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(71) Applicant: **Intersig NV**

9200 Dendermonde (BE)

(72) Inventor: **OCKET, Piet**

9200 Dendermonde (BE)

(74) Representative: **De Clercq & Partners**

**Edgard Gevaertdreef 10a
9830 Sint-Martens-Latem (BE)**

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(54) **METHOD FOR MANUFACTURING OF STRETCHED PROFILED WIRES**

(57) The present invention is in the field of materials for use in construction. In particular, the present invention relates to a method for manufacturing of stretched profiled wires comprising the steps of:

- (a) providing a metal wire having a profiled surface;
- (b) stretching of said profiled metal wire by means of a wire stretching device comprising at least two rotating

shafts, wherein the distance and/or angle between the rotating shafts can be controllably adjusted, wherein the profiled metal wire is secured between said rotating shafts to produce a stretched profiled metal wire;

- (c) applying a lubricant on the surface of said stretched metal wire.

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Description

FIELD OF THE INVENTION

[0001] The present invention is in the field of materials for use in construction. In particular, the present invention relates to a method for manufacturing of stretched profiled wires. These stretched profiled wires can be used as raw material in the manufactory of e.g. concrete reinforcements.

BACKGROUND

[0002] Profiled metal wires that have positive ribbing and/or negative indentations are used in a variety of applications in the building, contracting, and engineering industries. For example, a metal wire mesh consisting of profiled metal wires arranged in a grid can be used as a reinforcement cage that has an improved bonding to concrete. Compared to smooth wires, the profiled wires can minimize any concrete cracking that can occur due to stress. Accordingly, such profiled wires are commonly utilised in e.g., columns, beams, ground slabs, precast panels, footings, and so on.

[0003] The art describes variations on the metal wire profile, including various surface shapes and sizes, profile inclinations (*i.e.*, wherein the ribs are inclined at a specific angle with respect to the axis of the wire), profile distances (between adjacent ribs), and so on. Regardless of the provided wire profile, the metal wire must also be transformed to match the required construction dimensions in terms of wire length and diameter. According to the different grades and material, the metal wire will typically undergo various processing steps including wire stretching.

[0004] Plastic stretching of metal wires is a processing technique in which a metal wire is loaded to induce a permanent increase in wire length.

[0005] Plastic stretching of a metal wire is a processing technique that can be used to permanently change the diameter of the wire. This way, the mechanical properties of the wire can also be modified. The art teaches that plastic stretching of metal wires can be achieved by transferring between metal wire across rotating shafts and adjusting the distance and/or angle between the shafts.

[0006] Nonetheless, handling and transport of profiled wires can be difficult as a consequence of the profiled wire properties. In particular, the separation of adjacent profiled metal wires after stretching can be tiring due to their tendency to connect with each other and prevent sliding. Also, when transferring the profiled metal wires from the manufacturing centre to storage or further to on-site applications, the profiled metal wires can be difficult to handle, often requiring the use of additional tools or inefficient manual labour to handle individual wires. Accordingly, there is a need for a solution to the problems in the art related to the manufacturing of stretched profiled wires.

SUMMARY OF THE INVENTION

[0007] The present invention aims to provide a solution to the above-identified problems in the art by including at least one step of applying lubricant on the surface of stretched metal wire after at least one wire stretching process. Profiled wire has a high surface roughness when compared to smooth wire, which significantly increases the torsion and friction exerted by profiled wire during processing, for example when aligning or bending the wire into a specific structure like reinforcement cage. The presence of lubricant can reduce the profiled wire's surface roughness allowing for easier processing, handling and/or transport of the wires for application in e.g. the building, contracting, and engineering industry. Additional advantages brought about by the present invention and any embodiments thereof are discussed further throughout the present disclosure.

[0008] An initial overview of various aspect of the invention is provided below and specific embodiments are then described in further detail. This initial overview is intended to aid readers in understanding the technological concepts more quickly, but is not intended to identify key or essential features thereof, nor is it intended to limit the scope of the present subject-matter.

[0009] An aspect of the present invention relates to a method for manufacturing a stretched profiled wire, comprising the steps of:

- (a) providing a metal wire having a profiled surface;
- (b) stretching of said profiled metal wire by means of a wire stretching device comprising at least two rotating shafts, wherein the distance and/or angle between the rotating shafts can be controllably adjusted, wherein the profiled metal wire is secured between said rotating shafts to produce a stretched profiled metal wire;
- (c) applying a lubricant on the surface of said stretched metal wire.

[0010] In some embodiments of the method no lubricant is applied on the surface of the profiled metal wire before the stretching of said metal wire and the stretching is performed on a dry profiled metal wire.

[0011] In some embodiments of the method the lubricant comprises a soap; preferably a wire-drawing soap.

[0012] In some embodiments of the method the lubricant comprises sodium stearate and/or calcium stearate.

[0013] In some embodiments of the method the lubricant is applied on the stretched metal wire via spraying, dipping and/or brushing.

[0014] In some embodiments of the method the lubricant is applied on the metal wire surface with a yield of at least 50 g/ton of metal wire, preferably 75 g/ton, more preferably 100 g/ton, even more preferably 125 g/ton, even more preferably 150 g/ton, even more preferably 175 g/ton, even more preferably 200 g/ton.

[0015] In some embodiments of the method the wire

stretching step produces an elongation of the metal wire of at least 0.1%, preferably at least 0.5%, more preferably at least 1.0%, even more preferably at least 1.5%, even more preferably at least 2.0%.

[0016] In some embodiments the method comprises at least two steps of stretching of said profiled metal wire by means of a wire stretching device; wherein the step of applying a lubricant on the surface of said stretched metal wire is performed after at least one wire stretching steps.

[0017] In some embodiments of the method the initial wire stretching step produces an elongation of the metal wire of at least 0.1%, preferably at least 0.5%, more preferably at least 1.0%, even more preferably at least 1.5%, even more preferably at least 2.0%; and wherein the final wire stretching step produces an elongation of the metal wire of at least 0.1%, preferably at least 0.2%, more preferably at least 0.3%, even more preferably at least 0.4%, even more preferably about 0.5%.

[0018] In some embodiments of the method steps (a) to (c) are performed continuously.

[0019] In some embodiments the method comprises the step of rolling up said lubricated metal wire.

[0020] In some embodiments of the method the applying of a lubricant is performed after the step of rolling up said lubricated metal wire.

[0021] In some embodiments of the method the provided metal wire is a hot-rolled metal wire.

[0022] An aspect of the present invention relates to a device for the manufacturing of a stretched profiled wire, said device comprising:

- a wire feeder configured for providing profiled metal wire;
- at least one wire stretching device comprising at least two rotating shafts having an adjustable distance and/or angle between the rotating shafts; wherein the wire stretching device is configured to stretch the profiled metal wire provided by the wire feeder; and,
- at least one lubricant applicator configured for applying a lubricant on the surface of metal wire; wherein at least one lubricant applicator is configured for applying a lubricant on the surface of stretched metal wire produced by the wire stretching device.

[0023] In some embodiments the manufacturing device comprises a lubricant applicator configured for applying the lubricant on the stretched metal wire produced by the wire stretching device only.

[0024] In some embodiments the manufacturing device comprises a wire roller to roll up the lubricated metal wire.

DETAILED DESCRIPTION

[0025] The present invention will be described with respect to particular embodiments, but the invention is not

limited thereto but only by the claims. Any reference signs in the claims shall not be construed as limiting the scope thereof.

[0026] As used herein, the singular forms "a", "an", and "the" include both singular and plural referents unless the context clearly dictates otherwise.

[0027] The terms "comprising", "comprises" and "comprised of" as used herein are synonymous with "including", "includes" or "containing", "contains", and are inclusive or open-ended and do not exclude additional, non-recited members, elements or method steps. The terms "comprising", "comprises" and "comprised of" when referring to recited members, elements or method steps also include embodiments which "consist of" said recited members, elements or method steps.

[0028] Furthermore, the terms first, second, third and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order, unless specified. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein.

[0029] Unless otherwise defined, all terms used in disclosing the invention, including technical and scientific terms, have the meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. By means of further guidance, definitions for the terms used in the description are included to better appreciate the teaching of the present invention. The terms or definitions used herein are provided solely to aid in the understanding of the invention. All documents cited in the present specification are incorporated by reference in their entirety.

[0030] The recitation of numerical ranges by endpoints includes all numbers and fractions subsumed within the respective ranges, as well as the recited endpoints.

[0031] The term "about" is used to provide flexibility to a numerical range endpoint by providing that a given value may be "a little above" or "a little below" the endpoint. Unless otherwise stated, use of the term "about" in accordance with a specific number or numerical range should also be understood to provide support for such numerical terms or range without the term "about". For example, for the sake of convenience and brevity, when referring to a measurable value such as a parameter, an amount, a temporal duration, and the like, is meant to encompass variations of +/-10% or less, preferably +/-5% or less, more preferably +/-1% or less, and still more preferably +/-0.1% or less of and from the specified value, insofar such variations are appropriate to perform in the present disclosure. It is to be understood that the value to which the modifier "about" refers is itself also specifically, and preferably, disclosed.

[0032] The term "substantially" refers to the complete or nearly complete extent or degree of an action, characteristic, property, state, structure, item, or result. For

example, an object that is "substantially" enclosed would mean that the object is either completely enclosed or nearly completely enclosed. The exact allowable degree of deviation from absolute completeness may in some cases depend on the specific context. However, generally speaking the nearness of completion will be so as to have the same overall result as if absolute and total completion were obtained. The use of "substantially" is equally applicable when used in a negative connotation to refer to the complete or near complete lack of an action, characteristic, property, state, structure, item, or result. For example, a composition that is "substantially free of" particles would either completely lack particles, or so nearly completely lack particles that the effect would be the same as if it completely lacked particles. In other words, a composition that is "substantially free of" an ingredient or element may still actually contain such item as long as there is no measurable effect thereof.

[0033] Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present disclosure. Thus, appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Occurrences of the phrase "in one embodiment," or "in one aspect," herein do not necessarily all refer to the same embodiment or aspect. Furthermore, the particular features, structures or characteristics may be combined in any suitable manner, as would be apparent to a person skilled in the art from this disclosure, in one or more embodiments. Furthermore, while some embodiments described herein include some but not other features included in other embodiments, combinations of features of different embodiments are meant to be within the scope of the present disclosure, and form different embodiments, as would be understood by those in the art. For example, in the following claims and description, any of the claimed or described embodiments can be used in any combination.

[0034] The present invention aims to provide a solution to the above-identified problems in the art by including at least one step of applying lubricant on the surface of stretched metal wire after at least one wire stretching process. Profiled wire has a high surface roughness when compared to smooth wire, which significantly increases the torsion and friction exerted by profiled wire during processing, for example when aligning or bending the wire into a specific structure like reinforcement cage. The presence of lubricant can reduce the profiled wire's surface roughness allowing for easier processing, handling and/or transport of the wires for application in e.g. the building, contracting, and engineering industry. Also, processing of the lubricated metal wire can be made more silent.

[0035] Lubricant can be applied before wire stretching in order to relief tension between the wire and the wire

stretching device and reduce the risk of wire breakage. However, by the time the wire has been stretched most if not all traces of the lubricant will be removed. For example, lubricant can easily fall off from the wire surface during stretching or be scraped off by the rolling components of the wire stretching device. Moreover, commonly wire processing techniques like wire descaling and annealing are known to actively remove lubricant from the wire.

[0036] Moveable components of commonly used profiled wire processing devices, such as for example a stirrup bender for the production of stirrups and cut-to-size bars from profiled wires, will suffer from wear due to contact with the profiled wire's surface. As a result, these components need to be frequently restored or even replaced which affects the production yield. Moreover, to offset the increase in friction the presence of a more powerful drive for moving and aligning the profiled wire is required in the production line. However, the reduced friction of lubricated profiled wires can decrease wear of the processing device and increase production yields. Also, the lubricated profiles wires can alleviate the need for a more expensive drive such that it can be replaced by a less powerful and hence cheaper alternative.

[0037] Further, the lubricant can reduce wear of the profiled wire surface during wire processing to better preserve the ribs and/or indentations present on said profiled metal wire surface. This is particularly beneficial because wear of the wire profile may reduce the bonding to concrete. To compensate for the expected wear, profiled metal wire is typically produced with a more pronounced profile (i.e. higher ribs and/or deeper indentations), which requires more raw material and is more difficult to produce. Accordingly, the provision of lubricant may allow the production of less pronounced profiled wire by reducing its vulnerability to processing wear.

[0038] Below an initial overview of various aspect of the present invention is provided and specific embodiments thereof will be described in greater detail throughout the present disclosure. This initial overview is intended to aid readers in understanding the technological concepts more quickly, but is not intended to identify key or essential features thereof, nor is it intended to limit the scope of the present subject-matter.

[0039] In addition, one of ordinary skill in the art will recognize that, based on a reading of the present disclosure, that various aspects of the present invention can be combined unless otherwise stated. Accordingly, any specific embodiment of any specific aspect may be understood to also constitute a specific embodiment of another aspect without the explicit disclosure thereof. For example, an embodiment of the method for manufacturing of a profiled wire may be understood to also constitute an embodiment of the device configured for the manufacturing of said profiled wire, an embodiment of the use of said profiled wire, and so on.

[0040] An aspect of the present disclosure relates to a method for manufacturing a stretched profiled wire, com-

prising the steps of:

- (a) providing a metal wire having a profiled surface;
- (b) stretching of said profiled metal wire by means of a wire stretching device comprising at least two rotating shafts, wherein the distance and/or angle between the rotating shafts can be controllably adjusted, wherein the profiled metal wire is secured between said rotating shafts to produce a stretched profiled metal wire;
- (c) applying a lubricant on the surface of said stretched metal wire, i.e., after the wire stretching of said profiled metal wire by means of a wire stretching device.

[0041] In some embodiments the method may comprise more than one wire stretching step. For example, the method may comprise at least two wire stretching steps, whereby the initial wire stretching step produces an elongation of the metal wire characterised by a first wire elongation value and the final wire stretching step produces an elongation of the metal wire characterised by a second wire elongation value. Preferably the first wire elongation value is greater than the second wire elongation value. Exemplary wire elongation values are discussed further below in the present disclosure. The lubricant application step may then be performed after at least one wire stretching step or, according to a particular embodiment of the method, after each wire stretching step.

[0042] In accordance with the above-described embodiment, the method may comprise the steps of:

- (a) providing a metal wire having a profiled surface;
- (b) first stretching of said profiled metal wire by means of a wire stretching device as described in the present disclosure;
- (c) optionally, applying a lubricant on the surface of said first stretched metal wire;
- (d) second stretching of said profiled metal wire by means of a wire stretching device as described in the present disclosure; and,
- (e) optionally, applying a lubricant on the surface of said second stretched metal wire;

wherein the method comprises at least one step of applying a lubricant on the surface of stretched metal wire, preferably at least step (c) and/or step (e).

[0043] In some embodiments no lubricant is applied on the surface of the profiled metal wire prior to the wire stretching by means of a wire stretching device. In other words, the lubricant is only applied after wire stretching of the profiled metal wire by means of a wire stretching device. Accordingly, the provided metal wire may be a dry profiled metal wire, i.e. non-lubricated profiled metal wire. As such, at least one wire stretching device may be configured for stretching of said dry profiled metal wire. As explained above the stretching process typically re-

moves most if not all traces of lubricant.

[0044] In some embodiments the wire stretching of the profiled metal wire and the applying of lubricant on the stretched metal wire may be performed continuously and preferably simultaneously. Accordingly, in some embodiments of the method steps (a) to (c) may be performed continuously. The term continuously as used here refers to an in-line process whereby the metal wire passes through the sequential steps of the manufacturing method in a continuous manner. In other words, the various steps are performed successively without substantial delay and preferably simultaneously.

[0045] In a continuous process, the transport speed of the metal wire remains substantially constant during every step of the manufacturing process. The skilled person understands that because of the wire stretching process the speed at which wire is provided to the wire stretching device may differ from the speed at which stretched wire is extracted from said wire stretching device. Accordingly, because of the increased wire length, the speed by which the metal wire is transported when expressed in weight unit per time unit will typically remain constant, whereas when expressed in length unit per time unit it may vary between the different processing steps.

[0046] In some embodiments the provided metal wire may be a rolled-up metal wire and the providing of a metal wire may include a step of unrolling of the rolled-up metal wire. The metal wire may be rolled up during the production process as will be discussed further below in the present disclosure.

[0047] In some embodiments the stretched wire may be rolled up after the wire stretching step. For example, the stretched metal wire can be wound or rolled up into a roll or coil. The advantages thereof are discussed further below. The rolling up of the wire may be performed before or after applying of the lubricant as discussed below.

[0048] In an embodiment the method may comprise the steps of

- (c) applying a lubricant on the surface of said stretched metal wire; and,
- (d) rolling up of said lubricated metal wire.

[0049] In an embodiment the method may comprise the steps of

- (c) rolling up of said stretched metal wire; and,
- (d) applying a lubricant on the surface of said rolled-up metal wire.

[0050] Further to any one of the above embodiments, the method steps (a) to (d) may be performed continuously.

[0051] In accordance with a combination of the above-described embodiments, the method may comprise the steps of:

- (a) providing a metal wire having a profiled surface;
- (b) first stretching of said profiled metal wire by means of a wire stretching device as described in the present disclosure;
- (c) optionally, applying a lubricant on the surface of said first stretched metal wire;
- (d) second stretching of said profiled metal wire by means of a wire stretching device as described in the present disclosure;
- (e) optionally, applying a lubricant on the surface of said second stretched metal wire;
- (f) rolling of said second stretched metal wire; and,
- (g) optionally, applying a lubricant on the surface of said rolled-up metal wire.

wherein the method comprises at least one step of applying a lubricant on the surface of stretched metal wire, preferably at least step (c), step (e) and/or step (g).

[0052] In some embodiments the provided metal wire may be descaled, and the method may include a step of descaling of the metal wire. Preferably, the descaling of metal wire may be performed before the stretching of the profiled metal wire. Advantageously the descaling of provide metal wire may be performed by means of the wire stretching device that has been configured for the descaling of metal wire, for example, by being equipped with a wire descaling unit.

[0053] In some embodiments the metal wire may need to be passivated and the method may include a step of passivating of the metal wire. Preferably, the passivating of metal wire may be performed after the stretching of the profiled metal wire.

[0054] An aspect of the present disclosure relates to a device for manufacturing a stretched profiled wire, said device comprising:

- a wire feeder configured for providing profiled metal wire to the wire stretching device;
- at least one wire stretching device comprising at least two rotating shafts having an adjustable distance and/or angle; wherein the wire stretching device is configured to stretch the profiled metal wire provided by the wire feeder;
- at least one lubricant applicator configured for applying a lubricant on the surface of metal wire; wherein at least one lubricant applicator is configured for applying a lubricant on the surface of stretched metal wire produced by the wire stretching device.

[0055] In some embodiments the manufacturing device may comprise a at least two wire stretching devices, for example a first wire stretching device and a second wire stretching device. Preferably the at least two wire stretching devices are configured for stretching of the provided wire with a different wire elongation value. More preferably the first wire stretching device may be configured for stretching of the wire with a greater wire elongation value than the second wire stretching device. Ex-

emplary wire elongation values are discussed further below in the present disclosure.

[0056] Further, the least one lubricant applicator may be configured for applying lubricant on the surface of metal wire on the surface of stretched metal wire produced by the at least one wire stretching device. In an embodiment the lubricant applicator may be configured for applying lubricant on the surface of stretched metal wire produced by the first wire stretching device. In an embodiment the lubricant applicator may be configured for applying lubricant on the surface of stretched metal wire produced by the second wire stretching device.

[0057] Further still, in some embodiments the manufacturing device may comprise a at least two lubricant applicators, for example a first lubricant applicator and a second lubricant applicator. Preferably the at least two lubricant applicators may be configured for applying lubricant on the surface of stretched metal wire produced by different wire stretching device in accordance with the above-described embodiment. In an embodiment the first lubricant applicator may be configured for applying lubricant on the surface of stretched metal wire produced by the first wire stretching device and/or the second lubricant applicator may be configured for applying lubricant on the surface of stretched metal wire produced by the second wire stretching device.

[0058] In some embodiments the lubricant applicator may be configured for applying lubricant on the stretched metal wire produced by the wire stretching device only. In other words, the manufacturing device does not comprise any lubricant applicator configured for applying lubricant on the profiled metal wire before the stretching of said wire by said wire stretching device. Accordingly, the wire stretching device may be configured for stretching of non-lubricated profiled wire.

[0059] In some embodiments the wire feeder may comprise an actuator for transporting metal wire at a specific speed. Preferably, the wire feeder may comprise a wire unrolling device configured for unrolling a metal wire roll. In certain embodiments, the method described here comprises unrolling of the metal wire from a coil or bundle. Metal wire, such as for example hot-rolled metal wire, is usually transported in coils.

[0060] In some embodiments the manufacturing device may also comprise a wire roller to roll up the lubricated stretched metal wire into a coil at the end of the manufacturing process, i.e., after the lubricating step. This allows easier handling of the profiled metal wire and can ensure that the metal wire remains lubricated until application.

[0061] In some embodiments the wire stretching device may comprise an actuator configured for adjusting position of at least two rotating shafts to set the distance and/or angle between the at least two rotating shafts. The actuator may, for example, be an electrical motor configured to move the shaft position in at least two direction. Adjusting the distance and/or angle between the rotating shafts translates to a change of the force exerted

on the metal wire. In an exemplary embodiment the actuator may be controlled by a regulator or controller, for example a PID controller. PID controller (proportional-integral-derivative) is a controller commonly used in the art.

[0062] In some embodiments the manufacturing device may comprise a wire descaler. Descaling device will descale and clean a metal wire rod by removing mill skin from the metal wire in preparation for wire stretching. Mill skin is a form of oxidation which occurs with production of hot-rolled metal wire. The mill skin can be removed mechanically or chemically. Mechanical descaling may include deforming, brushing and/or blasting (such as sandblasting) of the metal wire. Wire descaling can typically be carried out before the wire stretching step. Advantageously, the wire stretching device may comprise a wire descaler or be configured for wire descaling through the provision of a wire descaling unit.

[0063] In some embodiments the manufacturing device may comprise a stress relief device. Stress relief is a metal-processing method in which the diameter of the wire is reduced further to a limited extent by guiding the metal wire over a number of rollers in close succession. This process also leads to an elongation of the wire, which however is usually small relative to the elongation achieved during plastic stretching. Stress relief can be carried out after wire stretching but before the final wire lubricating step. Advantageously, the stress relief device may be a second wire stretching device.

[0064] In some embodiments the manufacturing device may comprise a wire passivating device. Passivation leads to the spontaneous formation of a hard non-reactive surface film which hinders further corrosion and may be achieved by dipping the wire in one or more passivation solutions, as known by the skilled person. Passivation can be carried out after wire stretching but before the final wire lubricating step.

[0065] As described above, the profiled metal wire can be stretched using a metal wire stretching device in accordance with an embodiment of the present disclosure. Wire stretching devices are described in the art. In an embodiment the wire stretching device may comprise a plurality of rolling shaft rollers that are arranged on opposite sides of the provided profiled metal wire. For example, the wire stretching device may comprise four lower rolling shaft rollers that are arranged below the provided profiled metal wire and three upper rolling shaft that are arranged above the provided profiled metal wire, or vice versa. By raising/lowering the position of the upper/lower rolling shaft rollers the distance and/or angle between the adjacent upper and lower rolling shafts can be changed to stretch the wire with an elongation value that corresponds with the positional and/or angular change of the upper/lower rolling shaft rollers.

[0066] In some embodiments the wire stretching can produce an elongation of the metal wire of at least 0.1%, preferably at least 0.2%, even more preferably at least 0.5%, even more preferably at least 1.0%, even more

preferably at least 1.5%, even more preferably at least 2.0%.

[0067] In some embodiments the wire stretching can produce an elongation of the metal wire of at most 5.0%, preferably at most 4.5%, more preferably at most 4.0%, even more preferably at most 3.5%, even more preferably at most 3.0%, even more preferably at most 2.5%.

[0068] In some embodiments the wire stretching can produce an elongation of the metal wire of at least 0.1% to at most 5.0%, preferably at least 0.2% to at most 4.5%, more preferably at least 0.5% to at most 4.0%, even more preferably at least 1.0% to at most 3.5%, even more preferably at least 1.0% to at most 3.0%, for example 1.5%, 2.0%, or 2.5%.

[0069] In some embodiments the metal wire can be transported at a speed ranging from 0.5 m/sec to 20.0 m/sec, preferably from 1.0 m/sec to 17.5 m/sec, more preferably from 1.5 m/sec to 15.0 m/sec, even more preferably from 2.0 m/sec to 12.5 m/sec, even more preferably from 2.5 m/sec to 10.0 m/sec, for example 4.0 m/sec, 5.0 m/sec, 6.0 m/sec, 7.0 m/sec, 8.0 m/sec or 9.0 m/sec.

[0070] As described above, the profiled metal wire can be stretched at least twice comprising an initial stretching and a final stretching. In an embodiment the initial stretching, preferably the first stretching, may serve to elongate the metal wire to the desired wire length. In an embodiment the final stretching, preferably the second stretching, may serve to homogenize all the tension across the stretched wire. In a preferred embodiment the initial stretching may be characterised by a first wire elongation value and the final wire stretching step by a second wire elongation value. Preferably the first wire elongation value is greater than the second wire elongation value.

[0071] In an embodiment, the initial stretching, preferably the first stretching, can produce an elongation of the metal wire of at least 0.1%, preferably at least 0.2%, even more preferably at least 0.5%, even more preferably at least 1.0%, even more preferably at least 1.5%, even more preferably at least 2.0%.

[0072] In some embodiments the initial stretching, preferably the first stretching, can produce an elongation of the metal wire of at most 5.0%, preferably at most 4.5%, more preferably at most 4.0%, even more preferably at most 3.5%, even more preferably at most 3.0%, even more preferably at most 2.5%.

[0073] In an embodiment, the final stretching, preferably the first stretching, can produce an elongation of the metal wire of at least 0.1%, preferably at least 0.2%, even more preferably at least 0.3%, even more preferably at least 0.4%, even more preferably about 0.5%.

[0074] Profiled metal wire can be manufactured using a production method described in the art. One such method relates to the hot rolling of metal billets into wires. Accordingly, in one embodiment the provided profiled metal wire may be a hot rolled profiled metal wire. There are several benefits when using hot rolled metal over other production method of the art which makes it more suited for producing profiled wires that do not require a

clean finish in high quantities. For illustrative purposes the rolling production process is described below.

[0075] Raw material such as scrap metal is first melted into liquid metal and subsequently cast into a metal billet. This billet can be milled using an arrangement of horizontal and/or verticals mills comprising a plurality of box passes. The billet temperature during milling is increased to anywhere between 900°C to 1200 °C. The geometrical shape and dimensions of the passes will determine the shape and features of the metal wire. To obtain a profiled wire at least one mill, which is typically the final mill, will be a profiled mill that is configured to print indentations and/or ribs on the wire surface. Finally, the profiled metal wire can be cooled down to anywhere between 200°C to 300°C and bundled by dropping the profiled metal wires onto a capture pin.

[0076] Because of the high metal wire temperature, no lubricant can be added during or even after the hot rolling process. The lack of lubricant on hot rolled metal wire results in increased risk to damage the profiled metal wire surface and/or to wear down the profiled wire processing devices, such as spoolers, guiding wheels, guidings, bending equipment, straightening devices, etc.

[0077] Profiled metal wire is characterised by a sequence of positive ribbings and/or negative indentations. The properties of the profiled metal wire may be adjusted based on the material, length and cross section of the wire and its intended application in industry. For example, the profiled metal wire may include a sequence of transverse and/or longitudinal arranged ribs. The ribs may also be inclined at a specific angle with respect to the axis of the wire and/or be arranged with a specific pattern on the metal wire surface, such as spiral or helical. The profiled metal wire may have any geometrical cross section, which may for example include a round, square, rectangular, oval, ellipsoid, or irregularly shaped cross section.

[0078] The profiled metal wire may have a cross section ranging between 1.0 mm and 50.0 mm, preferably between 2.0 mm and 40.0 mm, more preferably between 3.0 mm and 30.0 mm, even more preferably between 4.0 mm and 25.0 mm, even more preferably between 5.0 mm and 20.0 mm, for example 6.0 mm, 8.0 mm, 10.0 mm, 12.0 mm, 14.0 mm, 16.0 mm or 18.0 mm. The skilled person may appreciate that because of the wire stretching process the profiled metal wire cross section can vary within a margin of error between different batches or even along the length of said wire. Accordingly, any reference to a specific cross section value implies a common margin of error, which can range anywhere from $\pm 1\%$ up to $\pm 10\%$ depending on the production quality. For example, a wire having a cross section of 15.9 mm or 16.1 mm may still be expected to be commercialised as a wire having a cross section of 16.0 mm.

[0079] For wires with a non-circular cross section and/or a profiled surface, the term "diameter" as used here means an equivalent diameter, more specifically the nominal centre line of the wire. The term "nominal centre line" indicates the diameter of a hypothetical wire

with a circular cross section, of the same length and content as the actual wire.

[0080] The profiled metal wires may be made in different grades from one or more metals or metal alloys, for example iron, steel, brass, bronze, copper, aluminium, etc. In a preferred embodiment, the metal wire is a steel wire or an iron wire. Steel wires can be produced from steel with high or low carbon content. The art described various lubricants which can be considered suitable for the purposes of the present disclosure. The lubricant may be provided in the form of a paste, powder, flakes, oil and/or emulsion. For example, raw materials used for the lubricant may include metal soaps, unreacted basic compounds, free fatty acids, and, as required for specific applications, minor amounts of various adjuvants such as fillers, pigments, dyes, extreme pressure additives, stabilizers, thickeners, waxes and polymers, esters, ethoxylates and metal wetting agents. In some embodiments the lubricant may comprise chalk.

[0081] In some embodiments the lubricant may comprise wire-drawing soap. Preferably, the soap may comprise sodium stearate and/or calcium stearate. The lubricant may also be a blended soap, for example comprising both sodium and calcium stearate. The listed soaps are particularly advantageous due to their transparent finish allowing easy and clear inspection of the produced wires at later stages in the production cycle.

[0082] The art described various techniques for the applying of a lubricant on the metal wire surface. For example, the lubricant may be continuously applied via spraying, dipping and/or brushing. Advantageously the lubricant application does not mechanically alter the metal wire by e.g. smoothening the wire which could diminish the advantageous effect of the wire profile. Preferably the lubricant is evenly distributed on the surface of said stretched metal wire.

[0083] Optionally, the application of lubricant can be verified with a device configured for measuring the presence of lubricant on the wire surface. For example, the presence of lubricant on the metal wire surface can be verified using an optical device such as a camera.

[0084] The amount of lubricant applied on the metal wire surface can be measured with respect to the wire length, surface area and/or weight. Nonetheless, the available surface area of profiled metal wire can be difficult to calculate, and as such the metal wire weight therefore provides a more reliable reference value. The lubricant yield can be tracked by measuring by weighing the profiled metal wire before and after lubricant application such that the difference in weight will correspond with the amount of applied lubricant (provided that possible traces of contamination are also considered). The determined amount of applied lubricant can then be divided by the desired reference value, such as the wire length, surface area and/or weight.

[0085] In some embodiments the lubricant is applied on the metal wire surface with a yield of at least 50 g/ton of metal wire (i.e., 10 g of lubricant for every ton of metal

wire), preferably 75 g/ton, more preferably 100 g/ton, even more preferably 125 g/ton, even more preferably 150 g/ton, even more preferably 175 g/ton, even more preferably 200 g/ton, even more preferably 225 g/ton, even more preferably 250 g/ton, even more preferably 300 g/ton.

[0086] In some embodiments the lubricant is applied on the metal wire surface with a yield of at most 1000 g/ton of metal wire (i.e., 1000 g of lubricant for every ton of metal wire), preferably 950 g/ton, more preferably 900 g/ton, even more preferably 850 g/ton, even more preferably 800 g/ton, even more preferably 750 g/ton, even more preferably 700 g/ton, even more preferably 650 g/ton, even more preferably 600 g/ton.

[0087] In some embodiments the lubricant is applied on the metal wire surface with a yield of at least 100 mg/m² of metal wire (i.e., 100 mg of lubricant for every m² of metal wire surface), for example 150 mg/m², preferably at least 200 mg/m², for example 250 mg/m², even more preferably at least 300 mg/m², for example 350 mg/m², even more preferably at least 400 mg/m², for example 450 mg/m², even more preferably at least 500 mg/m², for example 550 mg/m², even more preferably at least 600 mg/m², for example 700 mg/m², 800 mg/m² or 900 mg/m².

Claims

1. Method for manufacturing a stretched profiled wire, comprising the steps of:

(a) providing a metal wire having a profiled surface;

(b) stretching of said profiled metal wire by means of a wire stretching device comprising at least two rotating shafts, wherein the distance and/or angle between the rotating shafts can be controllably adjusted, wherein the profiled metal wire is secured between said rotating shafts to produce a stretched profiled metal wire;

characterised in that the method further comprises (c) applying a lubricant on the surface of said stretched metal wire.

2. The method of claim 1 wherein no lubricant is applied on the surface of the profiled metal wire before the stretching of said metal wire and the stretching is performed on a dry profiled metal wire.
3. The method of any one of claims 1 or 2 wherein the lubricant comprises a soap; preferably a wire-drawing soap.
4. The method of any one of claims 1 to 3 wherein the lubricant comprises sodium stearate and/or calcium stearate.

5. The method of any one of claims 1 to 4 wherein the lubricant is applied on the stretched metal wire via spraying, dipping and/or brushing.

6. The method of any one of claims 1 to 5 wherein the lubricant is applied on the metal wire surface with a yield of at least 50 g/ton of metal wire, preferably 75 g/ton, more preferably 100 g/ton, even more preferably 125 g/ton, even more preferably 150 g/ton, even more preferably 175 g/ton, even more preferably 200 g/ton.

7. The method of any one of claims 1 to 6 wherein the wire stretching step produces an elongation of the metal wire of at least 0.1%, preferably at least 0.5%, more preferably at least 1.0%, even more preferably at least 1.5%, even more preferably at least 2.0%.

8. The method of any one of claims 1 to 7 comprising at least two steps of stretching of said profiled metal wire by means of a wire stretching device; wherein the step of applying a lubricant on the surface of said stretched metal wire is performed after at least one wire stretching steps.

9. The method of claim 8 wherein an initial wire stretching step produces an elongation of the metal wire of at least 0.1%, preferably at least 0.5%, more preferably at least 1.0%, even more preferably at least 1.5%, even more preferably at least 2.0%; and wherein a final wire stretching step produces an elongation of the metal wire of at least 0.1%, preferably at least 0.2%, more preferably at least 0.3%, even more preferably at least 0.4%, even more preferably about 0.5%.

10. The method of any one of claims 1 to 9 wherein steps (a) to (c) are performed continuously.

11. The method of any one of claims 1 to 10 comprising the step of rolling up said lubricated metal wire.

12. The method of claim 11 wherein the applying of a lubricant is performed after the step of rolling up said lubricated metal wire.

13. The method of any one of claims 1 to 12 wherein the provided metal wire is a hot-rolled metal wire.

14. Device for the manufacturing of a stretched profiled wire, said device comprising:

- a wire feeder configured for providing profiled metal wire;

- at least one wire stretching device wire comprising at least two rotating shafts having an adjustable distance and/or angle; wherein the wire stretching device is configured to stretch the pro-

filed metal wire provided by the wire feeder; and,
- at least one lubricant applicator configured for
applying a lubricant on the surface of metal wire;
characterised in that the lubricant applicator is
configured for applying a lubricant on the surface
of stretched metal wire produced by the wire
stretching device. 5

15. Use of the device of claim 14 for the manufacturing
of a stretched profiled wire according to the method 10
of any one of claims 1 to 13.

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EUROPEAN SEARCH REPORT

Application Number

EP 22 16 1240

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 949 408 A1 (INTERSIG NV [BE]) 2 December 2015 (2015-12-02)	1-11, 13, 14	INV. B21C37/04
Y	* paragraphs [0008], [0011], [0052], [0053], [0062], [0068], [0075], [0082], [0083]; figure 1 * -----	12	B21F9/00 B21C47/26
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TECHNICAL FIELDS SEARCHED (IPC)

B21C
B21F
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The present search report has been drawn up for all claims

1

Place of search

Munich

Date of completion of the search

16 August 2022

Examiner

Augé, Marc

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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L : document cited for other reasons

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ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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