ROTONY BRAIDING MACHINE

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Appl. No.: 14/752,582

Filed: Jun. 26, 2015

Related U.S. Application Data
Continuation of application No. PCT/EP2013/003731, filed on Dec. 10, 2013.

Foreign Application Priority Data
Dec. 28, 2012 (DE) ................. 10 2012 025 302.8

Publication Classification
Int. Cl. D04C 3/46 (2006.01)
U.S. Cl. CPC D04C 3/46 (2013.01)

ABSTRACT
A rotary braiding machine for interweaving a strand shaped material into meshes is disclosed. In one aspect, the machine includes first coil carriers configured to rotate around the braid axis and second coil carriers configured to respectively move in respect to the first coil carriers. Each first coil carrier has a first coil and is configured to provide a first strand, wherein each second coil carrier has a second coil and is configured to provide a second strand. The surface of at least one closed guiding path is formed as a gear ring, wherein at least one gear wheel is rotatably mounted on the first coil carrier. The gear wheel combs with the gear ring and is engaged continuously with the gear ring, during a movement of the second strand around the first coil carrier.
ROTARY BRAIDING MACHINE
CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation application, and claims the benefit under 35 U.S.C. §§120 and 365 of PCT Application No. PCT/EP2013/003731, filed on Dec. 10, 2013, which is hereby incorporated by reference. PCT/EP2013/003731 also claimed priority from German Patent Application No. 10 2012 025 302.8 filed on Dec. 28, 2012, which is hereby incorporated by reference.

BACKGROUND

[0002] 1. Field
[0003] The described technology generally relates to a rotary braiding machine for interweaving a strand shaped material, for example, a wire or textile fibers, carbon fibers or other strand shaped carbon materials, into meshes.

[0004] 2. Description of the Related Technology
[0005] Such rotary braiding machines are used for fabricating hollow tubular meshes from the strand shaped material, such as metal wires, yarns or synthetic fibers, or by subsequent roll threading of such a tubular mesh for fabricating flat strand meshes or for braiding, for example, a cable with a wire mesh or for fabricating bodies of a low mass, for example, in a light weight construction, by braiding carbon fibers or of other strand shaped carbon materials. The application fields for the technical meshes being fabricated in such a way are, for example, protective shieldings for electric cables against electromagnetic fields or protective enclosures for cables or hoses against mechanical stresses. Another application is the fabrication of medical meshes for vascular implants, such as stents, vascular prostheses or the like.

SUMMARY OF CERTAIN INVENTIVE ASPECTS

[0006] One inventive aspect is a rotary braiding machine, for which a wire is the strand shaped material to be interwoven, e.g., for the fabrication of wire meshes. However, this is not a limitation. The described technology can also be applied to rotary braiding machines for the processing of any other strand shaped materials.

[0007] In some embodiments, the rotary braiding machine includes a plurality of coils, each of which is arranged in a coil carrier. For example, a coil is a cylindrical body for winding a wire to be interwoven, comprising, for example, a central body, which is arranged at the ends of the cylindrical body, the flanges having a larger diameter than that of the cylindrical body. The coil carrier is a device into which a coil can be accommodated, for example, into which it can be mounted rotatably around its longitudinal axis.

[0008] The rotary braiding machine can be a high speed level braiding machine.

[0009] The rotary braiding machine has a braid axis, e.g., a geometric axis, in which direction the mesh is formed and is drawn off by the machine, for example, by a stripping disk, and in which direction, if necessary, also the material to be interwoven is supplied to the machine. The braid axis can be arranged horizontally, vertically or inclinedly, for example, inclined by 45 degrees, respectively. Embodiments are described in the following using the example of a rotary braiding machine with a vertically disposed braid axis, but it can also be applied to a rotary machine with a braid axis which has been arranged differently.

[0010] The rotary braiding machine includes a plurality of first coil carriers which can rotate around the braid axis, and a plurality of second coil carriers, which can perform a relative movement in regard to the first coil carriers. Here, at least the first coil carriers are guided along a closed guiding path around the braid axis. Here, a guiding path should mean a curve the first coil carriers are following essentially during their movement. The first coil carriers do not necessarily have to lie on this curve and/or have to contact it. The guiding path is formed, for example, as a circular rail and forms a plain bearing path or roller bearing path, onto which the first coil carriers are hung up and can be moved by means of sliding guides and/or rolling bearings.

[0011] For a typical embodiment of such a rotary braiding machine, for example, six or twelve first coil carriers rotate on a circular guiding path, wherein the braid axis is extending through its center. Furthermore, six or twelve second coil carriers move likewise around the braid axis, and for example, with the same speed as the first coil carriers, but in the opposite direction to the first coil carriers. Here, the second first coil carriers are mounted so that they can rotate around the braid axis as well.

[0012] Each first coil carrier provides a strand of a first wire, which is continuously unwound or drawn off from the first coil which is mounted on the respective first coil carrier. Accordingly, each of the second coil carriers provides one strand of a second wire, which is continuously unwound or drawn off from the second coil which is mounted on the respective second coil carrier.

[0013] The first wires and the second wires are guided in a certain angle inward toward the braid axis, where they arrange themselves due to the rotation of the coil carriers and due to a simultaneous withdrawal movement of the mesh in spiral paths or are laid around the material to be braided, wherein the first wires are interwoven with the second wires.

[0014] In some embodiments, the first wires and the second wires are crossed in a certain pattern, e.g., they lay above or below each other wire, respectively. For example, at first, two adjacent second wires are each carried over two adjacent first wires, respectively and then carried under the next two adjacent first wires, respectively and so on (so-called “two over two braid binding”). Accordingly, it is also possible that, for example, every second wire is alternately carried above a first wire and then carried below a first wire (so-called “one over one braid binding”). The area, in which the crossed first and second wires lay against each other on the braid axis, is also called the braiding point.

[0015] The crossing over of the first and second wires is achieved in that the second wires are moved around periodically according to the desired cross over pattern around the corresponding first coil carriers and thus around the corresponding first wires. For the presently considered level braiding machine, this is achieved because every second wire can be raised over and can be lowered by a so-called thread lever, which is attached to the corresponding second coil carrier and which can be moved. In this way, the considered second wire can be carried over the first coil carrier, which is moving past in the opposite direction, or it can be carried under the first coil carrier, which results in a corresponding crossing over of the first and the second wire with an above or an below laying second wire, respectively.

[0016] By the guiding of the second wires over the thread lever, it is avoided that the entire second coil carriers, which may have a substantial mass, due to the second coils mounted
thereon and the second wires wound thereon, have to be raised or to be lowered as a whole.

[0017] For the described sequence of movements, every second wire can move all the way around every first coil carrier. Since the second wire is always guided in the direction of the braiding point, this results for this movement around the first coil carrier into an imaginary approximate conical surface.

[0018] For the moving of the second wire around the first coil carrier, the mounting of the first coil carrier on the closed guiding path has to be at least temporarily and/or at least partially interrupted, wherein the first coil carrier rotates around the braid axis on the guiding path, so that at this position the first coil carrier and second wire can cross their paths. For a typical embodiment of the considered rotary braiding machine, this is achieved in that the second wire is carried under the first coil carrier, which means that it “dives through” under the first coil carrier.

[0019] For this purpose, for example, for each second wire, a vertical slit shaped gap is provided for the closed guiding path for the first coil carrier, wherein the respective second wire can be lowered into the vertical slit shaped gap, whereupon the first coil carrier passes over the lowered second wire. Such gaps are distributed at regular intervals around the entire circumference of the guiding path arranged around at those positions where the second wires have to be lowered by means of their associated thread lever. Since the second coil carriers are fixedly connected to the guiding path, it is ensured that each second wire can be exactly immersed into the gap in the guiding path, without that a relative motion between the second wires and the gaps in the guiding path has to be considered.

[0020] By the periodic interruption of the guiding path by the gaps, for the conventional rotary braiding machines the problem arises that the sliding guides or the roller guides of the first coil carrier must be moved over these gaps permanently. The guides leave at the beginning of each gap the guiding path and must “thread in” at the end of the gap again into the guiding path.

[0021] This results into problems, especially at higher speeds and thus higher relative velocities between the first coil carriers and the guiding path, due to an increased wear of the guides and the guiding path, due to shocks induced and vibrations, and also to increased noise emissions of the rotary braiding machine.

[0022] Another aspect is an improved rotary braiding machine, especially with an improved guiding of the first coil carrier along the guiding path.

[0023] Another aspect is a rotary braiding machine with a braid axis for interweaving a wire to a wire mesh, the machine having a plurality of first coil carriers, which can rotate around the braid axis, and a plurality of second coil carriers, which can perform a movement relative in regard to the first coil carriers. In this case, each first coil carrier has a first coil and provides a first wire and each second coil carrier has a second coil and provides a second wire. The rotary braiding machine is adapted to interweave the first and second wires with each other. Furthermore, at least a first coil carrier is arranged so that at least a second wire can be completely moved around the at least one first coil carrier. At least the first coil carriers can be guided along at least one closed guiding path, which is rotating around the braid axis.

[0024] According to some embodiments, for such a rotary braiding machine, the surface of at least one closed guiding path is designed as a gear ring and the at least one first coil carrier has at least a gear wheel, which is rotatably mounted and which combs with the gear ring and is engaged with the gear ring and which is engaged constantly with the gear ring, for example, also during the movement of the least one second wire around the at least one first coil carrier.

[0025] Here, the “gear wheel” and “gear ring” can include a wheel or a closed, but not necessarily circular path, respectively, which is provided in its circumference or in its extension direction, respectively, alternately with teeth and tooth gaps, wherein the gear wheel can be engaged with the gear ring and it can be rolled off onto the gear ring.

[0026] By this, the first coil carrier moves by the roll off movement of the gear wheel to the gear ring in a quasi-continuous manner, e.g., essentially with a uniform and a constant speed, for example, without any jerks or other short-term accelerations along the path. The above mentioned problems in regard to the wear, the shocks, the vibrations and the noise emissions by constantly leaving the guiding paths by the guiding of and the rethreading of the guides in the guiding paths can be thus avoided to a large extent, because the combing of the gear wheels with gear rings is very well developed, for example, by the use of special gearings as an involute gearing, and the called quasi continuous movement becomes possible. In this way, higher rotational speeds of the first coil carrier are possible and thus a rotary braiding machine with higher productivity can be achieved.

[0027] The gear wheels and the at least one gear ring can be, for example, made of a metal or of a plastic. The latter allows for a dry run with a minimal lubrication or even without any lubrication. As a result, an oil contamination of the rotary braiding machine can be avoided, the oil contamination due to the centrifugal oil droplets, and a potential contamination of the product can also be avoided. Especially, certain products with higher quality standards requirements, for example for medical devices, such pollution may be even forbidden. Furthermore, corresponding countermeasures against oil contamination such as oil drip plates are not necessary.

[0028] The uniform roll off movement of the gear wheels on the gear ring does not lead to an excessive heating of the guides of the first coil carrier or of the guiding path, respectively, so that costly measures for a monitoring of the temperature and for preventing overheating of the components of the engine are not necessary.

[0029] The spaces between adjacent teeth of the gear ring and the gear ring, respectively, are referred to as “tooth gaps” in the following.

[0030] In the arrangement, a second wire can be immersed into a tooth gap between two adjacent teeth of the gear ring, while a first coil carrier having a gear wheel is moved past it. With an appropriate, sufficiently large dimensioning of the teeth compared to the diameter of the second wire, e.g., for big teeth and thin second wires, there is no contacting between the second wire and the teeth of the gear wheel rolling over it, because the teeth when using a normal gearing do not contact the deepest points of the tooth gaps in the gear ring. Thus, at this position, there will always be a continuous hollow space being transverse to the extending direction of the gear ring, through which the second wire can be guided. At the same time, the gear ring remains permanently engaged with the gear ring and does not have to leave the gear ring and to thread back to it again.

[0031] In some embodiments, the surface of the at least one closed guiding path has at least one continuous recess being
substantially transverse to the extending direction of the guiding path, which is deeper than the tooth gaps of the gear ring, wherein the at least one second wire is temporarily immersed in at least one recess during the movement of the at least one second wire around the at least one first coil carrier.

[0032] Such a recess is, for example, formed as a recess of a tooth gap of the at least one gear ring. Therefore, for the roll off movement of the gear wheel on the gear ring no changes arise, so that also a quasi-continuous movement of the first coil carrier on the guiding path is possible. In some embodiments, such a recess is provided for each second wire.

[0033] In some embodiments, a device is attached to the at least one first coil carrier in the region of the gear wheel, wherein the device prevents the coil carrier from an axial displacement in at least one direction. This device, for example, has the form of a disk which is mounted coaxially to the gear wheel on the first coil carrier, for example, parallel and whose diameter is greater than the inner gear diameter, e.g., the distance from the center of the gear wheel to the deepest points of its tooth gaps. Thus, the disk cannot move past the gear ring in the axial direction of the gear wheel, the gear ring being in engagement with the gear wheel, whereby the first coil carrier is prevented from an axial displacement in this direction.

[0034] In some embodiments, however, the diameter of the disk is so small that the hollow space, which is intended for the passing through of the second wire, for example, the deepest point of a tooth gap in the gear ring or a recess in the guiding path will not be covered by the disk, and thus the disk does not contact the second wire, when the first coil carrier moves past it.

[0035] The disk may also have a larger diameter than those referred to and it can have in addition on its outer edge at least one recess through which the second wire can be guided, when the first coil carrier is moved past. To this end, the positioning of the first coil carrier and the rotational movement of the gear wheel must be synchronized so that such a recess on the disk points in the direction of the gear ring at the moment, in which the gear wheel on the guiding path is directly over the hollow space for the passing through of the second wire.

[0036] In some embodiments, at the at least one first coil carrier, two gear wheels are mounted rotatably on opposite ends of the first coil carrier coaxially or almost coaxially to each other. In this case, for example, two closed guiding paths are provided, which are designed as gear rings and which extend concentrically with the braid axis, but not necessarily in the same plane. By this, the first coil carrier is mounted at two opposite ends relative to the two guiding paths and thus secured against tilting movements in the axial direction.

[0037] However, for this arrangement, accidental rotations of the first coil carrier around its own axis are still possible, and for example, torsional vibrations. However, this can be to a large extent avoided by a suitable arrangement of the components within the first coil carrier, for example, by means of a suitable position of the center of gravity and/or by means of inserts of permanent magnet.

[0038] Alternatively, at the first coil carrier, two adjacent gear wheels can be attached, both of which comb with the same gear ring, or in each case two toothed wheels on both sides of the first coil carrier, respectively combing with a gear ring. Thus, the first coil carrier is based stably on two or four points of contact with the gear ring and the gear rings, respectively and it cannot perform any inadvertent rotation around its own axis. For this variant, all the gear wheels are continuously engaged with the respective gear ring.

[0039] In some embodiments, the two gear rings and the two gear wheels each have the same number of teeth. Further, the two gear wheels are connected by a common shaft and therefore synchronized in speed and they are, if necessary, connected to a balancing device for a possible angular offset between the axes of the two gear wheels. If the arrangement of the other components in the first coil carrier does not allow such a continuous shaft, the speed synchronization may, for example, also be done via a countershaft, which is arranged parallel to the axis of the two gear wheels and which is coupled, for example, by means of two other smaller gear wheels, meshing with the two gear wheels. By the fact that the two gear wheels have the same rotation speed, the first coil carrier is always oriented radially, and the gear wheels do not tilt in the respective gear ring.

[0040] In some embodiments, a gear wheel and a device are attached to opposite ends of the at least one first coil carrier, wherein the device prevents the coil carrier from an axial displacement in at least one direction. The latter sliding locking device, which is, for example, formed as already described above, then replaces one of the gear wheels in the above described embodiment with two gear wheels. Further, the respective gear ring is, for example, replaced by a guiding path with a smooth surface, on which the sliding locking device can roll off.

[0041] In some embodiments, the first coil carriers move on a, viewed from the first coil carriers, convex, for example, a cylindrical, a conical or a truncated conical surface. However, as a special case, the convex surface may also be a flat disk.

[0042] In some embodiments, an axis of the surface, the axis of symmetry of the cylinder, the cone or the truncated cone, coincides with the braid axis of the rotary braiding machine. The at least one closed guiding path can be circular and arranged in a plane perpendicular to the braid axis. However, the surface of the guiding path can have, for example according to the shape of the surface, a non-zero angle with that plane.

[0043] The convex surface can be the outer surface of a corresponding body, for example, of a cylinder, a cone or a truncated cone, respectively.

[0044] The first coil carrier can move on a, viewed from the first coil carriers, concave, for example, a cylindrical, a conical or a truncated conical surface, wherein the further embodiments of this construction correspond to those described above for a convex surface.

[0045] The concave surface can be the inner surface of a corresponding body, for example, a hollow cylinder, a cone or a truncated cone, respectively.

[0046] Both of these arrangements for the movement of the first coil carriers, for example, on a conical or on a truncated conical surface, have the advantage that the first coil carriers are thereby positioned in the same angle relative to the braid axis, in which the first wires are to impinge on the braid axis. Therefore, another deflection of the first wires is not necessary.

[0047] The driving of the second coil carriers is, for example, realized as well as for the above described conventional rotary braiding machine, namely by a rigid connection between the second coil carriers and the revolving guiding path.

[0048] However, the first coil carrier cannot be rigidly connected to other machine parts to be driven by them, because
this rigid connection would collide with the second wires in a complete movement of the second wire around the first coil carrier.

[0049] Also the driving of the first coil carrier is, for example, realized just as for a conventional rotary braiding machine, namely by contacting machine components.

[0050] In some embodiments, however, it is provided that a driving means, which is arranged outside of the at least one first coil carrier, generates without contacting the rotational movement of the at least one first coil carrier around the braid axis.

[0051] Both the drive means and the at least one first coil carrier can have at least one magnet, for example, a permanent magnet or an electromagnet. The driving of the at least one first coil carrier is then carried out by a magnetic, non-contact coupling between the magnet in the driving means and the magnet in the first coil carrier over an air gap. The second wire can then be guided through this air gap, if it moves around the first coil carrier.

[0052] The air gap between the surface, in which the guiding path is extending, and the at least one first coil carrier is formed in this case, for example, in that the at least one gear wheel of the first coil carrier has a larger diameter than the remaining components, which are arranged in the coil carrier, or also as an eventual housing of the first coil carrier, whereby these components or this housing, respectively, is spaced from the surface, on which the guiding path is arranged and on which the gear wheel moves, whereby the gear wheel is supported on the guiding path.

[0053] However, it is also feasible to achieve such an air gap between the first coil carrier and the surface of the guiding path by other means than through different mounting of the gear wheel on the guiding path. For example, the first coil carrier could be held in levitation by repelling magnets, which are arranged in the first coil carrier and under the surface of the guiding path, e.g., by a magnetic levitation effect, or by the air flowing from surface of the guide path, e.g., by an air cushion effect, and thereby spaced from the surface of the guiding path. Then it would be possible to completely do without the gear wheel on the first coil carrier on the gear ring on the guiding path and to do without the corresponding recesses in the guiding path for the guiding of the second wire. In this case, the first coil carrier would not contact the surface of the guiding path at any point.

[0054] For at least one of the above embodiments, in which the rotational movement of the at least one first coil carrier around the braid axis is generated by magnets both in the driving means and in the first coil carrier, different variants are possible:

[0055] In some embodiments, the driving means comprises a plurality of fixed electromagnets, which are arranged on a closed path around the braid axis, in which a rotating magnetic field can be generated, which entrains the at least one first coil carrier by means of a magnetic coupling, and set it into a rotational movement around the braid axis. The driving of the at least one first coil carrier is carried out so similarly to the driving of a linear drive with an annular track or similarly to the driving of a synchronous machine with a fixed stator having a plurality of coils. In this arrangement, the driving means has no moving parts, whereby the driving means is to a large extent maintenance free.

[0056] However, the driving means can, for example, also have at least one magnet, for example, a permanent magnet or an electromagnet, which can move on a closed path around the braid axis, whereby a rotating magnetic field is generated, which entrains the at least one first coil carrier by magnetic coupling and set it into the rotational movement around the braid axis. The at least one magnet in the driving means is, for example, arranged on a rotatable rotor and generates a rotor fixed field which rotates with the rotor, which causes the desired magnetic coupling with the at least one first coil carrier.

[0057] In some embodiments, at least one magnet in the driving means and at least one magnet within the at least a first coil carrier are adapted to prevent an axial displacement of the at least one first coil carrier in at least one direction. For this purpose, the involved magnets can be arranged so that upon displacement of the first coil carrier in the axial direction magnetic restoring forces are generated also in the axial direction, effecting a recirculation of the first coil carrier to its starting position, for example which is centered in regard to the guiding path. This variant can provide an alternative to the above, for example, disk shaped device in the region of the gear wheel, which shall also prevent the first coil carrier from an axial displacement in at least one direction.

[0058] For this variant, the magnets for preventing an axial displacement of the at least one first coil carrier are, for example, at least partly identical with the magnets which are used for the driving of the at least one first coil carrier. Thereby, additional magnets, and thus manufacturing costs can be saved. However, also different magnets may be provided for the preventing of an axial displacement or for the driving of the at least one first coil carrier.

[0059] However, it is also possible that, as an alternative to the arrangement of the magnets in both the driving means and in the at least one first coil carrier, the rotational movement of at least one first coil carrier around the braid axis is generated by a driving means, for example, by at least one electric motor, which is disposed within the first coil carrier. In this case, the first coil carrier moves “autonomously” on the guiding path, that is to say without the influence of driving forces from the outside. The energy required to operate the electric motor can be provided, for example, by, for example, a rechargeable battery, which is also arranged within the first coil carrier. The charging of or the replacement of the battery, respectively, may be made simultaneously with the exchange of a blank for a full first coil in the first coil carrier, when the rotary braiding machine may therefore anyway.

[0060] Alternatively, however, the energy required for the operation of the electric motor can also be transmitted contact-free, for example, inductively, from a fixed power supply unit to the at least one first coil carrier, for example, for a direct supply of the electric motor or for the charging of a rechargeable battery being arranged within the first coil carrier.

[0061] Likewise, the controlling of the electric motor, which is arranged in the at least one first coil carrier, can be done by a wireless, for example, by a near field or through a wireless connection from a fixed control unit. In this way, it is possible to perform a simple common controlling of the movement of all of the first coil carriers and thus, for example, a synchronization of the speeds thereof.

[0062] Another aspect is a method of operating a rotary braiding machine, in which during the braiding the first coil carrier rotates around the braid axis and the second coil carriers perform a relative movement in regard to the first coil carriers, wherein further at least one first coil carrier is arranged so that at least a second wire can be completely moved around at least one first coil carrier, and wherein at least the first
coil carriers are guided along at least one closed guiding path, wherein the at least one second wire is moved around the at least one first coil carrier, wherein the gear wheel of the least one first coil carrier combs with the gear ring and it is constantly engaged at the same time with the gear ring.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0063] FIG. 1 is a perspective view from a slanted top of a rotary braiding machine according to one embodiment.

[0064] FIG. 2 illustrates a vertical section through the rotary braiding machine of FIG. 1.

[0065] FIG. 3 is a detailed illustration of FIG. 2 with a vertical section through a first coil carrier.

[0066] FIG. 4 illustrates a driving arrangement for a first coil carrier showing the teeth of an external rotor according to one embodiment.

[0067] FIG. 5 illustrates a driving arrangement for a first coil carrier showing an illustration of the magnets involved with an internal rotor according to one embodiment.

[0068] FIG. 6 is a vertical sectional view as in FIG. 3 with a magnetic holding device in the axial direction of the first coil carrier.

**DETAILED DESCRIPTION OF CERTAIN INVENTIVE EMBODIMENTS**

[0069] FIGS. 1 and 2 show a rotary braiding machine 1 according to some embodiments in a perspective view obliquely from above, and a vertical section through the axis of symmetry of the rotary braiding machine 1, respectively, the axis of symmetry corresponding to the braid axis 14. It is noted that for reasons of clarity, several parts of the machine are not shown, for example, those which are used for the fastening of other parts.

[0070] The rotary braiding machine 1, which is substantially rotationally symmetrically constructed, is mounted in the vertical direction by a carrier shaft 2 which is coaxial to the braid axis 14 and which is mounted at its lower end on a front side of a (not shown) foundation. A pivot mounting 3 is rigidly attached to the carrier shaft 2, wherein the pivot mounting 3 can be brought into rotation by the carrier shaft 2. The rotary driving of the carrier shaft 2 and thus of the pivot mounting 3 is done via a gear ring 20 at the lower end of the carrier shaft 2.

[0071] The pivot mounting 3 has the geometric shape of a vertically arranged essentially tapered towards the top truncated cone. On the inner, upper edge and on the outer, lower edge of the conical outer surface of the truncated cone, two circumferential guiding paths are mounted in the form of an inner gear ring 6 and an outer gear ring 7, whose teeth are extending outwards perpendicular to the surface of the truncated cone.

[0072] Below the pivot mounting 3, eight second coil carriers 5 are circumferentially and equally spaced attached to the pivot mounting 3 (partly hidden, fastening means are not shown on the pivot mounting 3). Thus, the second coil carriers 5 rotate in the same direction and with the same speed as the pivot mounting 3. On each second coil carrier 5 is mounted a second coil 51, whose axis is horizontal and onto which a second wire 11 is wound.

[0073] On the conical outer surface of the pivot mounting 3, eight first coil carriers 4 are also circumferentially arranged at equal intervals, wherein their axes point radially outwards at about the same angle as the conical surface of the pivot mounting 3 points downwards. The first coil carriers 4 have no fixed connection to the remaining parts of the rotary braiding machine 1, for example, not to the pivot mounting 3.

[0074] Each first coil carrier 4 has at its inner edge a tangentially arranged inner gear wheel 41 having seven teeth and on its outer edge a coaxial thero, also tangentially arranged outer gear wheel 42 with 18 teeth. Of course, other numbers of the teeth and/or other positions of the gear wheels 41, 42 relative to the first coil carrier 4 are possible. The axes of the two gear wheels 41, 42 are mounted in the side walls of a housing 44 being U-shaped in the longitudinal cross section. Inside the housing 44, a first coil 43 is mounted with its axis extending horizontal and thus perpendicular to the axes of the gear wheels 41, 42. Here, too, of course, other positions of the first coil 43 are possible relative to the components of the first coil carrier 4. On the first coil 43, a first wire 10 is wound. The first wire 10 is guided within the first coil carrier 4 on different deflection rollers 45 and then passes through a front boring in the housing 44 and through an axial boring in the inner gear wheel 41 of the first coil carrier 4.

[0075] In this case, the inner gear wheel 41 rolls off on the inner gear ring 6 and the outer gear wheel 42 rolls off on the outer gear ring 7.

[0076] Both the first wire 10 and the second wires 11 are guided substantially parallel to the conical outer surface of the pivot mounting 3 upward to a braiding button 8, wherein at its lower end a braiding point 9 is positioned, which is on the braid axis and at which the interweaving of the first wires 10 with the second wires 11 and the braiding of a hose is performed, respectively, which is fed from below from a (not shown) coil to the rotary braiding machine 1. The mesh or braided hose is passed from the rotary braiding machine 1 through the braiding button 8 upwards by a (not shown) roll off disk and it is wound on a (also not shown) coil.

[0077] For the purpose that the second wires 11 can move around the first coil carrier 4, after the unwinding from the second coil 51, each second wire 11 is guided via a thread lever 12, which can be moved up and down, and at the end thereof it is guided by a deflection roller 13 in the direction of the braiding button 8. In the highest position of the thread lever 12, the first coil carrier 4 can move through under the second wire 11. In the lowest position of the thread lever 12, the second wire 11 can immerse in a recess 71 in a tooth space of the outer gear ring 7 and in a corresponding recess 61 into a tooth space of the inner gear ring 6, which is arranged for each second wire 11 on the positions being at the same radius of the pivot mounting 3 lying on the circumference of the two gear rings. Once the second wire 11 is immersed into the two recesses 61 and 71, the first coil carrier 4 can move over the second wire 11 without contacting it. By this sequence of movements, the crossing over of the first wires 10 with the second wires 11 is carried out, which is the prerequisite for the formation of a mesh at the braiding button 8.

[0078] The driving of the first coil carrier 4 is done electromagnetically. For example, between the two gear rings 6 and 7 of the pivot mounting 3, a rotor 22 is disposed, which can be also rotated around the braid axis 14 and on which a plurality of magnets, for example, permanent magnets or electromagnets 16 is mounted in a radial outward, downward facing direction.

[0079] The rotor 22 is externally mounted by a ball bearing 18 on the carrier shaft 2 and it is connected via a driving shaft 23, which is coaxial to the braid axis and which is also mounted on the outside of the carrier shaft 2 by a ball bearing
18, with a gear ring 19, which is opposite in parallel to the gear ring 20 and which is facing the latter.

[0080] As the rotor 22 is arranged between the gear rings 6 and 7 and thus it is arranged within the pivot mounting 3 and thus it cannot be rigidly connected to the drive shaft 23, as it would otherwise have to penetrate the pivot mounting 3, the coupling of the rotor 22 with the driving shaft 23 is carried out without contacting by pairs of permanent magnets 24 and 25, which are arranged respectively on opposing sides of a mounting for the pivot mounting 3. However, other solutions with other conventional machine elements are also possible for the driving operation of the rotor 22.

[0081] Between the gear ring 20 for the driving of the pivot mounting 3 and the gear ring 19 for the driving of the rotor 22, a stationary gear 21 is arranged, which combs with the two gear rings 19, 20 and which is driven by an electric motor and a gear (both not shown). Thereby, the pivot mounting 3 and the rotor 22 are driven at the same speed but in the opposite direction.

[0082] In FIGS. 3 to 5, as an alternative for the driving of the first coil carrier 4 by a rotor 22, a driving by fixed electromagnet 16 in the sense of a linear motor is illustrated.

[0083] In FIG. 3, a first coil carrier 4 and its mounting on the pivot mounting 3 is illustrated in an enlarged sectional view. It can be seen that by the support of the inner gear wheel 41 on the outer gear wheel 42 on the outer gear wheel 7, there is generated an air gap 17 (in the embodiment having a height of about 2 mm) between the housing 44 of the first coil carrier 4 and the pivot mounting 3, through which the second wire 11 can be guided, as described above.

[0084] In the bottom of the housing 44, a disk shaped permanent magnet 15 is embedded, its north pole N and its south pole S are oriented perpendicularly to the conical surface of the pivot mounting 3. Beneath the surface of the pivot mounting 3, the electromagnets 16 are circumferentially arranged on the circumference at regular intervals.

[0085] It is noted, that the illustration of the permanent magnet 15 and the electromagnet 16 in FIG. 3 is a schematic one only. Instead of the permanent magnet 15 it may be used magnet systems with hard magnetic sections and soft magnetic sections and/or with a larger dimensioning in the axial direction of the first coil support 4 as shown in FIG. 3.

[0086] The electromagnets 16 form the guiding path of a linear motor, which sets all of the first coil carriers 4 at the same time as a slide into the rotational movement. For this purpose, a rotating magnetic field is generated in the pivot mounting 3 through a corresponding current feed to the electromagnet 16, which entrains the first coil carriers 4 by a magnetic coupling. The rotating magnetic field moves in the opposite direction of rotation of the pivot mounting 3. Thus, the first coil carriers 4 and the second coil carriers 5 and thus also the first wires 10 and the second wires 11 rotate in opposite directions at the same speed relative to the braiding button 8, resulting in a uniform and symmetrical mesh formation at the braiding point 8. By the driving of all the first coil carriers 4 by a common linear motor, it is further ensured that all of the first coil carriers 4 are driven at the same speed.

[0087] FIG. 4 shows a schematic illustration of the roll off movement of the outer gear wheel 42 of the first coil carrier 4 on the outer gear ring 7, wherein approximately the same illustration would result for an inner gear wheel 41 and the inner gear ring 6. The trajectory of the second wire 11 upwards or downwards, respectively, to the first coil carrier 4 and thus around the outer gear wheel 42 is also indicated schematically by two dotted lines. Furthermore, here are also illustrated the periodically arranged recesses 71 in the single tooth gaps of the outer gear ring 7, into which the second wire 11 can be immersed.

[0088] Six electromagnet coils 16 are illustrated in the inside of the pivot mounting 3, the electromagnet coils forming a section of the guiding path of the linear motor for the driving the first coil carrier 4. Due to the arrangement of the outer gear ring 7 on the conical outer surface of the pivot mounting 3, the linear motor is designed as an external rotor motor.

[0089] In FIG. 5, an alternative embodiment is shown, which does not correspond to the embodiment according to FIGS. 1 to 4. In this case, the pivot mounting 3 has the form of a hollow vertically arranged cylindrical truncated cone, which is tapered towards the top. The supply and the discharge of the material to be braided or of the fabricated meshes, respectively, is done from the bottom to the top. In this case, the first coil carriers 4 are arranged inwardly inclined downwards on the inner, conical surface of the pivot mounting 3. Thereby, the linear motor is designed as an inner rotor motor.

[0090] In FIG. 5, it is shown the detail of the arrangement of the magnets in the first coil carrier 4 and in the guiding path of the linear motor in the pivot mounting 3. Below the surface of the pivot mounting 3 is circumferentially arranged a plurality of ribs, which are individually wrapped with conductive wires to form the coil with an elongated cross section. In the first coil carrier 4 (here only represented by dotted lines on its periphery), a permanent magnetic arrangement is mounted on the pivot mounting 3 on its opposite edge, wherein the permanent magnetic arrangement is formed in a horseshoe shape in this case. For the magnetic coupling between the first coil carrier 4 and the electromagnet 16 in the pivot mounting 3, therefore, there is not only one pair of magnetic poles facing itself as shown in FIG. 3, but there are two such pairs, resulting in much stronger magnetic attraction forces. The compact, closed distribution of the field lines of the resulting magnetic coupling is also indicated in FIG. 5. Between the permanent magnet 15 and the pivot mounting 3 is again formed an air gap 17, through which the second wires 11 can be guided.

[0091] Finally, a magnetic holding device is shown in FIG. 6, by means of which a first coil carrier 4 can be secured from sliding below outwards or below inwards, respectively.

[0092] The magnetic holding device is formed by two identically constructed, horseshoe shaped arrangement of permanent magnets 15 in the first coil carrier 4 or below the surface of the pivot mounting 3, respectively, which each corresponds to the horseshoe shaped magnet arrangement of FIG. 5 and which are coupled magnetically to each other.

[0093] For the purpose that the two horseshoe shaped magnetic arrangements are always aligned opposite and thus can fulfill their holding function, the magnetic arrangement, which is arranged in the pivot mounting 3, can be synchronously rotating with the first coil carrier 4. This can be done most easily, when the magnets in the pivot mounting 3 do not form the fixed guiding path of a linear motor, but are arranged on a rotating rotor 22 as shown in FIGS. 1 and 2. Since the magnets in this case need not be periodically turned on and off in the pivot mounting 3, the permanent magnets 15 can also be used for this purpose. As illustrated in FIG. 6, the magnetic arrangement of the permanent magnets 15, which are
arranged on the rotatable rotor 22, then takes over at the same time the function of the rotational driving for the first coil carrier 4 and the holding function against slipping of the first coil carrier 4, whereby a particularly simple construction is achieved.

While the inventive technology has been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope as defined by the following claims.

What is claimed is:

1. A rotary braiding machine having a braid axis for interweaving a strand shaped material into meshes, the machine comprising:
- a plurality of first coil carriers configured to rotate around the braid axis; and
- a plurality of second coil carriers configured to relatively move with respect to the first coil carriers, wherein each of the first coil carriers includes a first coil and is configured to provide a first strand, wherein each of the second coil carriers includes a second coil and is configured to provide a second strand, wherein the rotary braiding machine is configured to interweave the first and second strands, wherein at least one of the first coil carriers is arranged such that at least one of the second strands can move completely around the at least one first coil carrier, wherein at least one of the first coil carriers is configured to be guided along at least one guiding path, which rotates around the braid axis, wherein the surface of the guiding path is formed as a gear wheel, wherein at least one gear wheel is rotatably mounted on the first coil carrier, and wherein the gear wheel is configured to comb with the gear ring and is engaged continuously with the gear ring, during a movement of the second strand around the first coil carrier.

2. The rotary braiding machine according to claim 1, wherein the surface of the guiding path comprises at least a continuous recess, which extends substantially transverse to the extension direction of the guiding path and which is deeper than the tooth spaces of the gear wheel, and wherein the second strand is temporarily immersed into the recess during the movement of the second strand around the first coil carrier.

3. The rotary braiding machine according to claim 1, wherein a device is attached at the first coil carrier in the region of the gear wheel, and wherein the device is configured to prevent an axial displacement of the first coil carrier in at least one direction.

4. The rotary braiding machine according to claim 1, wherein the first coil carrier includes two gear wheels at opposite ends of the first coil carrier, which are mounted rotatably coaxially or substantially coaxially to each other.

5. The rotary braiding machine according to claim 1, wherein the first coil carriers are configured to move on a surface, which, when viewed from the first coil carriers, is a convex surface, a cylindrical surface, a conical surface or a truncated cone shaped surface.

6. The rotary braiding machine according to claim 1, wherein the first coil carriers are configured to move on a surface, which, when viewed from the first coil carriers, is a concave surface, a cylindrical surface, a conical surface or a truncated cone shaped surface.

7. The rotary braiding machine according to claim 1, wherein the rotational movement of the first coil carrier around the braid axis is generated without contacting by a driving member which is arranged outside of the first coil carrier.

8. The rotary braiding machine according to claim 7, wherein each of the driving member and the first coil carrier comprises at least one magnet, including a permanent magnet and/or an electromagnet.

9. The rotary braiding machine according to claim 8, wherein the driving member comprises a plurality of fixed electromagnets, which are arranged on a closed path around the braid axis and which can generate a rotating magnetic field, which entrains the first coil carrier by a magnetic coupling and which brings it into the rotational movement around the braid axis.

10. The rotary braiding machine according to claim 8, wherein the driving member comprises at least one magnet, including a permanent magnet and/or an electromagnet, which can move around in a closed path around the braid axis, whereby a rotating magnetic field can be generated, which entrains the first coil carrier by a magnetic coupling and which brings it into the rotational movement around the braid axis.

11. The rotary braiding machine according to claim 8, wherein at least one magnet in the driving member and at least one magnet in the first coil carrier are configured to control the first coil carrier to restrain it against an axial displacement in at least one direction.

12. The rotary braiding machine according to claim 1, wherein the rotational movement of the first coil carrier around the braid axis is generated by a driving member, including an electric motor, which is placed within the first coil carrier.

13. The rotary braiding machine according to claim 1, wherein the strand shaped material comprises a wire, carbon fibers or textile fibers.

14. A method of operating a rotary braiding machine, wherein the rotary braiding machine has a braid axis for interweaving a strand shaped material into meshes, wherein the machine comprises a plurality of first coil carriers and a plurality of second coil carriers, wherein each of the first coil carriers includes a first coil and is configured to provide a first strand, wherein each of the second coil carriers includes a second coil and is configured to provide a second strand, and wherein the rotary braiding machine is configured to interweave the first and second strands, the method comprising:
- during the braiding, rotating the first coil carriers around the braid axis and relatively moving the second coil carriers with regard to the first coil carriers;
- arranging at least one of the first coil carriers such that at least one of the second strands completely move around the first coil carrier;
- guiding at least one closed guiding path;
- moving the second strand around the at least one first coil carrier; and
- combing the gear wheel of the first coil carrier with the gear ring and continuously engaging the gear wheel with the gear ring.

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