



(11)

EP 2 362 918 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
08.01.2014 Bulletin 2014/02

(51) Int Cl.:
D02G 3/12 ^(2006.01) **D02G 3/44** ^(2006.01)

(21) Application number: **09756749.9**

(86) International application number:
PCT/EP2009/065781

(22) Date of filing: **24.11.2009**

(87) International publication number:
WO 2010/060913 (03.06.2010 Gazette 2010/22)

(54) NEW METAL FIBER YARN WITH ENHANCED STRENGTH AND PROCESSABILITY

NEUES METALLFASERGARN MIT VERBESSERTER FESTIGKEIT UND VERARBEITBARKEIT

NOUVEAU FIL DE FIBRE MÉTALLIQUE DOTÉ D'UNE RÉSISTANCE ET D'UNE APTITUDE AU
TRAITEMENT AMÉLIORÉE

(84) Designated Contracting States:
**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 SE SI SK SM TR**

(30) Priority: **25.11.2008 EP 08169883**

(43) Date of publication of application:
07.09.2011 Bulletin 2011/36

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WO-A-2007/065606 JP-A- 10 018 189
JP-A- 51 006 846 US-A- 3 451 305
US-A- 3 601 970

- **DATABASEWPI** Section Ch, Week 2009 Thomson Scientific, London, GB; Class F02, AN 2009-
**A99066 XP002532653 "Metal fiber folded yarns
comprise metal fiber bundles containing metal
fibers" & CN 101 307 518 A (HUNAN HUITONG
ADVANCED MATERIALS CO LTD) 19 November
2008 (2008-11-19)**

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Description

Technical Field

5 **[0001]** The present invention relates to continuous metal fibers and bundles of continuous metal fibers, obtained by the bundled drawing of wires. More specifically, the present invention relates to high quality metal fiber yarns and methods of producing these metal fiber yarns.

Background Art

10 **[0002]** Metal fiber bundles can be obtained in various ways. Metal fibers can be obtained by a method of bundled drawing as described e.g. US3379000. Metal fibers can also be obtained e.g. by drawing till final diameter, also called end drawing. Typically, metal fibers are less than 60 μm in equivalent diameter. A metal fiber bundle is generally characterised as an array of parallel metal fibers. One type of metal fiber bundles include continuous metal fibers e.g. as obtained by bundled drawing or end drawing and combining these metal fibers into a bundle. Such metal fiber bundles can then be combined to produce metal fiber yarns. These yarns have properties such as a determined strength and electrical resistance.

15 **[0003]** US-A-3451305 discloses a limp fishing leader line material having 6 bundles of 90 filaments each and a nylon jacket covering the bundles, wherein the 6 bundles are twisted on a conventional wire strander at approximately 10 twists/inch.

20 **[0004]** CN-A-101307518 discloses a metal fiber yarn comprising 1 to 5000 bundles of metal fibers, each bundle comprises 1 to 1000 metal fibers M1, metal fibers M2 or metal fibers M3. The material of M1, M2 and M3 is different.

25 **[0005]** JP-A-10018189 discloses a twisted metal fiber yarn comprising two to four metal fiber bundles not preliminarily twisted, which are plastically deformed in spiral forms, and the metal fiber bundles are twisted in one direction and the bundles do not have an untwisting habit. The diameters of the metal fibers are 2-20 μm , and the number of the metal fibers constituting the metal fiber bundle is 100-2000. The number of fuzzes on the twisted metal fiber is ≤ 10 per 10cm of the longitudinal length of the fiber, and the twisting number of the metal fiber bundle is 100-500 twists/m.

30 **[0006]** WO-A-2007/065606 discloses an application of metal fiber yarn for weaving a textile fabric. The yarn in the textile fabric may be bundle drawn metal multifilament yarn or polymer multifilament yarn.

[0007] JP-A-51006846 discloses a manufacturing method of a metal fiber yarn. The method is a cold bundle drawn method, first, applying a covering on the bundles of metal wire, then drawing the bundles of metal wire, and then removing the covering.

35 **[0008]** To increase the strength of a metal fiber yarn with continuous metal fibers of a certain thickness, more metal fibers need to be in the yarn. This can be done in two ways: by increasing the amount of metal fibers in the bundles or by increasing the amount of metal fiber bundles in the yarn.

[0009] Increasing the amount of metal fibers per bundle in the yarn has, however, a negative effect on the flexibility of the metal fiber yarn.

[0010] Using more metal fiber bundles in the yarn has proven to be limited, i.e. an increase in the amount of metal fiber bundles, did not result in the expected and desired increase of the strength of the metal fiber yarn.

40 **[0011]** It was further noted that an increase in the amount of metal fiber bundles in the yarn also increased the occurrence of sleeving or decomposition of the yarn resulting in bad processability of the yarn, especially when the metal fiber yarns are made through bundled drawing followed by yarn construction on composite level. When such sleeving sensitive metal fiber yarn is used during subsequent processing, congestion in guiding parts or on small passages may occur.

45 **[0012]** The smaller than expected increase in breaking force of the yarns consisting out of 5 or more continuous metal fiber bundles occurring together with an increase in the sleeving phenomenon, made people in the art conclude that using 5 or more metal fiber bundles in a yarn was not favorable.

[0013] Accordingly, this invention seeks to provide metal fiber yarns with higher breaking force without losing flexibility and without leading to sleeving of the metal fiber yarns.

Disclosure of Invention

50 **[0014]** An aspect of the claimed invention provides a metal fiber yarn which comprises continuous bundle drawn metal fibers. The metal fiber yarn comprises at least 5 bundles of continuous fibers twisted together to form a yarn. All of the continuous fiber bundles in the metal fiber yarn are metal fiber bundles. Each bundle of continuous metal fibers comprises at least 30 metal fibers and preferably less than 2500 metal fibers. In a more preferred embodiment each bundle of continuous metal fibers comprises 1000 fibers. In an alternative preferred embodiment each bundle of continuous metal fibers comprises 275 or 90 fibers. In another alternative embodiment, the yarn comprises bundles with different amounts

of metal fibers, e.g. bundles with 275 fibers combined with bundles with 90 fibers. The amount of continuous fiber bundles in the yarn is preferably equal to or less than 30, such as 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29.

The continuous fiber bundles in the metal fiber yarn are mutually substantially equal in length per unit length of the metal fiber yarn; at the same time, the length of the continuous fiber bundles per unit length of the metal fiber yarn is larger than the unit length of the metal fiber yarn itself. Preferably, the continuous fiber bundles in the metal fiber yarn are twisted in the same direction and at the same pitch. Surprisingly it was found that the substantially equal lengths of the fiber bundles in the yarn provide a metal fiber yarn which apparently takes up the load by dividing the load equally over all fiber bundles in the yarn. As a consequence, increasing the amount of fiber bundles in the yarn provides the expected and desired increase in the breaking force, without losing flexibility of the yarn.

[0015] In the present invention, metal is to be understood as encompassing both metals and metal alloys (such as stainless steel) or compositions comprising both metal and non-metallic components (such as e.g. steel and carbon). Preferably, the metal fibers are made of stainless steel, such as e.g. AISI 316, 316L, 302, 304. In another preferred embodiment the metal fibers are made of FeCrAl-alloys, copper or nickel. In another preferred embodiment, the metal fibers are multilayer metal fibers such as described in JP 5-177243 and WO 2006/120045, e.g. metal fibers with a core of copper and an outer layer of stainless steel or metal fibers in three layers with a core of steel, an intermediate layer of copper and an outer layer of stainless steel.

[0016] The bundles of the yarns according to the present invention are obtained by a bundle-drawing process. Such a process is generally known and involves the coating of a plurality of metal wires (a bundle), enclosing the bundle with a cover material to obtain what is called in the art a composite wire, drawing the composite wire to the appropriate diameter and removing the cover and coating material of the individual wires (fibres) and the bundle, as e.g. described in US 3,379,000; US 3,394,213; US 2,050,298 or US 3,277,564. The fibers obtained with this process have a cross section which is polygonal, usually pentagonal or hexagonal in shape, and their circumference is usually serrated, as is shown in figure 2 of of US2050298. Compared to grouping a plurality of single-drawn fibres together to form a bundle, the bundle-drawn process allows the fibre diameter to be reduced further. It has been observed that a reduced fibre diameter also has a positive effect on the flexlife.

[0017] The metal fibers in the yarn have a preferred equivalent diameter in the range of 0,5 to 60 μm , more preferably in the range of 2 to 50 μm , even more preferably in the range of 6 to 40 μm , most preferably in the range of 8 to 30 μm .

[0018] Another aspect of the claimed invention provides a metal fiber yarn according to the invention wherein at least part of the metal fiber bundles are plastically preformed, e.g. crimped.

[0019] The metal fiber yarn can further be coated with a suitable coating, preferably Teflon, PVC, PVA, PTFE (polytetrafluoroethylene) FEP (copolymers of tetrafluoromethylene and hexafluoropropylene), MFA (perfluoroalkoxy polymer) or polyurethane lacquer. Alternatively, the metal fiber yarn can also comprise a lubricant.

[0020] An aspect of the invention provides a high strength metal fiber yarn with good processability and flexibility.

[0021] Another aspect of the invention provides the use of the metal fiber yarn of the invention as resistance heating elements in heatable textile applications, e.g. car seat heating.

[0022] Another aspect of the invention provides the use of the metal fiber yarn of the invention as sewing yarn.

[0023] Another aspect of the invention provides the use of the metal fiber yarn of the invention as lead wire.

[0024] Another aspect of the invention provides the use of the metal fiber yarn of the invention for the production of heat resistant textiles, such as separation material as used in the production of car glass, e.g. for the molding of car glass to the desired shape, or such as metal burner membranes e.g. in woven or knitted form.

[0025] Another aspect of the invention provides the use of the metal fiber yarn of the invention as reinforcement elements in composite materials.

[0026] Another aspect provides methods for producing the metal fiber yarns according to the present invention.

[0027] In a first method an exemplary metal fiber yarn according to the invention is obtained by providing at least 5 bundles of continuous metal fibers. At least 5 composite wires drawn to final diameter are provided, each of said composite wires comprising a number of metal filaments in a matrix. Then a removable core is provided. Removal process can be any process of removing that does not change the spatial arrangement of the surrounding bundles of continuous fibers or composite wires, such as: leaching, dissolving, burning, pulverising, evaporation, ... In one preferred embodiment this removable core is made of an iron wire. In an alternative preferred embodiment, this removable core is water soluble, e.g. made of polyvinylalcohol (PVA). In another preferred embodiment, the removable core comprises an acid susceptible polymer such as e.g. nylon or an acid susceptible metal such as e.g. copper.

A construction is then composed wherein the removable wire, fiber or yarn, or a group of removable wires, fibers and/or yarns, is in the core and the composite wires, form at least one layer around this core. The composite wires are twisted around the removable core in one or more layers. If parameters are set such that all composite wires in the layer of the construction have the same cabling angle, the length of all composite wires is substantially equal over a unit length of the construction. In case of more layers of continuous fiber bundles around the removable core, the cabling angle of the different layers is the same. Thereafter the removable core is removed by the appropriate method. In the preferred case

of more composite layers around the removable core, the cabling angle of the different layers is set such that after leaching the cabling angles of the different layers become the same. Thereafter, the matrix and sheet from the composite wires and the removable core are removed. In a first preferred embodiment, the sheet, matrix and removable core are dissolved in appropriate liquid, e.g. acid. In an alternative preferred embodiment, the matrix and sheet and removable core are removed in a two step process, wherein first the removable core is removed by dissolving in a first liquid, e.g. water and in a second step the matrix and sheet are removed by dissolving in a second liquid, e.g. appropriate acid. As the length of all composite wires is substantially equal over a unit length of the construction, the length of the metal fiber bundles is equal over a unit length of the metal fiber yarn after removal of the sheet, matrix and removable core. And, as the metal fiber bundles are twisted around the removable core, the length of the metal fiber bundles per unit length is larger than the length of the metal fiber yarn per unit length.

[0028] In a second method an exemplary metal fiber yarn according to the invention is obtained by providing at least 5 composite wires drawn till final diameter, each of said composite wires comprising a number of metal filaments in a matrix. A construction is composed by twisting the composite wires around each other. As the construction comprises at least 5 composite wires, one or more composite wires automatically migrate to the middle and the other ones compose one or more layers around these wires in the middle, as seen over the cross section of the construction. The obtained composites construction is then deformed by the use of a straightener. The straightening operation deforms the cross section of the construction in such a way that the free spaces between the composite wires are divided equally between the composite wires in the cross section of the construction. As a consequence the lengths of the composite wires become substantially equal over a unit length of the cord construction. Thereafter, the matrix and sheet from the composite wires are removed by dissolving the sheet and matrix in appropriate acid. As the length of all composite wires is substantially equal over a unit length of the construction, the length of the metal fiber bundles is substantially equal over a unit length of the metal fiber yarn.

[0029] In a third method an exemplary metal fiber yarn according to the invention is obtained by providing at least 5 fiber bundles, whereby each of the bundles is a bundle of bundle drawn metal fibers. Then a thorn is provided. The yarn is assembled by twisting the fiber bundles around the thorn. By this all fiber bundles are in the same layer of the yarn and have the same torsion pitch. As a consequence, the length of all fiber bundles is substantially equal over a unit length of the yarn and the length of the fiber bundles per unit length is larger than the length of the metal fiber yarn per unit length. In an alternative method, the metal fiber bundles are twisted around the thorn in two or more layers in one or more steps.

[0030] A fourth method is similar to the third method provided all bundles are still in the form of composite wires drawn till final diameter, with each of the composite wires comprising a number of metal filaments in a matrix. This method further comprises the step of removing the matrix and sheet from the composite wires after the composing step of the third method, by dissolving the sheet and matrix in appropriate acid. As the length of the different composite wires is substantially equal over the length of the construction before leaching, the length of the metal fiber bundles is substantially equal over the length of the metal fiber yarn after leaching. At the same time, the length of the metal fiber bundles per unit length is larger than the length of the metal fiber yarn per unit length.

[0031] A fifth method obtains the metal fiber yarn according to the invention by providing at least 5 fiber bundles, whereby each of the bundles is a bundle of bundle drawn metal fibers. A multi-bore orifice plate with the same amount of holes as the amount of fiber bundles in the yarn is provided. Said holes are evenly divided over an imaginary circle on the orifice plate. During yarn formation, the fiber bundles are guided through said multi-bore orifice plate before they are twisted to form the yarn. By this, all fiber bundles are in the same layer of the yarn and have the same torsion pitch. As a consequence, the length of all fiber bundles is substantially equal over a unit length of the yarn. And, as the fiber bundles are also twisted, the length of the fiber bundles per unit length is larger than the length of the metal fiber yarn per unit length. In an alternative embodiment, further layers can be added to the yarn by twisting fiber bundles around above obtained yarn.

[0032] A sixth method is similar to the fifth method provided all bundles, are still in the form of a composite wire, with each of the composite wires comprising a number of filaments in a matrix. This method further comprises the step of removing the matrix and sheet from the composite wires by dissolving the sheet and matrix in appropriate acid, after making the construction by use of the multi-bore orifice plate. As the lengths of the different composite wires are substantially equal over the length of the construction before leaching, the length of the metal fiber bundles is substantially equal over the length of the metal fiber yarn after leaching. And, as the composite wires are also twisted, the length of the metal fiber bundles per unit length is larger than the length of the metal fiber yarn per unit length.

[0033] A seventh method obtains the metal fiber yarn according to the invention by providing at least 5 fiber bundles, whereby each of the bundles is a bundle of bundle drawn metal fibers. In this method the yarn is made in two or more steps: in the first step at least 2 bundles of continuous fibers are twisted around each other and in a second step the remaining bundles are twisted around the first layer. More layers can be added in more steps. To obtain a substantially equal length of all fiber bundles in all layers, the cabling angles of the different layers need to be the same.

[0034] A ninth method is similar to the eighth method provided all bundles are still in the form of a composite wire drawn

till final diameter, with each of the composite wires comprising a number of filaments in a matrix. This method further comprises the step of removing the matrix and sheet from the composite wires by dissolving the sheet and matrix in appropriate acid, after making the construction. In this method the cabling angles of the different layers of the composite wires is set such that after leaching the cabling angles of the different layers become the same.

Definitions

[0035] The term "equivalent diameter" of a fiber is to be understood as the diameter of an imaginary circle having a surface area equal to the surface of the radial cross section of the fiber. In case of the bundle drawing operation, the cross section of a fiber has usually a pentagonal or hexagonal shape, and the circumference of the fiber cross section is usually serrated.

[0036] The term "fiber bundle" is to be understood as a grouping of individual continuous fibers.

[0037] The term "continuous fiber" is to be understood as a fiber of an indefinite or extreme length such as found naturally in silk or such as obtained by a wire drawing process. "Continuous metal fiber bundle" should in the context of this invention be understood as a bundle of continuous metal fibers, which are obtained by bundled drawing.

[0038] The term "yarn" is to be understood as a continuous strand of fibers, filaments or material in a form suitable for knitting, weaving, or otherwise intertwining to form a textile fabric. A yarn can therefore also be composed of first yarns taken together to form a new yarn.

[0039] The term "composite wire" is to be understood as the composite wire which is used in the bundled drawing process as known e.g. from US3379000, wherein the composite wire is the totality of metal filaments embedded in the matrix material enveloped in the sheath material. When the composite wire, which is drawn till the desired diameter, is leached, thereby removing the matrix and sheath material, the continuous metal filaments are released and are, from then on, called continuous metal fibers. In other words, the composite wire turns into a bundle of continuous metal fibers by the leaching process.

[0040] The term "unit length of a yarn" is to be understood as the unit length of the yarn when the yarn is in stretched condition.

[0041] The term "cabling angle" is known by the person skilled in the art, but in case of doubt, reference is made to the reference work K. Feyrer, Drahtseile: Bemessung, Betrieb, Sicherheit. Berlin: Springer-Verlag, 2000 on page 22-23.

Brief Description of Figures in the Drawings

[0042] Example embodiments of the invention are described hereinafter with reference to the accompanying drawings in which:

Figure 1 shows a graph setting out the average breaking force in function of the amount of continuous metal fiber bundles used in the metal fiber yarn.

Figure 2 shows the same graph as figure 1 supplemented with results obtained with the metal yarn according to the invention.

Figure 3 shows schematically starting materials for an exemplary method for obtaining the metal fiber yarn of the invention.

Figure 4 shows the method for measuring length of fiber bundles in a yarn. reference numbers

- 1: metal fiber yarn
- 2: horizontally movable clamp
- 3: rotatable clamp
- 4: wire
- 5: reversing pulley
- 6: weight (17N)
- 7: bundle of continuous fibers
- 8: removable wire

Mode(s) for Carrying Out the Invention

[0043] Examples of metal fiber yarns and different methods for obtaining the metal fiber yarn of the invention will now be described with reference to the Figures.

[0044] Figure 1 comprises a graph setting out the measured breaking force (F_m) in Newtons (N) of the metal fiber yarns made out of continuous metal fiber bundles consisting out of 275 stainless steel fibers of the AISI 316L type with an equivalent diameter of 12 micron, as a function of the amount of metal fiber bundles in the metal fiber yarn. The

average measured values are listed in Table 1. The breaking force is measured according to ISO 6892/82 with a gauge length of 150 mm, a pre-load of 3 N, a pre-load speed of 5mm/min and a test speed of 30 mm/min.

Table 1

Number of bundles in the yarn	Standardtypes Bekaert Bekinox®	Measured average Fm [N]	Fm [N] predicted by the formula
2	VN 12/2×275/175S/316 L	76	76
3	VN 12/3×275/175S/316 L	121	119
4	VN 12/4×275/100S/316 L	162	162
6	VN 12/6×275/120S/316 L	191	248
8	VN 12/8×275/100S/316 L	238	334
VNa/bxc/d/f wherein a Equivalent diameter of the metal fibers in μm b Number of metal fiber bundles in the metal fiber yarn c Number of metal fibers per bundle d Torsions per meter and direction of the torsion for all metal fiber bundles f Alloy of the metal fibers			

[0045] Here we see that the breaking force of the metal fiber yarn increases linearly with the amount of metal fiber bundles in the yarn for yarns comprising 4 or less metal fiber bundles. In this case the linear relation is given by $F_m[N] = 43 \cdot x - 10$ with F_m the breaking force of the yarn expressed in Newtons and x the amount of metal fiber bundles in the yarn. This linear relationship is no longer valid when the amount of metal fiber bundles in the yarn is more than 4: the increase in breaking force of the yarn is much lower. This effect might be explained, without pretending to be scientifically correct, by the following: when 5 or more bundles are combined into a yarn, the yarn tries to obtain the smallest diameter possible, so 1 or more bundles tend to move to the center of the yarn. A layered yarn is then obtained, wherein the bundles in the center of the yarn have shorter lengths than the bundles on the outer/next layer of the yarn.

[0046] In a first example a metal fiber yarn according to the invention is provided wherein the metal fiber yarn is produced using a removable core wire. Six composite wires, wherein the composite wires each contain 275 stainless steel fibers of the 316L type with an equivalent diameter of 12 micron, are grouped around a removable core, in this example an iron wire. As shown in Figure 2 and Table 2, the increase in breaking force is now in line with the linear relation as described above.

Table 2

Type of product	Manipulation performed	Measured Fm [N]	Fm [N] predicted by the formula
VN 12/6×275/120S/316 L	Standard	191	248
VN 12/6×275/120S/316 L	Removable core	250	248
VN 12/5×275/120S/316 L	Straightening	209	205

[0047] Figure 3 shows schematically further examples of constructions of removable core(s) (depicted in the figures as shaded circles 8) together with continuous fiber bundles (depicted in the figures as open circles 7) which are twisted together and wherein the removable core is removed, to form the metal fiber yarn of the invention. Alternatively, similar constructions can be made with composite wires around one or more removable wires, where after the whole construction is leached, to form the metal fiber yarn of the invention.

[0048] The length of the individual fiber bundles in the metal fiber yarn is measured on a torsion bench as shown in Figure 4. A length of 1 meter of metal fiber yarn (1) is clamped between two clamps as shown in Figure 4. One of the clamps (3) is rotatable, but cannot move horizontally, the other clamp (2) is not rotatable but can move back and forward horizontally along the stretching direction of the yarn. The horizontally movable clamp (2) is put under load by means of a wire (4) guided over a reversing pulley (5) and connected to a load of 17N (6).

The yarn is then twisted in the inverse direction of the torsion direction of the metal fiber bundles in the yarn and as many cycles are made as the amount of torsion cycles present in the metal fiber yarn.

Because of the torsion being removed out of the yarn, the yarn elongates. As the yarn is put under tension by the weight (6), the load moves downwards (b). As a consequence the horizontally movable clamp (2) moves backwards and the

elongation of the yarn is equal to the length (a) over which clamp (2) moves.

When the yarn consists out of multiple bundles with unequal lengths, the shortest bundle is under tension between the clamps and the other ones hang down. The distance between the clamps is now the length of the shortest bundle in the yarn. When the shortest bundle is cut, the yarn elongates again and now the second shortest bundle in the original yarn is under tension. This time the distance between the clamps is the length of the second shortest bundle in the yarn. This cutting, elongation and measuring of the length is repeated until the last bundle is under tension.

[0049] The term "length of a yarn" is thus to be understood in the light of this invention, as the length of the yarn when the yarn is stretched under a load of 17N. This is measured as the length L between the clamps on the torsion bench when the yarn is under the load of the 17N and before the yarn is being reversely twisted.

[0050] The term "length of a bundle" is to be understood as the length L_n of the single bundle x_n originating from the reversely twisted yarn consisting out of n bundles and put under a load of 17N. The length L_1 of the shortest bundle x_1 in the yarn is measured as the length between the clamps on the torsion bench when the yarn is reversely twisted and under a load of 17N. The length L_2 of the second shortest bundle x_2 in the yarn is measured as the length between the clamps on the torsion bench when the yarn is reversely twisted, under a load of 17N and the shortest bundle in the yarn x_1 has been cut through. The length L_n of every x_n th bundle in a yarn is measured as the length between the clamps on the torsion bench when the yarn is reversely twisted, under a load of 17N and all $x_1 \dots x_{n-1}$ shorter bundles in the yarn have been cut.

[0051] The lengths of all bundles in a yarn are considered "substantially equal" if the difference in length between the

bundles ΔL is lower than 1%, according to the formula
$$\frac{\max(L_1 \dots L_n) - \min(L_1 \dots L_n)}{\min(L_1 \dots L_n)} * 100\%$$

[0052] Tables 3 and 4 show the results obtained with above described measuring method for the standard available Bekinox® products.

Table 3

	L	L ₁	L ₂	L ₃	L ₄	L ₅	L ₆	L ₇	L ₈
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
standard Bekinox® products									
12/2×275/175S	1003	1003	1003						
12/2×275/175S	1002	1002	1002						
12/2×275/175S	1002	1003	1003						
12/3×275/175S	1002	1006	1006	1006					
12/3×275/175S	1002	1006	1006	1006					
12/3×275/175S	1002	1005	1005	1005					
12/4×275/100S	1002	1005	1005	1005	1006				
12/4×275/100S	1002	1005	1005	1006	1007				
12/4×275/100S	1002	1005	1005	1006	1007				
12/6×275/120S	1002	1000	1017	1019	1020	1022	1023		
12/6×275/120S	1002	1000	1018	1019	1020	1021	1022		
12/6×275/120S	1003	1001	1018	1020	1020	1023	1024		
12/8×275/100S	1002	998	998	1025	1025	1025	1027	1027	1028
12/8×275/100S	1002	998	998	1023	1024	1025	1025	1028	1029
12/8×275/100S	1002	998	998	1025	1025	1025	1027	1027	1028
removable core									
12/6×275/120S	1002	1014	1014	1014	1015	1015	1015		
12/6×275/120S	1002	1014	1014	1015	1015	1015	1016		
straightener									

(continued)

	L	L ₁	L ₂	L ₃	L ₄	L ₅	L ₆	L ₇	L ₈
	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
12/5×275/120S	1002	1016	1016	1017	1019	1020			
12/5×275/120S	1002	1016	1016	1017	1019	1020			
12/5×275/120S	1002	1015	1015	1017	1018	1019			

Table 4

	$\Delta L = (\max - \min) / \min$ [mm]	$(\max - \min) * 100\% / \min$ [%]
standard Bekinox® products		
12/2×275/175S	0	0,0
12/2×275/175S	0	0,0
12/2×275/175S	0	0,0
12/3×275/175S	0	0,0
12/3×275/175S	0	0,0
12/3×275/175S	0	0,0
12/4×275/100S	1	0,1
12/4×275/100S	2	0,2
12/4×275/100S	2	0,2
12/6×275/120S	23	2,3
12/6×275/120S	22	2,2
12/6×275/120S	23	2,3
12/8×275/100S	30	3,0
12/8×275/100S	31	3,1
12/8×275/100S	30	3,0
removable core		
12/6×275/120S	1	0,1
12/6×275/120S	2	0,2
straightener		
12/5×275/120S	4	0,4
12/5×275/120S	4	0,4
12/5×275/120S	4	0,4

[0053] In a second example a straightener was used for obtaining the metal fiber yarn of the invention. Now 5 composite wires, wherein the wires each contain 275 stainless steel filaments of the 316L type with an equivalent diameter of 12 micron, are twisted into a construction according to methods as known in the state of the art. Thereafter the construction is subjected to a straightening operation, which reduces length differences in between the individual composite wires. This straightened construction is then submitted to the leaching step. As shown in Figure 2 and Table 2, the breaking force of the metal fiber yarns is similar to the one predicted by the formula.

[0054] Thus there has been described a new metal fiber yarn and methods for obtaining such a yarn are provided. The metal fiber yarn constitutes a construction comprising continuous metal fibers forming a metal fiber yarn. The construction comprises at least 5 bundles of continuous fibers, whereby all bundles are bundles of drawn metal fibers. The bundles of continuous fibers are twisted together to form a yarn. Each bundle of metal fibers comprises at least 30

metal fiber filaments. The length of the continuous fiber bundles is substantially equal per unit length of the metal fiber yarn and the length of the fiber bundles per unit length of the metal fiber yarn is larger than the unit length of the metal fiber yarn itself.

[0055] Although the embodiments above have been described in detail, numerous variations and modifications will become apparent to those skilled in the art once the above disclosure is fully appreciated.

Claims

1. A metal fiber yarn comprising at least 5 bundles of continuous fibers (7), said bundles being twisted together, all of said at least 5 bundles of continuous fibers (7) are continuous metal fiber bundles, each of said continuous metal fiber bundles comprising at least 30 continuous metal fibers, the length of said bundles of continuous fibers (7) per unit length of said metal fiber yarn is larger than the unit length of said metal fiber yarn, **characterized in that** said continuous metal fibers are bundle drawn metal fibers, the length of said bundles of continuous fibers (7) is substantially equal per unit length of said metal fiber yarn, said length of said bundles of continuous fibers (7) is measured when said metal fiber yarn is reversely twisted under a load of 17N, the difference between said length of said bundles of continuous fiber (7) ΔL is lower than 1 % when calculated according to the formula:

$$\frac{\max(L_1 \dots L_n) - \min(L_1 \dots L_n)}{\min(L_1 \dots L_n)} * 100\%, \text{ wherein } L_1 \dots L_n \text{ are said lengths of said bundles of continuous fibers (7).}$$

2. A metal fiber yarn according to claim 1, wherein said bundles of continuous fibers all have the same twist direction and the same cabling angle.
3. A metal fiber yarn according to claims 1 to 2, wherein at least part of said bundle of continuous metal fibers comprises continuous stainless steel fibers.
4. A metal fiber yarn according to claims 1 to 3, wherein at least part of the metal fibers in said metal fiber bundles have a cross section comprising at least two concentric metal layers.
5. A metal fiber yarn according to claim 4 wherein the core of said fibers is copper and the outer layer is stainless steel.
6. A metal fiber yarn according to claim 4 wherein the core of said fibers is stainless steel and the outer layer is copper.
7. A metal fiber yarn according to any of the preceding claims, wherein the amount of said metal fiber bundles in the metal fiber yarn is equal to or less than 30.
8. A metal fiber yarn according to any of the preceding claims, wherein the amount of metal fibers per bundle is less than 2500.
9. A metal fiber yarn according to any of the preceding claims, wherein said continuous metal fibers have an equivalent diameter in the range of 8 to 30 μm .
10. A metal fiber yarn according to any of the preceding claims, wherein said metal fiber yarn further comprises a coating.
11. Use of the metal fiber yarn as in any of the preceding claims as resistance heating elements in heatable textile applications.
12. Use of the metal fiber yarn as in claim 11, wherein said heatable textile application is a car seat heating.
13. Use of the metal fiber yarn as in any of the claims 1 to 10 as a reinforcement element.

Patentansprüche

1. Metallfasergarn, umfassend mindestens 5 Endlosfaserbündel (7), wobei die Bündel miteinander verdreht sind, wobei

alle der mindestens 5 Endlosfaserbündel (7) Metallendlosfaserbündel sind, wobei die Metallendlosfaserbündel jeweils mindestens 30 Metallendlosfasern umfassen, wobei die Länge der Endlosfaserbündel (7) je Längeneinheit des Metallfasergarns größer ist als die Längeneinheit des Metallfasergarns, **dadurch gekennzeichnet, dass** die Metallendlosfasern im Bündel verstreute Metallfasern sind, dass die Länge der Endlosfaserbündel (7) im Wesentlichen der Längeneinheit des Metallfasergarns entspricht, dass die Messung der Länge der Endlosfaserbündel (7) beim Aufdrehen des Metallfasergarns unter einer Belastung von 17N erfolgt, wobei der Unterschied zwischen der Länge der Endlosfaserbündel (7) ΔL bei Berechnung entsprechend der Formel

$$\frac{\max(L_1 \dots L_n) - \min(L_1 \dots L_n)}{\min(L_1 \dots L_n)} * 100\%,$$

wobei $L_1 \dots L_n$ die Längen der Endlosfaserbündel (7) bedeuten, weniger als 1% beträgt.

2. Metallfasergarn nach Anspruch 1, bei dem die Endlosfaserbündel alle über die gleiche Drehrichtung und den gleichen Kablierungswinkel verfügen.
3. Metallfasergarn nach Anspruch 1 bis 2, bei dem das Metallendlosfaserbündel zumindest zum Teil Edelstahlfaserbündel umfasst.
4. Metallfasergarn nach Anspruch 1 bis 3, bei dem die in den Metallfaserbündeln vorliegenden Metallfasern zumindest zum Teil über einen mindestens zwei konzentrische Metallschichten umfassenden Querschnitt verfügen.
5. Metallfasergarn nach Anspruch 4, bei dem es sich bei dem Kern der Fasern um Kupfer und bei der Außenschicht um Edelstahl handelt.
6. Metallfasergarn nach Anspruch 4, bei dem es sich bei dem Kern der Fasern um Edelstahl und bei der Außenschicht um Kupfer handelt.
7. Metallfasergarn nach einem der vorhergehenden Ansprüche, bei dem die Menge der in dem Metallfasergarn vorliegenden Metallfaserbündel kleiner gleich 30 ist.
8. Metallfasergarn nach einem der vorhergehenden Ansprüche, bei dem die Menge der Metallfasern je Bündel weniger als 2500 ist.
9. Metallfasergarn nach einem der vorhergehenden Ansprüche, bei dem die Metallendlosfasern über einen äquivalenten Durchmesser von 8 bis 30 μm verfügen.
10. Metallfasergarn nach einem der vorhergehenden Ansprüche, bei dem das Metallfasergarn ferner eine Beschichtung umfasst.
11. Verwendung des Metallfasergarns gemäß einem der vorhergehenden Ansprüche als Widerstandsheizelemente bei Anwendungen im Bereich der beheizbaren Textilien.
12. Verwendung des Metallfasergarns nach Anspruch 11, bei dem es sich bei der Anwendung im Bereich der beheizbaren Textilien um eine Autositzheizung handelt.
13. Verwendung des Metallfasergarns gemäß einem der Ansprüche 1 bis 10 als Bewehrungselement.

Revendications

1. Fil de fibres métalliques comprenant au moins 5 faisceaux de fibres continues (7), lesdits faisceaux étant retordus ensemble, lesdits au moins 5 faisceaux de fibres continues (7) étant tous des faisceaux de fibres métalliques continues, chacun desdits faisceaux de fibres métalliques continues comprenant au moins 30 fibres métalliques continues, la longueur desdits faisceaux de fibres continues (7) par longueur unitaire dudit fil de fibres métalliques étant supérieure à la longueur unitaire dudit fil de fibres métalliques, **caractérisé en ce que** lesdites fibres métalliques continues sont des fibres métalliques étirées en faisceau, la longueur desdits faisceaux de fibres continues (7) étant sensiblement égale par longueur unitaire dudit fil de fibres métalliques, ladite longueur desdits faisceaux de fibres

continues (7) étant mesurée quand ledit fil de fibres métalliques est détordu sous une charge de 17 N, la différence entre ladite longueur desdits faisceaux de fibres continues (7) ΔL étant inférieure à 1 % lorsqu'elle est calculée selon la formule :

$$\frac{\max(L_1 \dots L_n) - \min(L_1 \dots L_n)}{\min(L_1 \dots L_n)} \times 100\%$$

dans laquelle $L_1 \dots L_n$ sont lesdites longueurs desdits faisceaux de fibres continues (7).

2. Fil de fibres métalliques selon la revendication 1, dans lequel lesdits faisceaux de fibres continues ont tous la même direction de torsion et le même angle de câblage.
3. Fil de fibres métalliques selon les revendications 1 et 2, dans lequel au moins une partie dudit faisceau de fibres métalliques continues comprend des fibres continues d'acier inoxydable.
4. Fil de fibres métalliques selon les revendications 1 à 3, dans lequel au moins une partie des fibres métalliques dans lesdits faisceaux de fibres métalliques à une section transversale comprenant au moins deux couches métalliques concentriques.
5. Fil de fibres métalliques selon la revendication 4 dans lequel le coeur desdites fibres est du cuivre et la couche externe est de l'acier inoxydable.
6. Fil de fibres métalliques selon la revendication 4 dans lequel le coeur desdites fibres est de l'acier inoxydable et la couche externe est du cuivre.
7. Fil de fibres métalliques selon l'une quelconque des revendications précédentes, la quantité desdits faisceaux de fibres métalliques dans le fil de fibres métalliques étant égale ou inférieure à 30.
8. Fil de fibres métalliques selon l'une quelconque des revendications précédentes, dans lequel la quantité de fibres métalliques par faisceau est inférieure à 2500.
9. Fil de fibres métalliques selon l'une quelconque des revendications précédentes, dans lequel lesdites fibres métalliques continues ont un diamètre équivalent dans la gamme de 8 à 30 μm .
10. Fil de fibres métalliques selon l'une quelconque des revendications précédentes, ledit fil de fibres métalliques comprenant en outre un revêtement.
11. Utilisation du fil de fibres métalliques selon l'une quelconque des revendications précédentes comme élément de chauffage par résistance dans des applications de textile chauffant.
12. Utilisation du fil de fibres métalliques selon la revendication 11, ladite application de textile chauffant étant le chauffage de sièges de voiture.
13. Utilisation du fil de fibres métalliques selon l'une quelconque des revendications 1 à 10 comme élément de renforcement.

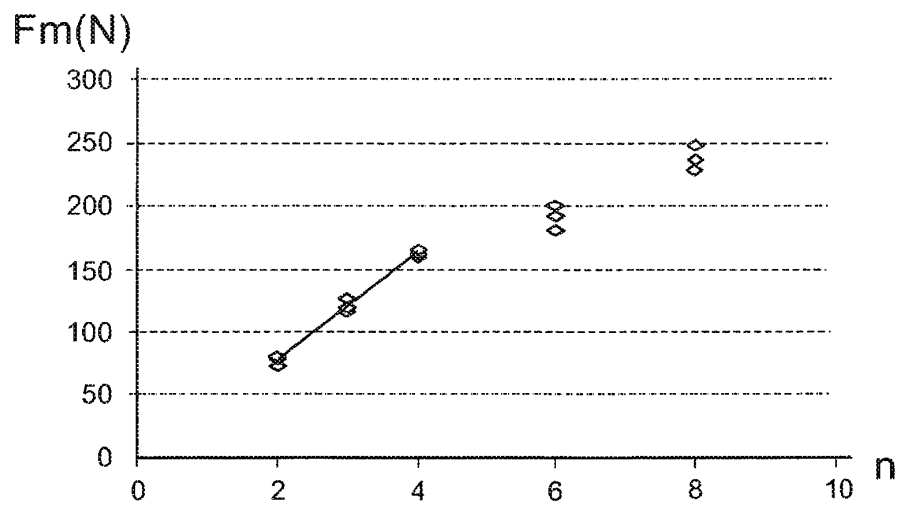


Fig. 1

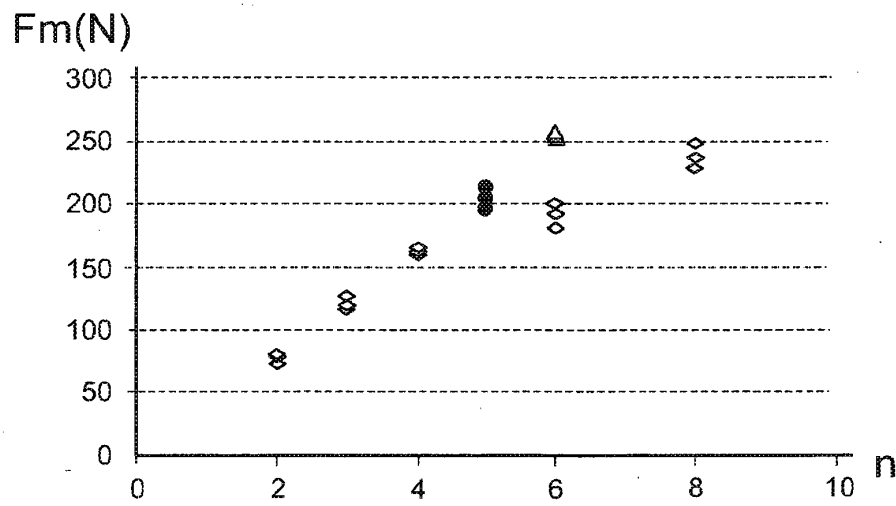


Fig. 2

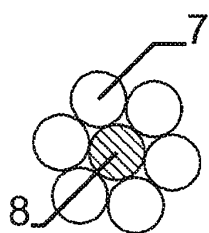


Fig. 3a

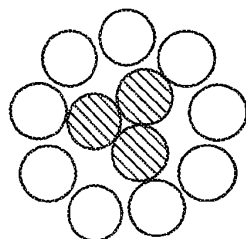


Fig. 3b

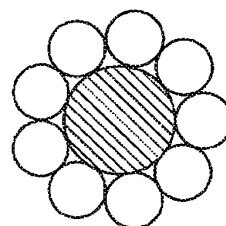


Fig. 3c

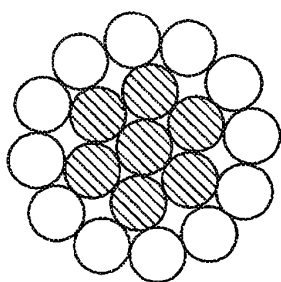


Fig. 3d

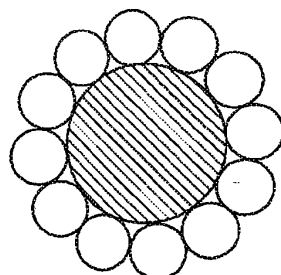


Fig. 3e

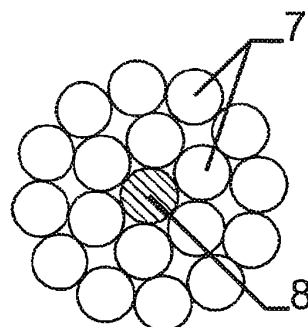


Fig. 3f

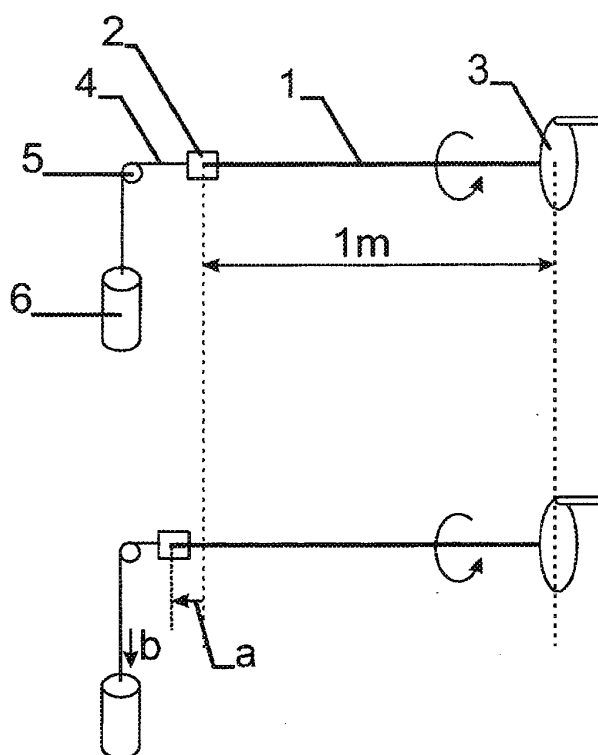


Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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