, and much endurable sealing structure.

[0054] The sealing structure at the ends of the steel wire cable is a reliable mechanical sealing structure, configured to prevent the corrosion resulting from the water penetration into the PE cable. In the meanwhile, the sealing structure, as a substitute of a heat shrink sleeve, is utilized for sealing, thus overcoming the problem of damage of the heat shrink sleeve.

[0055] The technical solution to solve the above described technical problem is as follows: an endurable sealing structure at an end of the steel wire cable. The sealing structure fits together with the connecting cylinder of the anchor and comprises: the elastic sealing ring, a sealing press ring, and a sealing cover. The sealing press ring is disposed in the port of the connecting cylinder and an outer end of the sealing press ring is exposed outside the connecting cylinder. A press surface is formed on the inner wall of the connecting cylinder relative to the inner end face of the sealing press ring. The elastic sealing ring is disposed between the inner end face of the sealing press ring and the press surface. Under the press of the press surface, the elastic sealing ring is deformed and attached to the outer wall of the steel wire cable. The sealing cover is disposed on a front end of the connecting cylinder and possesses a Harvard structure. A front part of the sealing cover contacts and fits with the outer wall of the steel wire cable and a corresponding contact surface is provided with a sealing ring. A rear part of the sealing cover contacts and fits with the sealing press ring or the connecting cylinder and a corresponding contact surface is provided with a sealing strip.

[0056] The anchor is performed with hot galvanizing or paints coating for corrosion resistance. A thickness of the hot galvanizing is equal to or larger than 90 μm , and a thickness of the paints coating is determined according to specifications and design requirements of a steel structure.

[0057] The casting of the anchor is carried out by chill casting of heading anchor or by hot casting of anchor, operations of which are as follows:

A. Chill casting of heading anchor

[0058]

a. Ends of the steel wires are fixed in anchor cups on a casting platform, oil stains and rusts are removed from portions of the steel wires inside the anchor cups, and inner walls of the anchor cups are synchronously washed.

b. The ends of the steel wires are uniformly dispersed corresponding to holes of anchor plates, and each steel wire is headed by using a heading machine. Heading dimensions are as follows: heading diameter $\geq 14 D$, heading height $\geq 1.0 D$, and D represents

a diameter of the steel wires.

c. A chilled filler comprising steel balls, a stone dust, an epoxy resin, a curing agent, di-n-butyl, and a diluent is provided and uniformly mixed. A mixture of the chilled filler is poured into the anchor cups while vibrating by using a vibration pump to fully fill gaps among the anchor cup and steel wires with the mixture of the chilled filler.

B. Hot casting of anchor

[0059] The hot casting anchor adopts a zinc alloy for casting, and a zinc-copper alloy and a zinc-copper-aluminum alloy are the common two alloys.

[0060] The zinc-copper alloy comprises 98 ± 0.2 wt. % of zinc and 2 ± 0.2 wt. % of copper, and the zinc-copper-aluminum alloy comprises 4 - 7 wt. % of aluminum, 1 - 2 wt. % of copper, and 91 - 95 wt. % of zinc. The casting is performed as follows:

a. Ends of the steel wires are perpendicularly fixed in anchor cups on the casting platform, steel wires comprising a zinc-aluminum alloy plating are dispersed inside the anchor cups in the form of concentric circles. Oil stains and rusts are then removed from surfaces of the steel wires, and the inner walls of the anchor cups are simultaneously washed.

b. The center of the steel wire cable is kept coincide with centers of the anchor cups, and steel wires are prevented from contacting the anchor cups.

c. Bottom openings of the anchor cups are sealed to prevent the alloy from leaking via the bottom openings. The anchor cups are preheated.

d. The zinc-copper alloy or the zinc-copper-aluminum alloy is poured into the anchor cups for one-step casting while avoiding any vibration or disruption.

7) Performing tension detection or top pressure detection

[0061] The tension detection or the top pressure detection are important means to detect the quality of the steel wire cable. According to fillers for the casting of the anchor, the tension detection is performed on the steel wire cable with chilled-casted anchor or the top pressure detection is performed on the steel wire cable with hot-casted anchor before leaving a plant, which is specifically as follows:

For the steel wire cable with the chilled-casted anchor, the steel wire cable is stretched by an overstretching force which is set to be between 1.1 and 1.5 folds of a designed tension of the steel wire cable and satisfies that a retraction value of a casting body inside the anchor cup after stretching is equal to or less than 6 mm.

[0062] The overstretching force is then unloaded to be 20% of the original overstretching force or to be the designed tension of the steel wire cable after the stretching. A length of the steel wire cable is measured at a constant temperature in the dark, and a stressless length of the steel wire cable is calculated at a reference temperature according to the following equation:

$$L_{CO} = \frac{L_{CP}}{1 + \frac{P_{20}}{EA} + \alpha(t - t_0)}$$

in which, L_{CO} represents the stressless length, m , of the steel wire cable at the reference temperature; L_{CP} represents a length, m , of the steel wire cable loaded with a tension force of P_{20} ; P_{20} represents 20% of the overstretching force, N ; A represents a nominal area, mm^2 , of the steel wire bunch of the steel wire cable; E represents an elastic modulus, MPa ; α represents a coefficient of linear expansion of a stay cable which is equal to $0.000012/^\circ C$; t represents the constant temperature, $^\circ C$, when measuring a length of the stay cable; and t_0 represents a designed reference temperature, $^\circ C$, of the stay cable.

[0063] An error of the stressless length of the steel wire cable at the reference temperature satisfies the following requirements:

when $L_{CO} \leq 100$ m, the error is less than or equal to 10 mm; and

when $L_{CO} > 100$ m, the error is less than or equal to $L_{CO}/20000 + 5$ mm.

[0064] For the steel wire cable with hot-casted anchor, a top pressure is applied to the steel wire cable. The top pressure is 1.25 folds of the designed tension of the steel wire cable and satisfies that a retraction value of the casting body inside the anchor cup after the top pressure detection is equal to or less than 6 mm.

8) Coiling

[0065] The steel wire cable is coiled by a coil frame. Before the coiling, an outer surface of the steel wire cable is packed, and layers of the steel wire cables are successively coiled by using the coil frame. An inner diameter of a resulting coil is equal to or larger than 20 folds of an outer diameter of the steel wire cable and is equal to or larger than 1.6 m.

9) Storing

[0066] Finished product of the steel wire cable adopts indoor storage or outdoor storage. When the indoor storage is adopted, an oilcloth is used to cover the steel wire cable. A storage site is equipped with ventilation and fire-

proof facilities to ensure the quality and the safety of the stored steel wire cables.

Claims

1. A method for fabricating a steel wire cable comprising an extruded polyethylene and a zinc-aluminum alloy plating, the method comprising:

- 1) fabricating a steel wire comprising a zinc-aluminum alloy plating

preparing a zinc-aluminum alloy plating on a surface of the steel wire, in which, the zinc-aluminum alloy adopts a Zn95Al5 having an aluminum content of between 4.2 and 7.2 wt. % or a Zn90Al10 having the aluminum content of between 9.2 and 12.2 wt. %, and a weight of the zinc-aluminum alloy plating is equal to or larger than 300 g/m²;

- 2) fabricating a steel wire having a standard length

making a central wire as a standard wire and determining a length of the standard wire by baseline measurement, applying a certain tension force to two ends of a steel wire to straighten the steel wire and performing stress correction and temperature correction to prepare a steel wire having a standard length; making certain markers for cutting at two ends of the steel wire; making the steel wire having the standard length as a reference, and controlling an overall length of the steel wire cable by a transfer method;

- 3) twisting a steel wire bunch

relaxing steel wires, positioning the standard wire at a center position of a cross section of the steel wire cable to be formed by a plurality of layers of the steel wires; twisting a steel wire bunch to the left with a torsion angle of between 2° and 4°; wrapping the twisted steel wire bunch to the right by a wrapping bandage to yield a naked steel wire cable as a semi-product; and calculating a relaxed length L' of other layers of steel wires surrounding the standard wire considering the length of the standard wire and a torsion rate according to the following equation:

$$L_0 = L' \times \cos \alpha + K$$

in which, α represents the torsion angle ranging from 2° to 4°; K represents a fabrication allowance, m , which is selected according to specifications and operations; L' represents the relaxed length, m , of other layers of the steel wires surrounding the standard wire; and L_0 represents the length, m , of the standard wire at the

center position;

- 4) extruding

preparing a double-layered protective polyethylene outside the naked steel wire cable, in which the double-layered protective polyethylene has a density of between 0.942 and 0.978 g/cm³, environmental stress crack resistance property of $\geq 5000 F_0/h$, and a melt index of ≤ 0.45 g/10 min; before extruding, presetting a die aperture of an extruder and an extrusion velocity according to an outer diameter of the naked steel wire cable and thicknesses of two layers of polyethylene; in which, the die aperture of the extruder is provided with two layers of discharge channel, and the two layers of polyethylene simultaneously cover the naked steel wire cable during the extrusion;

- 5) cutting

determining original cutting positions of the steel wire cable, locally stripping the double-layered protective polyethylene, finding the markers for cutting at two ends of the standard wire at the center position of the steel wire cable; cutting the steel wire cable by using a non-liquid cutting machine and ensuring end faces of the steel wire cable perpendicular to an axis of the steel wire cable; stripping the double-layered protective polyethylene according to a preset length to expose the steel wires;

- 6) casting anchor

providing an anchor functioning as a main connecting structure to transmit a tension of the steel wire cable to a tower and a girder; performing hot galvanizing or paints coating on the anchor for corrosion resistance, in which, a thickness of the hot galvanizing is equal to or larger than 90 μm , and a thickness of the paints coating is determined according to specifications and design requirements of a steel structure; casting the anchor by chill casting of heading anchor or by hot casting of anchor, operations of which are as follows:

A. chill casting of heading anchor

- a. fixing ends of the steel wires in anchor cups on a casting platform, removing oil stains and rusts from portions of the steel wires inside the anchor cups, and synchronously washing inner walls of the anchor cups;

- b. uniformly dispersing the ends of the steel wires corresponding to holes of anchor plates, and heading each steel wire by using a heading machine, in which, heading dimensions are as follows: heading diameter $\geq 14 D$, heading height $\geq 1.0 D$, and D represents a di-

ameter of the steel wires;

c. providing and uniformly mixing a chilled filler comprising steel balls, a stone dust, an epoxy resin, a curing agent, di-n-butyl, and a diluent; pouring a mixture of the chilled filler into the anchor cups while vibrating by using a vibration pump to fully fill gaps among the anchor cup and steel wires with the mixture of the chilled filler;

B. hot casting of anchor

providing a zinc-copper alloy comprising 98 ± 0.2 wt. % of zinc and 2 ± 0.2 wt. % of copper, or a zinc-copper-aluminum alloy comprising 4 - 7 wt. % of aluminum, 1 - 2 wt. % of copper, and 91 - 95 wt. % of zinc; and performing casting as follows:

- a. perpendicularly fixing ends of the steel wires in anchor cups on the casting platform, dispersing steel wires comprising a zinc-aluminum alloy plating inside the anchor cups in the form of concentric circles, removing oil stains and rusts from surfaces of the steel wires, and simultaneously washing the inner walls of the anchor cups;
- b. keeping the center of the steel wire cable coincide with centers of the anchor cups and preventing steel wires from contacting the anchor cups;
- c. sealing bottom openings of the anchor cups to prevent the alloy from leaking via the bottom openings; and pre-heating the anchor cups;
- d. pouring the zinc-copper alloy or the zinc-copper-aluminum alloy into the anchor cups for one-step casting while avoiding any vibration or disruption;

7) performing tension detection or top pressure detection

according to fillers for the casting of the anchor, performing tension detection on the steel wire cable with chilled-casted anchor or performing top pressure detection on the steel wire cable with hot-casted anchor before leaving a plant, which is specifically as follows:

for the steel wire cable with the chilled-casted anchor, stretching the steel wire cable by an overstretching force which is set to be between 1.1 and 1.5 folds of a designed tension of the steel wire cable and satisfies that a retraction value of a casting body inside the anchor cup after stretching is equal to or less than 6 mm;

unloading the overstretching force to be 20% of the original overstretching force or to be the designed tension of the steel wire cable after the stretching; measuring a length of the steel wire cable at a constant temperature in the dark, and calculating a stressless length of the steel wire cable at a reference temperature according to the following equation:

$$L_{CO} = \frac{L_{CP}}{1 + \frac{P_{20}}{EA} + \alpha(t - t_0)}$$

in which, L_{CO} represents the stressless length, m , of the steel wire cable at the reference temperature; L_{CP} represents a length, m , of the steel wire cable loaded with a tension force of P_{20} ; P_{20} represents 20% of the overstretching force, N ; A represents a nominal area, mm^2 , of the steel wire bunch of the steel wire cable; E represents an elastic modulus, MPa ; α represents a coefficient of linear expansion of a stay cable which is equal to $0.000012/^\circ C$; t represents the constant temperature, $^\circ C$, when measuring a length of the stay cable; and t_0 represents a designed reference temperature, $^\circ C$, of the stay cable;

for the steel wire cable with hot-casted anchor, applying, to the steel wire cable, a top pressure which is 1.25 folds of the designed tension of the steel wire cable and satisfies that a retraction value of the casting body inside the anchor cup after the top pressure detection is equal to or less than 6 mm; and

8) coiling

packing an outer surface of the steel wire cable, coiling layers of the steel wire cables successively by using a coil frame, in which, an inner diameter of a resulting coil is equal to or larger than 20 folds of an outer diameter of the steel wire cable and is equal to or larger than 1.6 m.

2. The method of claim 1, **characterized in that** when determining the length of the standard wire in 2), stress correction and temperature correction are then carried out according to the following equation:

$$L = L_0 \times [(1 + F/EA) + \alpha(T - 20)]$$

in which, L represents a length (m) of the steel wire in a stressed state, L_0 represents a designed length, m , of the steel wire in an unstressed state, F repre-

sents a tensioning force, N , E represents an elastic module, MPa , of the steel wire, and fabrication of the standard wire adopts a measured value, A represents an area of a cross section, m^2 , of the steel wire, and fabrication of the standard wire adopts the measured value, α represents an expansion coefficient of the steel wire, and T represents a temperature of the environment.

3. The method of claim 1, **characterized in that** in extrusion process in 4), a magnetic field is arranged above the steel wire cable to make the steel wire cable in a suspension state; after the extrusion process, the double-layered protective polyethylene and the naked steel wire cable are concentrically arranged.
4. The method of claim 1, **characterized in that** an outer surface of the double-layered protective polyethylene is provided with helical lines or embossments, and a drag coefficient is equal to or smaller than 0.8.
5. The method of claim 1, **characterized in that** structures of the anchors in 6) adopt a nut-screwing type anchor, an anchor plate gap adjusting type anchor, or a fork-ear pin joint type anchor at two ends of the steel wire cable.
6. The method of claim 1, **characterized in that** in 7), an error of the stressless length of the steel wire cable at the reference temperature satisfies the following requirements:
 - when $L_{C0} \leq 100$ m, the error is less than or equal to 10 mm; and
 - when $L_{C0} > 100$ m, the error is less than or equal to $L_{C0}/20000 + 5$ mm.
7. The method of claim 1, **characterized in that** the wrapping bandage is a bandage made from a polyester fiber; the wrapping bandage has a width of between 40 and 60 mm and a tensile strength of equal to or high than $500 \text{ N}/25 \text{ mm}^2$.

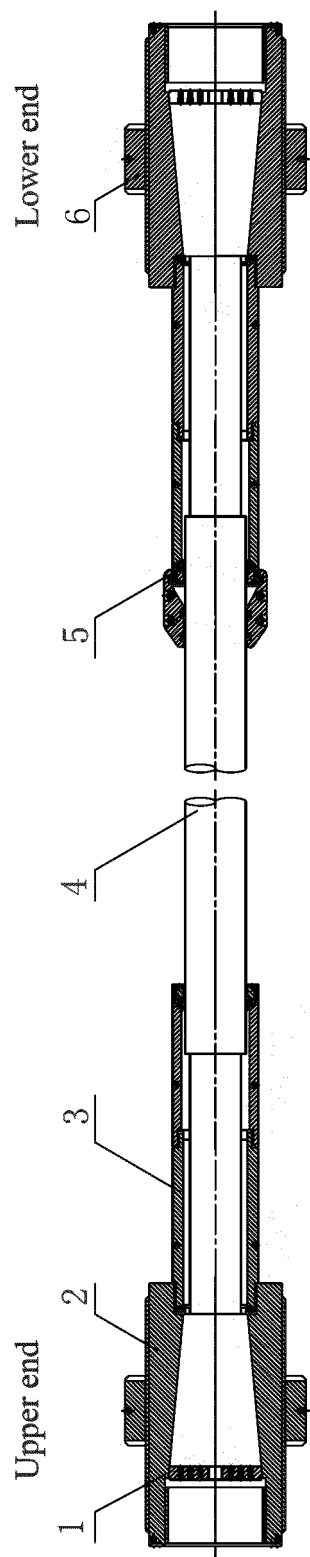


FIG. 1

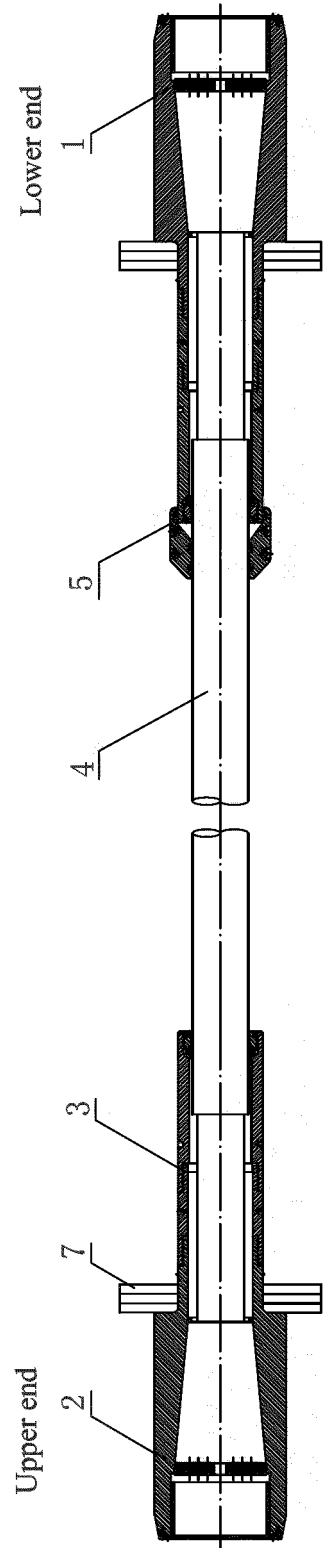


FIG. 2

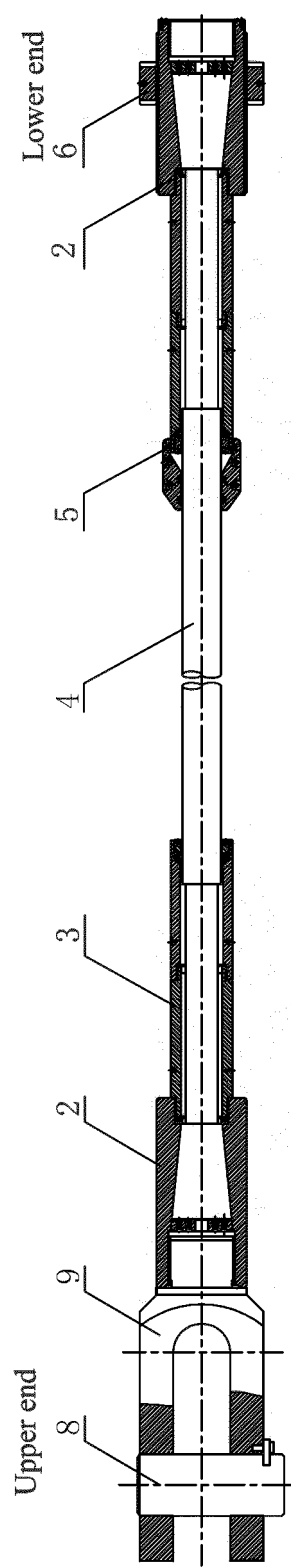


FIG. 3

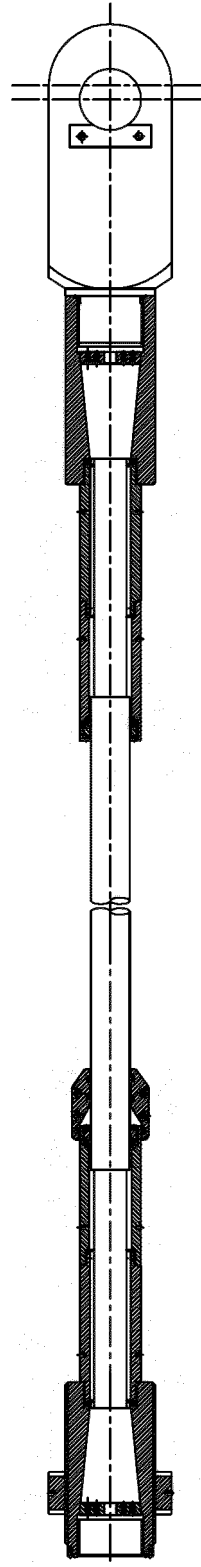


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2016/083894

A. CLASSIFICATION OF SUBJECT MATTER

E01D 19/16 (2006.01) i; D07B 1/10 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E01D; D07B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNKI, WPI, EPODOC: dragline, hawser, steel wire, hot extrude, extrusion molding, layup, anchor-filling, cord?, cable?, wire?, steel, extrud+, polyethylene, zinc, aluminum, alloy, twist+, anchor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 101608431 A (SHANGHAI PUJIANG CABLE CO., LTD. ZHEJIANG PUJIANG CABLE CO., LTD.) 23 December 2009 (23.12.2009) see description, page 3, paragraph 2 to page 4, paragraph 1	1-7
A	CN 2635725 Y (YUAN, Guodong) 25 August 2004 (25.08.2004) see the whole document	1-7
A	CN 1091791 A (N.V. BEKAERT S.A) 07 September 1994 (07.09.1994) see the whole document	1-7
A	CN 1672906 A (JIANGSU FA'ERSHENG XINRI IRON CABLE CO., LTD.) 28 September 2005 (28.09.2005) see the whole document	1-7
A	CN 201704627 U (SHANGHAI PUJIANG CABLE CO., LTD.) 12 January 2011 (12.01.2011) see the whole document	1-7

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family

Date of the actual completion of the international search
23 August 2016Date of mailing of the international search report
28 September 2016Name and mailing address of the ISA
State Intellectual Property Office of the P. R. China
No. 6, Xitucheng Road, Jimenqiao
Haidian District, Beijing 100088, China
Facsimile No. (86-10) 62019451

Authorized officer

HAO, Guiliang

Telephone No. (86-10) 62085399

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/083894

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 202007007210 U1 (DYWIDAG SYSTEMS INT GMBH) 16 August 2007 (16.08.2007) see the whole document	1-7
A	JP 2014232638 A (J POWER SYSTEMS CORP.) 11 December 2014 (11.12.2014) see the whole document	1-7
A	EP 0855471A1 (FREYSSINET INT STUP) 29 July 1998 (29.07.1998) see the whole document	1-7

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
 Information on patent family members

 International application No.
 PCT/CN2016/083894

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 101608431 A	23 December 2009	None	
CN 2635725 Y	25 August 2004	None	
CN 1091791 A	07 September 1994	CA 2109904 C	14 September 2004
		CN 1043536 C	02 June 1999
		AU 668433 B2	02 May 1996
		ZA 9309119 B	05 August 1994
		ZA 9309119 A	05 August 1994
		DK 0602733 T3	27 July 1998
		JP 3598125 B2	08 December 2004
		EP 0602733 B1	12 November 1997
		DE 69315181 D1	18 December 1997
		AT 160188 T	15 November 1997
		CA 2109904 A1	19 June 1994
		EP 0602733 A1	22 June 1994
		AU 5209593 A	30 June 1994
		BR 9305084 A	26 July 1994
		JP H06240590 A	30 August 1994
		ES 2111709 T3	16 March 1998
		US 5461850 A	31 October 1995
		DE 69315181 T2	02 April 1998
CN 1672906 A	28 September 2005	None	
CN 201704627 U	12 January 2011	None	
DE 202007007210 U1	16 August 2007	DE 102008022448 A1	18 December 2008
		DE 102008022448 A8	23 April 2009
JP 2014232638 A	11 December 2014	None	
EP 0855471 A1	29 July 1998	FR 2739113 A1	28 March 1997
		DK 0855471 T3	22 April 2002
		PT 855471 E	28 June 2002

INTERNATIONAL SEARCH REPORT
Information on patent family membersInternational application No.
PCT/CN2016/083894

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
		DE 69709844 D1	28 February 2002
		FR 2739113 B1	05 December 1997
		AT 211518 T	15 January 2002
		EP 0855471 B1	02 January 2002
		DE 69709844 T2	05 September 2002
		ES 2170341 T3	01 August 2002