

FOUR-WAY SHUTTLE AND WAREHOUSE STORAGE SYSTEM

TECHNICAL FIELD

[0001] The present disclosure generally relates to the technical field of automated warehousing and transportation and, in particular, to a four-way shuttle and a warehouse storage system.

BACKGROUND

[0002] The four-way shuttle is an automated warehousing and transportation device capable of moving in all four directions (forward, backward, left, and right) in the plane along a preset track. The four-way shuttle is generally provided with two sets of driving apparatuses to drive the four-way shuttle in the front-rear direction and the left-right direction, respectively. Such a configuration requires two sets of motors mounted in the four-way shuttle as well as a transmission mechanism and a reduction gearbox that cooperate with the motors to drive multiple drive wheels. Additionally, the four-way shuttle also needs to be configured for vertical motion to achieve direction change, so an electric motor and a transmission mechanism capable of outputting the stroke in the vertical direction also need to be provided in the four-way shuttle.

[0003] The power system of the existing four-way shuttle is complex and features intersecting multiple drive shafts and transmission shafts. The power system presents substantial design challenges, affects the arrangement of components in the four-way shuttle, and impedes the reduction of the overall height of the four-way shuttle. Furthermore, the complex power system also leads to an increase in costs and undermines the improvements in reliability and transmission efficiency of the four-way shuttle.

[0004] The contents of the Background are merely technology known to the inventors and do not represent the prior art in the art.

SUMMARY

[0005] In view of at least one disadvantage in the existing art, the present disclosure provides a four-way shuttle, comprising:

[0006] a first bracket;

[0007] a first roller group, wherein the first roller group comprises a plurality of first rollers whose axial directions are parallel in a horizontal plane and which are arranged on the first bracket, and at least part of the first rollers are each provided with a first hub motor;

[0008] a second bracket;

[0009] a second roller group, wherein the second roller group comprises a plurality of second rollers whose axial directions are parallel in the horizontal plane, the axial directions of the second rollers are perpendicular to the axial directions of the first rollers, the second rollers are arranged on the second bracket, and at least part of the second rollers are each provided with a second hub motor; and

[0010] a jacking mechanism, wherein the jacking mechanism is arranged between the first bracket and the second bracket and is configured to be capable of driving the second bracket to move in a vertical direction relative to the first bracket such that lower edges of the second rollers are above or below lower edges of the first rollers.

[0011] According to an aspect of the present disclosure, the plurality of first rollers in the first roller group are arranged in two columns, each column comprises a plurality of first rollers, and at least one of the plurality of first rollers in each column is provided with the first hub motor;

[0012] the plurality of second rollers in the second roller group are arranged in two columns, each column comprises a plurality of second rollers, and at least one of the plurality of second rollers in each column is provided with the second hub motor.

[0013] According to an aspect of the present disclosure, the second bracket comprises:

[0014] a jacking beam, wherein the jacking beam is fixedly connected with the jacking mechanism; and

[0015] a first connecting portion, wherein the first connecting portion is arranged between the jacking beam and the first bracket and fixedly connected with the jacking beam, and a guide mechanism is arranged between the first connecting portion and the first bracket and configured to define motion of the jacking beam in the vertical direction.

[0016] According to an aspect of the present disclosure, the second bracket comprises at least two jacking beams, the at least two jacking beams are arranged in parallel, and the at least two jacking beams are fixedly connected with the same jacking mechanism or are each fixedly connected with one jacking mechanism respectively.

[0017] According to an aspect of the present disclosure, the second bracket further comprises:

[0018] at least two second connecting portions, wherein the at least two second connecting portions are fixedly connected with the jacking beam; and

[0019] a third connecting portion, wherein the third connecting portion is movably connected with the first connecting portion and the at least two second connecting portions.

[0020] According to an aspect of the present disclosure, the first connecting portion and a part of the at least two second connecting portions are hinged with the third connecting portion; the first connecting portion and the other part of the at least two second connecting portions are connected with the third connecting portion through a slide groove hole.

[0021] According to an aspect of the present disclosure, the four-way shuttle further comprising:

[0022] a stabilizing mechanism, wherein the stabilizing mechanism is movably connected with the first bracket and the second bracket, arranged in an extending direction of the jacking beam and configured to be capable of keeping the jacking beam horizontal.

[0023] According to an aspect of the present disclosure, the stabilizing mechanism has a double parallelogram structure.

[0024] According to an aspect of the present disclosure, the jacking mechanism comprises a drive source and a transmission member, and the transmission member is any one of a lift chain, a cam or an eccentric wheel.

[0025] According to an aspect of the present disclosure, the four-way shuttle further comprising:

[0026] a carrying portion, wherein the carrying portion is arranged on the second bracket, and a pressure sensor is arranged between the carrying portion and the second bracket.

[0027] According to an aspect of the present disclosure, those part of the first rollers provided with the first hub motor and those part of the second rollers provided with the second hub motor are drive wheels, the drive wheel comprising:

[0028] a housing having a mounting cavity and an axle hole, wherein the axle hole communicates with the mounting cavity;

[0029] an axle, wherein one end of the axle extends into the axle hole and is rotatably connected with the housing;

[0030] an axial coil winding module arranged within the mounting cavity and connected with the axle, wherein the axial coil winding module is configured to generate a first magnetic field when energized; and

[0031] a permanent magnet connected with the housing, wherein the permanent magnet is configured to generate a second magnetic field;

[0032] wherein torque is generated between the permanent magnet and the axial coil winding module through interaction between the first magnetic field and the second magnetic field and drives the housing to rotate about the axle.

[0033] According to an aspect of the present disclosure, the housing comprises a first side plate, a second side plate and a steel ring, wherein the first side plate and the second side plate are each provided with a first through hole, respectively, the first side plate and the second side plate are substantially parallel to each other, and the steel ring is connected between the first side plate and the second side plate.

[0034] According to an aspect of the present disclosure, the drive wheels further comprise a bearing, wherein the bearing is connected between the housing and the axle.

[0035] According to an aspect of the present disclosure, a wiring hole is arranged within the axle, and the wiring hole is configured to be adapted to arrange a power supply line and a signal line.

[0036] According to an aspect of the present disclosure, the other end of the axle is provided as a flange.

[0037] According to an aspect of the present disclosure, the drive wheels further comprise a soft outer cladding, wherein the soft outer cladding is arranged on a peripheral sidewall of the housing.

[0038] According to an aspect of the present disclosure, the outer cladding is a rubber ring, a polyurethane ring or a silicone ring.

[0039] According to an aspect of the present disclosure, the drive wheels further comprise an end cover, wherein the end cover is arranged at one end of the axle hole and connected with the housing, and the axle extends from the other end of the axle hole.

[0040] According to an aspect of the present disclosure, the drive wheels further comprise an encoder, wherein the encoder is connected with the housing and/or the axle and configured to convert an angular displacement of the housing into an electric signal.

[0041] The present disclosure further provides warehouse storage system, comprising:

[0042] at least one four-way shuttle as described above;

[0043] a first track, wherein the first roller group of the four-way shuttle is configured to be capable of rolling along the first track; and

[0044] a second track, wherein the second roller group of the four-way shuttle is configured to be capable of rolling along the second track, and the second track and the first track are perpendicular to each other.

[0045] Compared with the prior art, the embodiments of the present disclosure provide a four-way shuttle. The four-way shuttle is directly driven to move in two mutually perpendicular directions by the first hub motor and the second hub motor, and no intersecting transmission shafts need to be set in the four-way shuttle, thereby simplifying the power system, effectively reducing the structural size of the four-way shuttle, facilitating the lightweight and compact design of the

four-way shuttle, improving transmission efficiency, and enabling a more flexible internal structural arrangement of the four-way shuttle. The embodiments also contribute to the modularization of the components of the four-way shuttle, reduce the failure rate, simplify the assembly process, and reduce the assembly and maintenance costs. The present disclosure also includes embodiments of a warehouse storage system to which the aforementioned four-way shuttle is applied.

BRIEF DESCRIPTION OF THE DRAWINGS

[0046] The drawings are used for providing a further understanding of the present disclosure and constitute a part of the specification. The drawings are intended to explain the present disclosure in conjunction with the embodiments of the present disclosure and do not constitute a limitation on the present disclosure. In the drawings:

[0047] FIG. 1 is a structure view of a four-way shuttle in an embodiment of the present disclosure;

[0048] FIGS. 2A and 2B are cross-sectional views of the four-way shuttle in different directions in an embodiment of the present disclosure;

[0049] FIG. 3 is a schematic view showing the cooperation among a first connecting portion, a second connecting portion and a third connecting portion in an embodiment of the present disclosure;

[0050] FIG. 4 is a schematic view of a first track and a second track in an embodiment of the present disclosure;

[0051] FIG. 5 shows a schematic view of a drive wheel of a four-way shuttle according to an embodiment of the present disclosure;

[0052] FIG. 6 shows a section view of the drive wheel of the four-way shuttle according to an embodiment of the present disclosure; and

[0053] FIG. 7 shows a schematic view of a four-way shuttle according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0054] In the following, only some exemplary embodiments are briefly described. The described embodiments can be modified in various different ways without departing from the spirit or scope of the present disclosure, as would be apparent to those skilled in the art. Accordingly, the drawings and descriptions are to be regarded as illustrative and not restrictive in nature.

[0055] In the description of the present disclosure, it needs to be understood that the orientation or position relations denoted by such terms as “central” “longitudinal” “latitudinal” “length” “width” “thickness” “above” “below” “front” “rear” “left” “right” “vertical” “horizontal” “top” “bottom” “inside” “outside” “clockwise” “counterclockwise” and the like are based on the orientation or position relations as shown in the accompanying drawings, and are used only for the purpose of facilitating description of the present disclosure and simplification of the description, instead of indicating or suggesting that the denoted devices or elements must be oriented specifically, or configured or operated in a specific orientation. Thus, such terms should not be construed to limit the present disclosure. In addition, such terms as “first” and “second” are only used for the purpose of description, rather than indicating or suggesting relative importance or implicitly indicating the number of the denoted technical features. Accordingly, features defined with “first” and “second” can, expressly or implicitly, include one or more of the features. In the description of the present disclosure, “plurality” means two or more, unless otherwise defined explicitly and specifically.

[0056] In the description of the present disclosure, it needs to be noted that, unless otherwise specified and defined explicitly, such terms as “installation” “coupling” and “connection” should be broadly understood as, for example, fixed connection, detachable connection, or integral connection; or mechanical connection, electrical connection or intercommunication; or direct connection, or indirect connection via an intermediary medium; or internal communication between two elements or interaction between two elements. For those skilled in the art, the specific meanings of such terms herein can be construed in light of the specific circumstances.

[0057] Herein, unless otherwise specified and defined explicitly, if a first feature is “on” or “beneath” a second feature, this can cover direct contact between the first and second features, or contact via another feature therebetween, other than the direct contact. Furthermore, if a first feature is “on”, “above”, or “over” a second feature, this can cover the case that the first feature is right above or obliquely above the second feature, or just indicate that the level of the first feature is higher than that of the second feature. If a first feature is “beneath”, “below”, or “under” a second feature, this can cover the case that the first feature is right below or obliquely below the second feature, or just indicate that the level of the first feature is lower than that of the second feature.

[0058] The disclosure below provides many different embodiments or examples so as to realize different structures described herein. In order to simplify the disclosure herein, the following will give the description of the parts and arrangements embodied in specific examples. Of course, they are only for the exemplary purpose, not intended to limit the present disclosure. Besides, the

present disclosure can repeat a reference number and/or reference letter in different examples, and such repeat is for the purpose of simplification and clarity, which does not represent any relation among various embodiments and/or arrangements as discussed. In addition, the present disclosure provides examples of various specific processes and materials, but those skilled in the art can also be aware of application of other processes and/or use of other materials.

[0059] The preferred embodiments of the present disclosure will be described below with reference to the drawings. It should be appreciated that the preferred embodiments described here are only for the purpose of illustrating and explaining, instead of limiting, the present disclosure.

[0060] FIGS. 1 to 2B show the structure of a four-way shuttle 100 according to embodiments of the present disclosure. The four-way shuttle 100 will be described below with reference to FIGS. 1 to 2B.

[0061] As shown in FIG. 1, the four-way shuttle 100 includes a first bracket 110, a first roller group 120, a second bracket 130, a second roller group 140 and a jacking mechanism 150. For example, the first bracket 110 and the second bracket 130 may constitute the overall frame structure of the four-way shuttle 100. Preferably, as shown in FIG. 1, the four-way shuttle 100 is a substantially rectangular parallelepiped structure, and the first bracket 110 and the second bracket 130 may be arranged in a substantially rectangular parallelepiped shape. The second bracket 130 and the first bracket 110 may be in a nested configuration. For example, the second bracket 130 is arranged inside or outside the first bracket 110.

[0062] Further, the first bracket 110 includes, for example, a bottom plate. The bottom plate may be an integrated flat plate structure or a hollow grid structure. The arrangement of the bottom plate can improve the structural stability of the first bracket 110.

[0063] The first roller group 120 includes multiple first rollers 121 whose axial directions are parallel to each other. The rotation axes of the multiple first rollers 121 are all located in a horizontal plane, and the horizontal plane herein represents the horizontal plane of the four-way shuttle 100 when horizontally placed. The rotation axes of the multiple first rollers 121 may be located in the same horizontal plane or may be located in different horizontal planes. For example, the lower edges of the multiple first rollers 121 are aligned with each other. The multiple first rollers 121 may be set to have different sizes. Preferably, the multiple first rollers 121 have the same size, and their rotation axes are located in the same horizontal plane.

[0064] The multiple first rollers 121 are arranged on the first bracket 110, and at least part of the first rollers 121 are each provided with a first hub motor 122 (serving as drive wheels). As shown in FIG. 1, in the embodiments herein, the axial directions of the multiple first rollers 121 are parallel to each other, and the multiple first rollers 121 are all arranged on the first bracket 110.

When all or part of the first rollers 121 roll under the driving of the first hub motors 122, the first rollers 121 can drive the four-way shuttle 100 to move in a direction perpendicular to the rotation axes of the first rollers 121 in the horizontal plane. Hereinafter, for convenience of description, the direction in which the first rollers 121 drive the four-way shuttle 100 to move is defined as the X direction, the direction of the rotation axes of the first rollers 121 is defined as the Y direction, and the vertical direction is defined as the Z direction.

[0065] The second roller group 140 includes multiple second rollers 141. The axial directions of the multiple second rollers 141 are set to be parallel to each other in the horizontal plane and are perpendicular to the axial directions of the first rollers 121. As shown in FIG. 1, the axial directions of the first rollers 121 is the Y direction, and the axial directions of the second rollers 141 is the X direction. Similarly, the rotation axes of the multiple second rollers 141 may be located in the same horizontal plane or may be located in different horizontal planes. Preferably, the multiple second rollers 141 have the same size, and their rotation axes are located in the same horizontal plane.

[0066] The multiple second rollers 141 are all arranged on the second bracket 130, and at least part of the second rollers 141 are each provided with a second hub motor 142 (serving as drive wheels). The axial directions of the multiple second rollers 141 are all in the Y direction. When the second hub motors 142 in part of the second rollers 141 drive the second rollers 141 to rotate, the second rollers 141 can drive the four-way shuttle 100 to move in the Y direction.

[0067] The jacking mechanism 150 is arranged between the first bracket 110 and the second bracket 130. The jacking mechanism 150 is configured to be capable of driving the second bracket 130 to move in a vertical direction relative to the first bracket 110 such that lower edges of the second rollers 141 are above or below the lower edges of the first rollers 121. The specific structure of the jacking mechanism 150 will be described in the subsequent embodiments.

[0068] For example, the second bracket 130 is arranged above the first bracket 110, the lower edges of the second rollers 141 are higher than the lower edges of the first rollers 121, the first rollers 121 are in contact with a carrying structure, the second rollers 141 are suspended relative to the carrying structure, and the four-way shuttle 100 is driven by the first rollers 121 to move in the X direction. When the jacking mechanism 150 drives the second bracket 130 to move in the Z direction such that the second bracket 130 moves towards the first bracket 110, correspondingly, the second rollers 141 move as the second bracket 130 moves, and the lower edges of the second rollers 141 are gradually lowered. When the lower edges of the second rollers 141 are lower than the lower edges of the first rollers 121, the second rollers 141 are in contact with the carrying structure, and the first rollers 121 are suspended relative to the carrying structure. At this point, the

first rollers 121 can no longer drive the four-way shuttle 100 to move, and the four-way shuttle 100 is driven by the second rollers 141 in the Y direction. Correspondingly, the same is true for the embodiments in which the second bracket 130 is arranged below the first bracket 110. The four-way shuttle 100 can change directions through the jacking mechanism 150 such that the four-way shuttle 100 can have a two-dimensional range of motion in the horizontal plane.

[0069] In the embodiments herein, at least part of the first rollers 121 are driven by the first hub motors 122, at least part of the second rollers 141 are driven by the second hub motors 142, and no driving apparatuses or transmission apparatuses need to be provided in the four-way shuttle 100, thereby greatly simplifying the internal structure of the four-way shuttle 100 and facilitating the lightweight and compact design of the four-way shuttle 100. For example, no intersecting transmission shafts need to be provided, and the overall height of the four-way shuttle 100 can be reduced. Additionally, the first rollers 121, the first hub motors 122, the second rollers 141 and the second hub motors 142 in the embodiments herein can be integrated into a power module and assembled in the form of modules with the first bracket 110 and the second bracket 130, thereby reducing the assembly difficulty and the assembly costs. Furthermore, when the power module is damaged, the damaged power module can be quickly replaced and repaired, thereby reducing the maintenance difficulty and maintenance costs.

[0070] In the preferred embodiments of the present disclosure, as shown in FIG. 2A, the four-way shuttle 100 operates with tracks. For example, the tracks are arranged in the X direction and the Y direction, and the four-way shuttle 100 can move on the tracks in the X direction and the Y direction to reach different working positions. Preferably, two mutually parallel tracks may be arranged in the X direction, and two mutually parallel tracks may be arranged in the Y direction.

[0071] Correspondingly, as shown in FIG. 1, the multiple first rollers 121 in the first roller group 120 are arranged in two columns to correspond to two parallel tracks in the X direction. Each column of first rollers 121 includes multiple first rollers 121, for example, two as shown in FIG. 1 or more such as three or four, to reduce the pressure on the track. At least one of the multiple first rollers 121 in each column is provided with a first hub motor 122. For example, as shown in FIG. 1, each column includes two first rollers 121, and one of the two first rollers 121 in each column is provided with a first hub motor 122 or the two first rollers 121 are each provided with a first hub motor 122. For the four first rollers 121 in the two columns, the first rollers 121 in the same row in the X direction may be provided with first hub motors 122. For example, two first rollers 121 on the lower right side in FIG. 1 are each provided with a first hub motor 122. Alternatively, the first hub motors 122 may also be staggered. For example, the first roller 121 on the leftmost side and

the first roller 121 on the rightmost side in FIG. 1 are each provided with a first hub motor 122. Alternatively, three or four of the first rollers 121 are each provided with a first hub motor 122.

[0072] Similarly, in the embodiments herein, the multiple second rollers 141 in the second roller group 140 are arranged in two columns. Each column of second rollers 141 includes multiple second rollers 141. At least one of the multiple second rollers 141 in each column is provided with a second hub motor 142. Specifically, as shown in FIG. 2B, the second roller 141 on the left side of FIG. 2B is provided with a second hub motor 142, and the second roller 141 on the right side of FIG. 2B is a driven wheel without the second hub motor 142. For example, the four-way shuttle 100 includes four second rollers 141. The four second rollers 141 are arranged in two columns, with two second rollers 141 in each column. For the four second rollers 141, any one or two of the second rollers 141 in each column are provided with a second hub motor 142.

[0073] In the embodiments herein, at least one first hub motor 122 is arranged in one column of first rollers 121, and at least one second hub motor 142 is arranged in one column of second rollers 141, thereby facilitating the improvement of the uniform distribution of force onto the four-way shuttle 100, avoiding the deviation of the first rollers 121 and the second rollers 141 relative to the tracks, reducing the lateral pressure among the first rollers 121, the second rollers 141 and the tracks, and improving structural stability and service life.

[0074] According to the preferred embodiments of the present disclosure, the second bracket 130 includes a jacking beam 131 and a first connecting portion 132. The jacking beam 131 is fixedly connected with the jacking mechanism 150, and the jacking mechanism 150 may be configured to be capable of driving the jacking beam 131 to move in the vertical direction.

[0075] The first connecting portion 132 is arranged between the jacking beam 131 and the first bracket 110 and fixedly connected with the jacking beam 131. A guide mechanism 160, for example, is arranged between the first connecting portion 132 and the first bracket 110. The guide mechanism 160 can define the motion direction of the jacking beam 131 such that the jacking beam 131 can only move in the vertical direction.

[0076] Specifically, for example, the guide mechanism 160 may be any structure capable of achieving linear movement, such as an oil-free bushing, a linear (vertical direction) guide track and a guide wheel group, which is not limited in the present disclosure.

[0077] Multiple guide mechanisms 160 may be arranged at multiple positions on the four-way shuttle 100. For example, the guide mechanisms 160 may be arranged at positions near four corners of the four-way shuttle 100 having a substantially rectangular parallelepiped shape shown in FIG. 1, thereby improving the stability of the four-way shuttle 100 and preventing the second bracket 130 from tilting relative to the first bracket 110. The jacking beam 131 may be arranged at

an intermediate position of the four-way shuttle 100 and the first connecting portion 132 may extend to the edge of the four-way shuttle 100 to cooperate with the guide mechanism 160.

[0078] According to the preferred embodiments of the present disclosure, the second bracket 130 includes at least two jacking beams 131. The two jacking beams 131 are arranged in parallel and preferably arranged at positions near the edge of the four-way shuttle 100, thereby improving the structural strength of the second bracket 130 and facilitating to balance the center of gravity of the four-way shuttle 100.

[0079] The at least two jacking beams 131 in the embodiments herein may be configured to be fixedly connected with the same jacking mechanism 150, so that one jacking mechanism 150 can simultaneously drive multiple jacking beams 131 to move in the vertical direction, for example, through a transmission apparatus. The at least two jacking beams 131 may also be configured to respectively fixedly connected with one jacking mechanism 150. When multiple jacking beams 131 are fixedly connected with multiple jacking mechanisms 150, respectively, the multiple jacking mechanisms 150 are preferably controlled synchronously to enable the jacking beams 131 to be raised or lowered by the same height, thereby preventing the second bracket 130 from tilting.

[0080] According to the preferred embodiments of the present disclosure, the second bracket 130 further includes at least two second connecting portions 133 and a third connecting portion 134. The second connecting portions 133 are fixedly connected with the jacking beam 131. Specifically, the jacking beam 131 and the second connecting portions 133 may be integrally formed or may be fixed to each other by welding, riveting, bonding, bolting or the like. Further, the first connecting portion 132 and the third connecting portion 134 may also be provided with reinforcement ribs to improve the overall strength of the second bracket 130.

[0081] The second bracket 130 further includes a third connecting portion 134. The third connecting portion 134 is configured to be movably connected with the first connecting portion 132 and the at least two second connecting portions 133. The second connecting portion 133 is fixedly connected with the jacking beam 131 and the third connecting portion 134 is connected with at least two second connecting portions 133 so that the strokes of the two or more jacking beams 131 in the vertical direction can be synchronized. The third connecting portion 134 is movably connected with the first connecting portion 132 and the at least two second connecting portions 133, which can absorb a part of the deformation caused by the height difference between the multiple jacking beams 131 in the vertical direction, thereby avoiding excessive compression between the first connecting portion 132 and the guide mechanism 160 and the resulting structural damage.

[0082] In the preferred embodiments of the present disclosure, as shown in FIG. 3, the first connecting portion 132 and part of the at least two second connecting portions 133 are hinged with the third connecting portion 134, for example, at a hinge hole 135. The first connecting portion 132 and the other part of the at least two second connecting portions 133 are connected with the third connecting portion 134 through a slide groove hole 136. The slide holes 136 can provide displacement ranges in the horizontal direction and the vertical direction of motion.

[0083] Specifically, the four-way shuttle 100 includes two jacking beams 131. Two second connecting portions 133 are fixedly connected with the two jacking beams 131, respectively. The third connecting portion 134 (for example, one end of the third connecting portion 134) is hinged with one of the second connecting portions 133 and the first connecting portion 132, for example, at the hinge hole 135 on the left side, as shown in FIG. 3. The other end of the third connecting portion 134 is also connected with the other second connecting portion 133 and the first connecting portion 132 through the slide groove hole 136. When the heights of the two jacking beams 131 are not in the same horizontal plane, the third connecting portion 134 rotates and displaces to allow the two jacking beams 131 to be located at different heights, thereby avoiding excessive lateral pressure between the first connecting portion 132 and the guide mechanism 160, preventing structural damage, and improving the service life. Meanwhile, the assembly difficulty and the requirements for mounting accuracy can also be reduced.

[0084] In the preferred embodiments of the present disclosure, the four-way shuttle 100 further includes a stabilizing mechanism 170. The stabilizing mechanism 170 is movably connected with the first bracket 110 and the second bracket 130 and arranged in the extending direction of the jacking beam 131. The stabilizing mechanism 170 is configured to be capable of keeping the jacking beam 131 horizontal. For example, the stabilizing mechanism 170 is an X-shaped structure with a middle hinge, and the upper and lower four endpoints are hinged with the first bracket 110 and the second bracket 130 respectively to keep the jacking beam 131 horizontal. With the stabilizing mechanism 170, the jacking beam 131 can be prevented from tilting during the lifting or lowering process. For example, when the load on the four-way shuttle 100 is unbalanced and the pressure on one single side is too large, the stabilizing mechanism 170 can keep the jacking beam 131 horizontal to prevent the four-way shuttle 100 from overturning.

[0085] Specifically, as shown in FIG. 2B, in the embodiments herein, the stabilizing mechanism 170 has a double parallelogram structure, the upper and lower four endpoints are hinged with the first bracket 110 and the second bracket 130, respectively, and the middle is hinged through a rigid link. When the jacking beam 131 is raised or lowered, the stabilizing mechanism 170 can prevent the jacking beam 131 from tilting to the left or right side in FIG. 2B, thereby improving the

stability of the four-way shuttle 100 and preventing the four-way shuttle 100 from overturning due to unbalanced loading.

[0086] According to the preferred embodiments of the present disclosure, the jacking mechanism 150 includes a drive source (not shown) and a transmission member 151. The drive source may be an electric motor, and the transmission member 151 is any one of a lift chain, a cam or an eccentric wheel.

[0087] Specifically, as shown in FIG. 2A, the transmission member 151 is a lift chain, and the drive source can drive the jacking beam 131 to move linearly (in the vertical direction) through the lift chain.

[0088] Alternatively, as shown in FIG. 2B, the transmission member 151 is an eccentric wheel, and a slide groove may be correspondingly arranged on the second bracket 130 to match the eccentric wheel. When the eccentric wheel rotates, the eccentric wheel is limited by the slide groove to enable the jacking beam 131 to be raised or lowered. Further, to restrict the motion of the second bracket 130 in the horizontal direction, the guide mechanism 160 may be configured to include a guide shaft 161 and a sliding bearing seat 162. The guide shaft 161 is arranged on the first bracket 110, and the sliding bearing seat 162 is arranged on the side surface of the jacking beam 131 to cooperate with the guide shaft 161 to define the motion of the jacking beam 131 in the horizontal direction.

[0089] According to the preferred embodiments of the present disclosure, as shown in FIG. 2A, the four-way shuttle 100 further includes a carrying portion 180. The carrying portion 180 is arranged on the second bracket 130, and a pressure sensor 181 is arranged between the carrying portion 180 and the second bracket. Objects that need to be transferred by the four-way shuttle 100 may be placed on the carrying portion 180, and the pressure sensor 181 can be used for weighing the objects, thereby improving the automation of the four-way shuttle 100, reducing manual operation, improving accuracy, and providing more data support for a warehouse storage system.

[0090] The present disclosure also includes an embodiment of a warehouse storage system 1 which can be used for transferring goods within a warehouse, for example, during outbound or inbound operations. The warehouse storage system 1 includes at least one four-way shuttle 100 (not shown in FIG. 4) described in the aforementioned embodiments.

[0091] The warehouse storage system 1 further includes a first track 200 and a second track 300. The first roller group 120 of the four-way shuttle 100 is configured to be capable of rolling along the first track 200. The second roller group 140 of the four-way shuttle 100 is configured to be capable of rolling along the second track 300. The first track 200 and the second track 300 are perpendicular to each other.

[0092] The four-way shuttle 100 can move within the coverage range of the first track 200 and the second track 300 and, when moving to the position where the first track 200 and the second track 300 intersect with each other, can change directions through the jacking mechanism 150.

[0093] At present, the traveling mechanism of the four-way shuttle generally adopts a dual-motor drive scheme. That is, independent motors are configured for the motion in the X-axis direction and the motion in the Y-axis direction, respectively, and the power is transmitted to multiple drive wheels through transmission systems such as transmission shafts, gearboxes or chains, so as to achieve smooth motion of the shuttle. Such a dual-motor drive solution complicates the layout of the shuttle and affects the design and height of the whole shuttle. Moreover, multiple complex customized transmission systems not only increase the manufacturing costs, but may also reduce the reliability and transmission efficiency of the system.

[0094] FIG. 5 shows a schematic view of a drive wheel 300 of a four-way shuttle according to an embodiment of the present disclosure, and FIG. 6 shows a section view of the drive wheel 300 of the four-way shuttle according to an embodiment of the present disclosure. The following will be described in detail in conjunction with FIGS. 5 and 6.

[0095] As shown in FIGS. 5 and 6, the drive wheel 300 includes a housing 310, an axle 320, an axial coil winding module 330 and a permanent magnet. The housing 310 is substantially cylindrical. A mounting cavity 311 is arranged inside the housing 310 and can be used for accommodating and mounting other accessories (which will be specifically described in detail later) of the drive wheel 300. An axle hole 312 is arranged in the axial direction of the housing 310, and the axle hole 312 and the mounting cavity 311 communicate with each other. One end of the axle 320 extends into the axle hole 312 and is rotatably connected with the housing 310, and the other end may be used for being connected with the shuttle frame of the four-way shuttle to establish the connection between the drive wheel 300 and the shuttle frame. The axial coil winding module 330 is arranged within the mounting cavity 311. The axial coil winding module 330 is substantially annular and has a connecting hole formed in its middle part. The connecting hole is substantially coaxial with the axle hole 312, and one end of the axle 320 extending into the axle hole 312 passes through the connecting hole. The axial coil winding module 330 and the axle 320 are connected with each other through a key connection (a flat key, a spline, etc.), a screw connection and the like. The permanent magnet (not shown) can be fixedly connected on the inner side of the housing 310. Torque may be generated between the permanent magnet and the axial coil winding module 330 through the interaction between a first magnetic field and a second magnetic field and drive the housing 310 to rotate about the axle 320, thereby driving the four-way shuttle 400 to move. The first magnetic field is a magnetic field generated when the axial coil

winding module 330 is energized, and the second magnetic field is a magnetic field generated by the permanent magnet. Since the second magnetic field is generated by the permanent magnet and its strength is basically stable, the strength of the first magnetic field and the torque generated through the interaction between the two magnetic fields can be accurately controlled by accurately controlling the current of the axial coil winding module 330, thereby achieving the accurate control of the rotational speed of the housing 310 and providing a stable drive force for the four-way shuttle 400 under changing loads or different track conditions. In the embodiments herein, only one set of a permanent magnet and an axial coil winding module 330 is shown. In some application scenarios, if the drive wheel 300 is required to output larger torque, multiple sets of permanent magnets and axial coil winding modules 330 may be provided to achieve the parallel connection of the axial coil winding modules 330, thereby greatly increasing the output torque of the drive wheel 300.

[0096] According to an embodiment of the present disclosure, as shown in FIGS. 5 and 6, the housing 310 may include a first side plate 313, a second side plate 314 and a steel ring 315. The first side plate 313 and the second side plate 314 are circular metal plates. A first through hole 316 is arranged at the center of both the first side plate 313 and the second side plate 314, and the two first through holes 316 constitute the axle hole 312. The first side plate 313 and the second side plate 314 are parallel to each other, and the steel ring 315 is fixedly connected between the first side plate 313 and the second side plate 314 (for example, by welding, riveting, bolting or the like). Preferably, the steel ring 315 protrudes from the outer edges of the first side plate 313 and the second side plate 314, and when the drive wheel 300 travels on the track, the steel ring 315 directly bears the external load. Preferably, the first side plate 313 and/or the second side plate 314 may be made of magnetic steel, and thus the first side plate 313 and/or the second side plate 314 can provide the second magnetic field as the permanent magnet, thereby reducing the volume of the drive wheel 300 and simplifying the structure of the drive wheel 300.

[0097] According to an embodiment of the present disclosure, as shown in FIG. 5, one or more reinforcement ribs 317 may be arranged on the outer sides of the first side plate 313 and the second side plate 314, respectively. The reinforcement ribs 317 may be arranged around the first through hole 316 (the axle hole 312). Through the reinforcement ribs 317, the load can be effectively dispersed and transmitted, and the local stress concentration of the first side plate 313/second side plate 314 when subjected to stress can be reduced, thereby reducing the risk of deformation or damage of the first side plate 313/second side plate 314 and enabling the traveling wheels to be adapted to more complex and demanding working environments. Furthermore, the arrangement of the reinforcement ribs 317 can also improve the rigidity of the first side plate 313/second side plate

314 and make the first side plate 313/second side plate 314 more stable when subjected to impact or vibration, thereby reducing the problem of inaccurate positioning of the traveling wheel due to the deformation of the first side plate 313/second side plate 314.

[0098] According to an embodiment of the present disclosure, as shown in FIG. 6, the drive wheel 300 further includes a bearing 350. A smooth and efficient rotational connection between the housing 310 and the axle 320 can be achieved through the bearing 350. Specifically, mounting grooves 318 may be arranged on the inner sides of the first side plate 313 and the second side plate 314, respectively, and the mounting grooves 318 are coaxial with the corresponding first through holes 316. Two bearings 350 may be arranged. The two bearings 350 are embedded in their respective mounting grooves 318, and each bearing 350 is closely connected with the axle 320 to ensure the stability and reliability of the housing 310 during rotation. Each bearing 350 is mounted in the corresponding mounting groove 318 and connected with the axle 320.

[0099] According to an embodiment of the present disclosure, as shown in FIG. 6, the drive wheel 300 further includes an end cover 360. The end cover 360 can be used for blocking the axle hole 312 to reduce the possibility of impurities such as dust entering the mounting cavity 311. Specifically, as shown in FIG. 6, the axle 320 is inserted into the axle hole 312 from the side where the second side plate 314 is located, and the end cover 360 is connected on the outer side of the first side plate 313 and blocks the first through hole 316 (the axle hole 312) on the first side plate 313.

[0100] According to an embodiment of the present disclosure, as shown in FIG. 6, the drive wheel 300 further includes an encoder 370. The encoder 370 is connected with the housing 310 and/or the axle 320 and configured to be capable of converting the angular displacement of the housing 310 into an electric signal. Specifically, the encoder 370 may be a magnetic encoder 370. The magnetic encoder 370 includes a magnetic drum 371, a sensor 372 and a processor 373. The magnetic drum 371 may be mounted on the inner side of the end cover 360, and the sensor 372 (for example, a magnetoresistive sensor 372 or a Hall element) and the processor 373 may be mounted at the end of the axle 320. The processor 373 may calculate the rotational speed of the housing 310 according to the output signal of the sensor 372 and feed it back to a driver for closed-loop control. In some embodiments, the encoder 370 may also be a photoelectric encoder 370, an inductive encoder 370 or the like.

[0101] According to an embodiment of the present disclosure, as shown in FIGS. 5 and 6, the drive wheel 300 further includes a soft outer cladding 380. The soft outer cladding 380 may be, for example, a rubber ring, a polyurethane ring or a silicone ring. The soft outer coating 380 is arranged on the peripheral sidewall of the housing 310 (that is, the soft outer coating 380 is

arranged on the outer side of the steel ring 315). The soft outer cladding 380 can increase the friction between the drive wheel 300 and the track, reduce the traveling noise of the drive wheel 300, and play a cushioning and protective role for the housing 310. Preferably, the soft outer cladding 380 has a wedge-shaped cross-section to engage with the track for position limiting.

[0102] According to an embodiment of the present disclosure, as shown in FIG. 6, a wiring hole 321 may be arranged within the axle 320. The wiring hole 321 is configured to arrange lines such as a power supply line 391 and a signal line 392. The power supply line 391 can be used for supplying power to the axis coil winding module, and the signal line 392 can be used for supplying power and transmitting signals to the encoder 370. Specifically, the axle 320 may include a first axle section 322 and a second axle section 323. The first axle section 322 is bolted with the second axle section 323. A second through hole 324 is arranged on the first axle section 322 along the axis. A third through hole 325 is arranged on the second axle section 323 along the axis. A groove 326 is arranged on the end surface of the second axle section 323 near the first axle section 322. The groove 326 communicates with the third through hole 325. The second through hole 324, the third through hole 325 and the groove 326 together constitute the wiring hole 321. The axle 320 is designed into two sections to facilitate the arrangement of the signal line 392, the power supply line 391 and the like, thereby reducing the assembly difficulty of the drive wheel 300.

[0103] According to an embodiment of the present disclosure, as shown in FIGS. 5 and 6, the axle 320 may be a flange shaft, that is, the end of the axle 320 outside the housing 310 is provided as a flange 327, to facilitate the connection between the drive wheel 300 and the shuttle frame of the four-way shuttle 400.

[0104] Compared with the prior art, the embodiments of the present disclosure provide a drive wheel 300 of a four-way shuttle 400. Through the magnetic field interaction between the permanent magnet and the axial coil winding module 330, the drive wheel 300 can generate sufficient torque to drive the housing 310 to rotate around the axle 320 and then drive the four-way shuttle 400 to move. The drive wheel 300 has the characteristics of large torque and small volume and can provide large output torque while occupying a small space, thereby providing a stable drive force for the four-way shuttle 400 under changing loads or different track conditions.

[0105] FIG. 7 shows a schematic view of a four-way shuttle 400 according to an embodiment of the present disclosure. The following will be described in detail in conjunction with FIG. 7.

[0106] As shown in FIG. 7, the four-way shuttle 400 includes a bottom plate 410, a first frame body 420, a second frame body 430 and multiple drive wheels 300 described above. The first frame body 420 is arranged above the bottom plate 410. The first frame body 420 and the bottom plate 410 may be connected through a lifting mechanism (not shown, the lifting mechanism may

be a cam mechanism, a rack and pinion mechanism or the like). The second frame body 430 is arranged between the bottom plate 410 and the first frame body 420, and the second frame body 430 and the bottom plate 410 are fixedly connected with each other. The multiple drive wheels 300 may be divided into two parts. One part of the drive wheels 300 are mounted on the first frame body 420 (that is, the axles 320 of the part of the drive wheels 300 are fixedly connected with the first frame body 420), and the part of the drive wheels 300 can drive the shuttle frame to move in the first direction. The other part of the drive wheels 300 are mounted on the second frame body 430 (that is, the axles 320 of the part of the drive wheels 300 are fixedly connected with the second frame body 430), and the part of the drive wheels 300 can drive the shuttle frame to move in the second direction. Specifically, the traveling direction of the four-way shuttle 400 can be adjusted by adjusting the height of the bottom plate 410 through the lifting mechanism. For example, when the bottom plate 410 is at a higher position, the drive wheels 300 mounted on the second frame body 430 are in contact with the track, and the four-way shuttle 400 can travel in the first direction; when the bottom plate 410 is at a lower position, the drive wheels 300 mounted on the first frame body 420 are in contact with the track, and the four-way shuttle 400 can travel in the second direction.

[0107] According to an embodiment of the present disclosure, as shown in FIG. 7, the first frame body 420 may include two connecting beams 421 and two first mounting beams 422. The two first mounting beams 422 are arranged on the front side and the rear side of the bottom plate 410, respectively. The two connecting beams 421 are connected between the two first mounting beams 422. The axles 320 of the aforementioned part of the drive wheels 300 are fixedly connected with the corresponding first mounting beams 422.

[0108] According to an embodiment of the present disclosure, as shown in FIG. 7, the second frame body 430 may include two second mounting beams 431 and two reinforcement beams 432. The two second mounting beams 431 are fixed on the left side and the right side of the bottom plate 410, respectively. The two reinforcement beams 432 are fixed on the front side and the rear side of the bottom plate 410, respectively. The reinforcement beams 432 are provided with avoidance notches for avoiding the connecting beams 421. The axles 320 of the aforementioned other part of the drive wheels 300 are fixedly connected with the corresponding second mounting beams 431. The second frame body 430 can not only provide mounting positions for the drive wheels 300, but also reinforce the bottom plate 410 to improve the load bearing capacity of the bottom plate 410.

[0109] According to an embodiment of the present disclosure, as shown in FIG. 7, four wheels may be arranged on the first frame body 420. These four wheels may all be drive wheels 300.

Alternatively, the four wheels may include two drive wheels 300 and two driven wheels 440, and the two drive wheels 300 may be arranged coaxially or diagonally. Correspondingly, four wheels may also be arranged on the second frame body 430. These four wheels may all be drive wheels 300. Alternatively, the four wheels may include two drive wheels 300 and two driven wheels 440, and the two drive wheels 300 may be arranged coaxially or diagonally.

[0110] Compared with the prior art, the embodiments of the present disclosure provide a four-way shuttle 400. The four-way shuttle 400 is directly driven by the drive wheel 300, and the complex transmission system and the reduction gears are canceled, which not only greatly reduces the overall costs and layout difficulty of the four-way shuttle 400, but also reduces the failure rate of the shuttle, thereby improving the reliability and service life of the shuttle.

[0111] The drive wheels 300 shown in Figs. 5-7 can be applied to the four-way shuttle 100 shown in Figs. 1-4. Specifically, the first rollers and the second rollers in the four-way shuttle 100 can adopt the drive wheels 300 shown in Figs. 5-7, and the first hub motor and the second hub motor can adopt the configuration shown in Figs. 5-7, in which, through the magnetic field interaction between the permanent magnet and the axial coil winding module, the drive wheel 300 can generate sufficient torque to drive the housing to rotate around the axle and then drive the four-way shuttle to move.

[0112] Compared with the prior art, the embodiments of the present disclosure provide a drive wheel of a four-way shuttle. Through the magnetic field interaction between the permanent magnet and the axial coil winding module, the drive wheel can generate sufficient torque to drive the housing to rotate around the axle and then drive the four-way shuttle to move. The drive wheel has the characteristics of large torque and small volume and can provide large output torque while occupying a small space, thereby providing a stable drive force for the four-way shuttle under changing loads or different track conditions. The embodiments of the present disclosure further provide a four-way shuttle. The four-way shuttle is directly driven by the drive wheel, and the complex transmission system and the reduction gears are canceled, which not only greatly reduces the overall costs and layout difficulty of the four-way shuttle, but also reduces the failure rate of the shuttle, thereby improving the reliability and service life of the shuttle.

[0113] Finally, it should be noted that the above are merely preferred embodiments of the present disclosure and are not used to limit the present disclosure. Although the present disclosure has been described in detail with reference to the aforementioned embodiments, those skilled in the art can still modify the technical solutions described in the aforementioned embodiments or make equivalent substitutions on part of the technical features therein. Any modifications, equivalent substitutions and improvements made within the spirit and principle of the present disclosure fall within the scope of the present disclosure.

CLAIMS

1. A four-way shuttle, comprising:

a first bracket;

a first roller group, wherein the first roller group comprises a plurality of first rollers whose axial directions are parallel in a horizontal plane and which are arranged on the first bracket, and at least part of the first rollers are each provided with a first hub motor;

a second bracket;

a second roller group, wherein the second roller group comprises a plurality of second rollers whose axial directions are parallel in the horizontal plane, the axial directions of the second rollers are perpendicular to the axial directions of the first rollers, the second rollers are arranged on the second bracket, and at least part of the second rollers are each provided with a second hub motor; and

a jacking mechanism, wherein the jacking mechanism is arranged between the first bracket and the second bracket and is configured to be capable of driving the second bracket to move in a vertical direction relative to the first bracket such that lower edges of the second rollers are above or below lower edges of the first rollers.

2. The four-way shuttle according to claim 1, wherein the plurality of first rollers in the first roller group are arranged in two columns, each column comprises a plurality of first rollers, and at least one of the plurality of first rollers in each column is provided with the first hub motor;

the plurality of second rollers in the second roller group are arranged in two columns, each column comprises a plurality of second rollers, and at least one of the plurality of second rollers in each column is provided with the second hub motor.

3. The four-way shuttle according to claim 1, wherein the second bracket comprises:

a jacking beam, wherein the jacking beam is fixedly connected with the jacking mechanism; and

a first connecting portion, wherein the first connecting portion is arranged between the jacking beam and the first bracket and fixedly connected with the jacking beam, and a guide mechanism is arranged between the first connecting portion and the first bracket and configured to define motion of the jacking beam in the vertical direction.

4. The four-way shuttle according to claim 3, wherein the second bracket comprises at least two jacking beams, the at least two jacking beams are arranged in parallel, and the at least two jacking beams are fixedly connected with the same jacking mechanism or are each fixedly connected with one jacking mechanism respectively.

5. The four-way shuttle according to claim 4, wherein the second bracket further

comprises:

at least two second connecting portions, wherein the at least two second connecting portions are fixedly connected with the jacking beam; and

a third connecting portion, wherein the third connecting portion is movably connected with the first connecting portion and the at least two second connecting portions.

6. The four-way shuttle according to claim 5, wherein the first connecting portion and a part of the at least two second connecting portions are hinged with the third connecting portion; the first connecting portion and the other part of the at least two second connecting portions are connected with the third connecting portion through a slide groove hole.

7. The four-way shuttle according to any one of claims 3 to 6, further comprising:

a stabilizing mechanism, wherein the stabilizing mechanism is movably connected with the first bracket and the second bracket, arranged in an extending direction of the jacking beam and configured to be capable of keeping the jacking beam horizontal.

8. The four-way shuttle according to claim 7, wherein the stabilizing mechanism has a double parallelogram structure.

9. The four-way shuttle according to any one of claims 1 to 6, wherein the jacking mechanism comprises a drive source and a transmission member, and the transmission member is any one of a lift chain, a cam or an eccentric wheel.

10. The four-way shuttle according to any one of claims 1 to 6, further comprising:

a carrying portion, wherein the carrying portion is arranged on the second bracket, and a pressure sensor is arranged between the carrying portion and the second bracket.

11. The four-way shuttle according to any one of claims 1 to 6, wherein those part of the first rollers provided with the first hub motor and those part of the second rollers provided with the second hub motor are drive wheels, the drive wheel comprising:

a housing having a mounting cavity and an axle hole, wherein the axle hole communicates with the mounting cavity;

an axle, wherein one end of the axle extends into the axle hole and is rotatably connected with the housing;

an axial coil winding module arranged within the mounting cavity and connected with the axle, wherein the axial coil winding module is configured to generate a first magnetic field when energized; and

a permanent magnet connected with the housing, wherein the permanent magnet is configured to generate a second magnetic field;

wherein torque is generated between the permanent magnet and the axial coil winding

module through interaction between the first magnetic field and the second magnetic field and drives the housing to rotate about the axle.

12. The four-way shuttle according to claim 11, wherein the housing comprises a first side plate, a second side plate and a steel ring, wherein the first side plate and the second side plate are each provided with a first through hole, respectively, the first side plate and the second side plate are substantially parallel to each other, and the steel ring is connected between the first side plate and the second side plate.

13. The four-way shuttle according to claim 11, wherein the drive wheels further comprise a bearing, wherein the bearing is connected between the housing and the axle.

14. The four-way shuttle according to claim 11, wherein a wiring hole is arranged within the axle, and the wiring hole is configured to be adapted to arrange a power supply line and a signal line.

15. The four-way shuttle according to claim 11, wherein the other end of the axle is provided as a flange.

16. The four-way shuttle according to claim 11, wherein the drive wheels further comprise a soft outer cladding, wherein the soft outer cladding is arranged on a peripheral sidewall of the housing.

17. The four-way shuttle according to claim 11, wherein the outer cladding is a rubber ring, a polyurethane ring or a silicone ring.

18. The four-way shuttle according to claim 11, wherein the drive wheels further comprise an end cover, wherein the end cover is arranged at one end of the axle hole and connected with the housing, and the axle extends from the other end of the axle hole.

19. The four-way shuttle according to claim 11, wherein the drive wheels further comprise an encoder, wherein the encoder is connected with the housing and/or the axle and configured to convert an angular displacement of the housing into an electric signal.

20. A warehouse storage system, comprising:

at least one four-way shuttle according to any one of claims 1 to 19;

a first track, wherein the first roller group of the four-way shuttle is configured to be capable of rolling along the first track; and

a second track, wherein the second roller group of the four-way shuttle is configured to be capable of rolling along the second track, and the second track and the first track are perpendicular to each other.