DESCRIPTION

TITLE OF THE INVENTION:

APPLICATION METHOD

Field

[0001] The present disclosure relates to an application method.

Background

[0002] There are known conveyance devices such as palletizing devices and depalletizing devices that stack an item on a pallet or the like, unload an item from a pallet, or transfer an item from any pallet to another pallet. The palletizing devices and the depalletizing devices are, for example, robots having multijoint arms.

[0003] Various methods of fixing and holding such a movable device such as a robot to a floor surface or a wall surface via a base have been disclosed (for example, Patent Literatures 1, 2, and 3). However, in the fixing by a magnet in Cited Literature 1, the floor surface is limited to metal, and the fixing force is weaker than that of an anchor bolt. In addition, in Cited Literatures 2 and 3, since the fixing is achieved with a hooking portion installed on a floor surface or a wall surface, pre-construction is required at an installation place and it is not possible to perform relocation.

[0004] Furthermore, in order to provide a vibration-isolating effect in addition to the load support and fixing of the movable device and the base, for example, a method of applying a falling suppression device using a silicone-based elastic adhesive disclosed in Patent Literature 4 is considered. In this method, the device is easily relocated since the device can be removed. However, since the fixing force is weak, it is necessary to use another fixing method (for example, adhesive) in combination to prevent a horizontal shift.

Citation List

Patent Literature

[0005] Patent Literature 1: JP 2021-171784 A

Patent Literature 2: JP 2013-061053 A

Patent Literature 3: JP 2020-138289 A

Patent Literature 4: JP 2019-120358 A

Summary

Technical Problem

[0006] The support and fixing members described above are worn out and gradually deteriorate by the weight applied from the base and the operation of the device, and thus the vibration-isolating effect and the fixing force decrease. In addition, when these members are not appropriately installed, the members may be worn out and may deteriorate more quickly.

[0007] The present disclosure solves the above-described problems, and an object of the present disclosure is to provide an application method by which an adhesive can be applied with an appropriate adhesion area.

Solution to Problem

[0008] To achieve the above object, an application method according to the present disclosure is of applying, in a state where a movable device that is at least partially movable with respect to a base is fixed to the base, a gel-like support member that is interposed between the base and a floor surface to support the base, and an adhesive that is interposed between the base and the floor surface to adhere the base to the floor surface. The application method includes: calculating a required adhesion area based on design values of the base and the movable device and a tensile strength of the adhesive; determining an adhesive safety factor of an application area of the adhesive according to a load level estimated based on operating conditions including a speed, an operating rate, an installation environment, and a weight of the movable device; and calculating a width of the adhesive to be applied based on the adhesive safety factor, the required adhesion area, and a length over which the adhesive is to be applied.

Advantageous Effects of Invention

[0009] According to the present disclosure, it is possible to effectively apply an adhesive with an appropriate adhesion area.

Brief Description of Drawings

[0010] FIG. 1 is a schematic diagram of a conveyance device installed using an application method according to an embodiment.

FIG. 2 is a plan view of the base illustrated in FIG. 1.

FIG. 3 is a schematic diagram illustrating an example of application of the adhesive illustrated in FIG. 1.

FIG. 4 is a schematic diagram illustrating an example of application of the gel illustrated in FIG. 1.

FIG. 5 is a flowchart describing a flow of the application method according to the present embodiment.

FIG. 6 is a schematic diagram illustrating an example of an arrangement map of the gels.

FIG. 7 is a schematic diagram illustrating an example of an arrangement map of the gels.

FIG. 8 is a flowchart describing a flow of a reapplication method according to the present embodiment.

[0011] (Embodiments)

Hereinafter, embodiments of the present disclosure will be described in detail with reference to the drawings. Note that the present invention is not limited by the embodiments. Components in the following embodiments include those that can be easily substituted by those skilled in the art, those that are substantially the same, and those that are equivalent thereto. Furthermore, the components in the following embodiments can be omitted, substituted, or changed in various ways without departing from the gist of the present disclosure. In the following embodiments, components necessary for illustrating the embodiment will be described, other components will be omitted, the same configurations will be denoted by the same reference numerals, and different configurations will be denoted by different reference numerals.

[0012] <Conveyance Device>

FIG. 1 is a schematic diagram of a conveyance device to which an application method according to the present embodiment is applied. A conveyance device 1 illustrated in FIG. 1 is a device that stacks an item R on a pallet P1 (palletizing), unloads an item R from a pallet P2 (depalletizing), or transfers an item from any pallet P2 to another pallet P1 in a facility such as a warehouse in which logistics management is performed.

[0013] Here, the pallet is defined by JAPAN PALLET ASSOCIATION as "a pallet that has a structure having a surface for placing cargo consolidated into a single unit, and allows for all of loading, unloading, transportation, and storage by human labor or dedicated vehicles such as forklifts, including those having superstructures". In the

present embodiment, the pallet refers to a container or a table on which an item R is stacked. That is, the pallet referred to herein is not limited to a so-called flat plate-shaped table. The pallet includes carts and the like and may have any shape. The item R is to be stacked on a pallet, and is, for example, a product to be shipped. The item R include plastic containers, cardboard boxes, bags, and the like provided to pack a product and the like.

[0014] As illustrated in FIG. 1, the conveyance device 1 includes a base 10, a gel 20 that is a support member, an adhesive 30, and a movable device 40. In the present embodiment, one horizontal direction is defined as an X-axis direction, a horizontal direction orthogonal to the X-axis direction is defined as a Y-axis direction, and a vertical direction orthogonal to the X-axis direction and the Y-axis direction is defined as a Z-axis direction. The conveyance device 1 is assumed to be supported and fixed on a floor surface Gr such as concrete that is a horizontal plane parallel to the X-axis direction and the Y-axis direction and has high rigidity.

[0015] The base 10 has a shape of a plate formed of a material having high rigidity such as an iron plate. The base 10 is supported and fixed to the floor surface Gr that is an installation surface on the lower surface side via the gel 20 that is a support member and the adhesive 30. The base 10 is ideally supported and fixed in a substantially horizontal posture, and is inclined with respect to the horizontal posture due to a variation in the amount of decrease in the horizontal plane when the thickness of the gel 20 decreases as described later. The base 10 supports the movable device 40 on the upper surface side.

[0016] FIG. 2 is a plan view of the base illustrated in FIG. 1. As illustrated in FIG. 2, the base 10 of the present embodiment includes four areas 10-1, 10-2, 10-3, and 10-4. Each of the areas 10-1, 10-2, 10-3, and 10-4 has a single square plate shape. Two areas are aligned side by side in the X-axis direction and two areas are aligned side by side in the Y-axis direction. The areas 10-1, 10-2, 10-3, and 10-4 jointly support and fix the movable device 40 to be described later. Each of the areas 10-1, 10-2, 10-3, and 10-4 supports and fixes one leg portion 421, which is provided at each of four corners of a robot pedestal 42 of the movable device 40 to be described later. The base 10 has a bolt hole (not illustrated) formed for inserting an anchor bolt 422 for fixing the leg portion 421 to the base 10.

[0017] The gel 20 illustrated in FIG. 1 is a gel-like support member, has adhesiveness, and has a plate shape formed of a resin-based or rubber-based elastic material such as a silicone-based material. The gel 20 is disposed between the floor surface Gr and a lower surface of the base 10 to support the load applied from the base 10 and the movable device 40 supported by the base 10 in the Z-axis direction by compression and damp vibrations.

[0018] The adhesive 30 is, for example, a silicone resin having adhesion properties allowing adhesion at least between the floor surface Gr and the base 10, and is stored in a liquid state and cured by drying or the like. The adhesive 30 fixes the floor surface Gr and the base 10 by being filled in a gap between the floor surface Gr and the base 10 and being cured, for example, in a state where the base 10 is supported by the gel 20.

[0019] The movable device 40 is a device that operates in a state of being supported and fixed to the base 10. The movable device 40 of the present embodiment is a palletizing device and is a robot having a multijoint arm. The movable device 40 is subjected to shaking, vibration, and movement of its center of gravity due to turning or deformation of an arm 44 and a load of the item R held by an end effector 46. That is, an exciting force is generated with respect to the base 10 as the movable device 40 operates.

[0020] The movable device 40 has a robot pedestal 42, the arm 44 including a plurality of links 442 connected to a plurality of joints 441, and the end effector 46. The robot pedestal 42 is a rectangular parallelepiped base member made of a material having high rigidity such as carbon steel (SS material). As illustrated in FIG. 2, the robot pedestal 42 has the leg portions 421 at four corners on the lower surface side. Each leg portion 421 is fixed by the anchor bolt 422, whereby the robot pedestal 42 is fixed to the base 10. In the example illustrated in FIG. 2, one leg portion 421 is fixed to the base 10 by two anchor bolts 422.

[0021] The arm 44 illustrated in FIG. 1 is supported on the robot pedestal 42 so as to be able to turn around the axis and move upward and downward. The joint 441 is a rotation axis serving as a joint of the arm 44. The link 442 connects the adjacent joints 441. The end effector 46 is connected to a front end of the arm 44. The end effector 46 is a gripping portion that grips the item R by suction, clamping, or a combination thereof.

[0022] In addition, the movable device 40 has a drive portion (not illustrated). The drive portion includes, for example, a rotation mechanism causing relative rotation between the links 442 at the joint 441, and a suction mechanism, a clamping mechanism or the like that drives the end effector 46. The rotation mechanism at the joint 441 is realized by, for example, a known mechanism such as a rotation actuator including a motor, a rack-and-pinion mechanism including an air cylinder, or a wire or link mechanism. In addition, the suction mechanism at the end effector 46 is realized by a mechanism that drives a rotary cylinder or a piston cylinder by a motor or a compressor, or a known mechanism including a suction source such as a vacuum pump or an ejector. In addition, the clamping mechanism at the end effector 46 is realized by a known mechanism such as a rotation actuator including a motor, a linear motion actuator including a motor, an air cylinder, or the like, a rack-and-pinion mechanism including an air cylinder, or a wire or link mechanism.

[0023] In addition, the conveyance device 1 may further include, for example, an image pickup device, a lighting device, a notification device, a control device, an input device, and the like (not illustrated). The image pickup device picks up images of a target pallet P1 or P2 on which the item R is to be stacked or unloaded, the item R stacked on the pallet P2, the arrangement of the items R stacked, and the like, and acquires image data allowing identification of the position and identity of the image pickup target. The lighting device irradiates the image pickup target of the image pickup device with light. The notification device includes a display device, a light emitting device, a speaker, a vibrator, and the like for causing an operator to recognize predetermined notification information. The control device is a computer that controls the conveyance device 1, and has an arithmetic processing device, a storage device, an input-output interface, and the like. The input device is realized by, for example, a keyboard, a mouse, a physical switch, a button, a touch panel, or the like. In the present embodiment, the description that the conveyance device 1 includes the image pickup device, the lighting device, the notification device, the control device, and the input device also includes an aspect in which the function of each device is configured as a function of a part of the conveyance device 1 or a conveyance system in which the conveyance device 1 is arranged.

[0024] The conveyance device 1 is managed by a management device (not illustrated).

The management device is a system that manages operations of the devices in a logistics management facility in which the conveyance device 1 of the present embodiment is arranged. The management device is, for example, a warehouse control system (WCS) or a warehouse management system (WMS), but is not limited to the WCS and the WMS and may be any system. The management device may be, for example, a backend system such as other production management systems. The management device is provided at any position. The management device may be provided within the facility in which the conveyance device 1 is arranged, or may be provided at a position away from the facility to manage the facility from a distant position.

[0025] <Adhesive Application Method>

The adhesive 30 undergoes changes in physical properties such as a decrease in adhesive force due to deterioration caused by aging. In addition, a horizontal shifting force is applied to the base 10 as the movable device 40 turns on the base 10. Therefore, the adhesive 30 is shear-deformed or broken, and the base 10 is shifted in the X-axis direction and the Y-axis direction with respect to the floor surface Gr. For example, as the base 10 turns with respect to the floor surface Gr, the adhesive surface of the base 10 is shifted in the X-axis direction and the Y-axis direction with respect to the adhesive surface of the floor surface Gr. Therefore, the adhesive 30 needs to be applied with an appropriate adhesion area and reapplied periodically.

[0026] FIG. 3 is a schematic diagram illustrating an example of application of the adhesive illustrated in FIG. 1. As illustrated in FIG. 3, the adhesive 30 is annularly applied, for example, to one area 10-1 in a substantially constant width along a position that is a predetermined distance away from the peripheral edge of the base 10. The same operation is also performed on the other areas 10-2, 10-3, and 10-4.

[0027] When the application area of the adhesive 30 per area is denoted by As [mm^2], the width of the adhesive 30 to be applied is denoted by Aw [mm], and the peripheral length is denoted by Al [mm], the application area As is represented by Equation (1) below.

$$As = Aw \times Al \quad (1)$$

[0028] In addition, when the required adhesion area per area is denoted by As_0 [mm^2] and the safety factor is denoted by Q, the application area As per area is represented by

Equation (2) below.

$$As = Q \times As_0 \quad (2)$$

[0029] The required adhesion area As_0 is calculated based on the bolt fastening force per area of the anchor bolts 422 which fasten the movable device 40 to the base 10. When the bolt fastening force per area is denoted by Bf [N], the anchor strength per anchor bolt 422 is denoted by Bs [N/mm^2], and the number of anchor bolts 422 per area is denoted by Bn [number], the bolt fastening force Bf per area is represented by Equation (3) below. The anchor strength Bs of the anchor bolt 422 is a manufacturer's designated value.

$$Bf = Bs \times Bn \quad (3)$$

[0030] In addition, when the tensile strength per unit area of the adhesive 30 is denoted by Af [N/mm^2], the required adhesion area As_0 is represented by Equation (4) below. The tensile strength Af per unit area of the adhesive 30 is a manufacturer's designated value.

$$As_0 = Bf/Af \quad (4)$$

[0031] Here, as shown in Table 1, the safety factor Q is determined according to a load level applied to the adhesive 30. The load level is determined by a cumulative value of load points (1) to (4). When the load point is 3 or less, the load level is I, and the safety factor Q is 2. When the load point is 4 or more and 12 or less, the load level is II, and the safety factor Q is 4. When the load point is 13 or more and 27 or less, the load level is III, and the safety factor Q is 6.

[0032]

Table 1

Load Level	Load Point (1) × (2) × (3) × (4)	Safety Factor Q
I	≤ 27	2
II	≤ 54	4
III	≤ 81	6

[0033] As shown in Table 2, the load point (1) is determined based on an operating condition (1). The operating condition (1) is the weight (box weight) of the item R conveyed by the conveyance device 1. When the box weight is less than 10 kg, the load point (1) is 1. When the box weight is 10 kg or more and less than 20 kg, the load point (1) is 2. When the box weight is 20 kg or more, the load point (1) is 3.

[0034]

Table 2

Operating Condition (1)	
Box Weight	Load Point (1)
Light (< 10 kg)	1
Medium (10 - 20 kg)	2
Heavy (20 kg ≤)	3

[0035] As shown in Table 3, the load point (2) is determined based on an operating condition (2). The operating condition (2) is the speed of the arm 44. When the speed override of the arm 44 relative to the maximum speed is less than 30%, the load point (2) is 1. When the speed override is 30% or more and less than 80%, the load point (2) is 2. When the speed override is 80% or more, the load point (2) is 3.

[0036]

Table 3

Operating Condition (2)	
Arm Speed	Load Point (2)
Override Small (< 30)	1
Override Medium (< 80)	2
Override Large (< 100)	3

[0037] As shown in Table 4, the load point (3) is determined based on an operating condition (3). The operating condition (3) is an operating rate of the movable device 40. When the operating rate is several hours/day, the load point (3) is 1. When the operating rate is ten-plus hours/day, the load point (3) is 2. When the operation is continuously performed, the load point (3) is 3.

[0038]

Table 4

Operating Condition (3)	
Operating Rate	Load Point (3)
Several Hours/Day	1
Ten-Plus Hours/Day	2
Continuous Operation	3

[0039] As shown in Table 5, the load point (4) is determined based on an operating

condition (4). The operating condition (4) is an installation environment in which the movable device 40 is installed. When the movable device 40 is installed in a sealed space in which the temperature and humidity are stable, the load point (4) is 1. When the movable device 40 is installed in an open space influenced by the fluctuating outside air temperature and outside humidity, the load point (4) is 3. When the movable device 40 is installed in an intermediate environment between the above environments, the load point (4) is 2.

[0040]

Table 5

Operating Condition (4)	
Installation Environment	Load Point (4)
Sealed	1
Intermediate	2
Open	3

[0041] <Gel Application Method>

The gel 20 undergoes plastic deformation and its thickness decreases as a load from the base 10 and the movable device 40 supported by the base 10 is continuously applied thereto. Therefore, the vibration-isolating effect decreases. In addition, the base 10 and the movable device 40 sink, and a shift occurs between a coordinate control value and an actual position when the item R is conveyed by operating the movable device 40. In addition, when there is a variation in the amount of thickness decrease between a plurality of the gels 20, the base 10 and the movable device 40 are inclined, and the load on each portion of the movable device 40 increases. Therefore, the gel 20 needs to be applied with an appropriate adhesion area and reapplied periodically.

[0042] FIG. 4 is a schematic diagram illustrating an example of application of the gel illustrated in FIG. 1. FIG. 4 illustrates an example of arrangement of the gels 20 in the area 10-1 of the base 10 as an example. As illustrated in FIG. 4, the gels 20 are disposed in a dispersed manner at a plurality of places within the area 10-1 in plan view. In the example illustrated in FIG. 4, the gels 20 are disposed near four corners and at a center of the area 10-1 having a normal shape. Among the gels 20, four gels 20 are disposed at a corner corresponding to the area immediately below the leg portion 421 of the robot pedestal 42 of the movable device 40 to be described later, and one gel 20 is disposed at each of the other corners and the center.

[0043] When the number of gels 20 to be installed between the base 10 and the floor surface Gr is denoted by Gn [number], the number of areas of the base 10 is denoted by Pn [number], the number of required gels per area is denoted by Gn_0 [number], and the safety factor is denoted by S, the number Gn of gels is represented by Equation (5) below.

$$Gn = S \times Gn_0 \times Pn \quad (5)$$

[0044] The number Gn_0 of required gels is calculated based on the total weight of the target to be supported by the gels 20. When the total weight is denoted by W [N], the weight of the base 10 is denoted by W_1 [N], the weight of the movable device 40 is denoted by W_2 [N], and the maximum weight of the item R to be conveyed by the movable device 40 is denoted by W_3 [N], the total weight W is represented by Equation (6) below.

$$W = W_1 + W_2 + W_3 \quad (6)$$

[0045] In addition, when the load capacity per gel 20 is denoted by Gf [N], the number Gn_0 of required gels per area is represented by Equation (7) below. The load capacity Gf per gel 20 is a manufacturer's designated value.

$$Gn_0 = W/Gf/Pn \quad (7)$$

[0046] Here, the safety factor S is determined according to a load level applied to the gel 20 as shown in Table 6. The load level is determined by a cumulative value of the load points (1) to (3). The load points are common to Tables 2 to 4. When the load point is 3 or less, the load level is I, and the safety factor S is 3. When the load point is 4 or more and 12 or less, the load level is II, and the safety factor S is 5. When the load point is 13 or more and 27 or less, the load level is III, and the safety factor S is 7.

[0047]

Table 6

Load Level	Load Point (1) × (2) × (3)	Safety Factor S
I	≤ 3	3
II	≤ 12	5
III	≤ 27	7

[0048] <Flow of Application Method>

FIG. 5 is a flowchart describing a flow of the application method according to the present embodiment. The flowchart illustrated in FIG. 5 is executed by an

arithmetic portion of the control device of the conveyance device 1 or the management device on the basis of programs and data stored in advance in a storage portion. For example, when receiving a predetermined start command input by an operator, the arithmetic portion proceeds to Step S1 illustrated in FIG. 5 and starts the processing.

[0049] The storage portion stores in advance the type and maximum weight W_3 of the item R to be conveyed by the conveyance device 1, the operating conditions of the conveyance device 1, the weight W_1 and number Pn of areas of the base 10, the number Bn of anchor bolts 422 per area, the peripheral length Al of the adhesive 30 to be applied, the weight W_2 of the movable device 40, and various manufacturer's designated values. The operating conditions of the conveyance device 1 include at least a speed (override) of the arm 44, an operating rate, and an installation environment. In addition, the storage portion is assumed to store in advance the shape of the base 10, the fixing position of the robot pedestal 42, the number Gn of gels to be applied, the arrangement map of the gels 20, and the corresponding arrangement rules.

[0050] In Step S1, the arithmetic portion calculates the bolt fastening force Bf of the anchor bolts 422 per area (areas 10-1, 10-2, 10-3, and 10-4) of the base 10 from the anchor strength Bs per anchor bolt 422 and the number Bn of anchor bolts 422 per area using Equation (3) described above.

[0051] Next, in Step S2, the arithmetic portion calculates the required adhesion area As_0 per area of the base 10 from the bolt fastening force Bf and the tensile strength Af per unit area of the adhesive 30 using Equation (4) described above. That is, the required adhesion area As_0 is determined by the design values of the base 10 and the movable device 40 and the manufacturer's designated value for the adhesive 30.

[0052] Next, in Step S3, the arithmetic portion determines the safety factor Q of the application area As of the adhesive 30 according to Table 1 described above, based on the operating conditions shown in Tables 2 to 5 described above.

[0053] Next, in Step S4, the arithmetic portion calculates the application area As of the adhesive 30 from the required adhesion area As_0 and the safety factor Q using Equation (2) described above. Next, the arithmetic portion calculates the width Aw of the adhesive 30 from the application area As and the peripheral length Al of the adhesive 30 to be applied to one area using Equation (1) described above.

[0054] Next, in Step S5, the arithmetic portion calculates the total weight W of the

target to be supported by the gels 20 from the weight W_1 of the base 10, the weight W_2 of the movable device 40, and the maximum weight W_3 of the item R to be conveyed by the movable device 40 using Equation (6) described above.

[0055] Next, in Step S6, the arithmetic portion calculates the number Gn_0 of required gels per area from the total weight W, the load capacity Gf per gel 20, and the number Pn of areas of the base 10 using Equation (7) described above.

[0056] Next, in Step S7, the arithmetic portion determines the safety factor S of the number Gn of gels according to Table 6 described above, based on the operating conditions shown in Tables 2 to 4 described above.

[0057] Next, in Step S8, the arithmetic portion calculates the number Gn of gels 20 to be installed between the base 10 and the floor surface Gr from the number Gn_0 of required gels, the safety factor S, and the number Pn of areas of the base 10 using Equation (5) described above.

[0058] Next, in Step S9, the arithmetic portion determines the arrangement of the gels based on the shape of the base 10, the fixing position of the robot pedestal 42 with respect to the base 10, the number Gn of gels, and the predetermined arrangement rules. The method of applying the adhesive 30 and the gel 20 is determined as above, and the processing of the flowchart illustrated in FIG. 5 is ended.

[0059] <Example of Arrangement Map of Gels>

As described above, the shape of the base 10, the fixing position of the robot pedestal 42, the number Gn of gels to be applied, the arrangement map of the gels 20, and the corresponding arrangement rules are prepared in advance. An example of the arrangement map of the gels 20 is, for example, as in the example of the application illustrated in FIG. 4. FIGS. 6 and 7 are each a schematic diagram illustrating an example of the arrangement map of the gels.

[0060] In the example illustrated in FIG. 6, a base 10A has one square area, the fixing position of the robot pedestal 42 is at the center, and the number Gn of gels is 9. In this case, one gel 20 is disposed at each of the four corners of the base 10 and at each of the four corners of the robot pedestal 42, and the remaining one gel is disposed at the center.

[0061] In the example illustrated in FIG. 7, a base 10B has one perfect circular area, the fixing position of the robot pedestal 42 is at the center, and the number Gn of gels is 9.

In this case, one gel 20 is disposed at each of the four corners of the robot pedestal 42, and the five remaining gels are disposed at equal intervals along the peripheral edge of the base 10.

[0062] <Flow of Reapplication Method>

The support and fixing using the gel 20 and the adhesive 30 determined and applied by the above-described application method gradually deteriorate due to wear caused by the weight applied from the base and the operation of the device, and thus the vibration-isolating effect and the fixing force decrease. Accordingly, reapplication is required to be performed at an appropriate time. The appropriate time is predicted, for example, by monitoring the amount of shift of the base 10. The vertical sinking of the base 10 indicates a decrease in thickness of the gel 20, and the horizontal shift of the base 10 indicates deformation or breakage of the adhesive 30.

[0063] The operating time (number of times of conveyance) of the movable device 40 from the application to the reapplication is sufficiently ensured through appropriate application. However, when the load level is higher during the actual operating situation than the assumed operating condition, the increase in amount of shift of the base 10 may accelerate, and the operating time of the movable device 40 before an allowable value requiring reapplication is reached may be reduced. Therefore, when the reapplication is performed, it is preferable to correct the width Aw of the adhesive 30, the number Gn of gels, and the arrangement of the gels 20 according to the actual operating situation.

[0064] FIG. 8 is a flowchart describing a flow of a reapplication method according to the present embodiment. The flowchart illustrated in FIG. 8 is executed by the arithmetic portion of the control device of the conveyance device 1 or the management device on the basis of programs and data stored in advance in the storage portion. For example, when receiving a predetermined start command input by an operator, the arithmetic portion proceeds to Step S11 illustrated in FIG. 8 and starts the processing.

[0065] In Step S11, the arithmetic portion acquires an actual operating situation of the conveyance device 1. The operating situation information to be acquired includes at least the items listed in Tables 2 to 5 described above.

[0066] Next, in Step S12, the arithmetic portion corrects the safety factor Q of the application area As of the adhesive 30 according to Tables 1 to 5 described above,

based on the operating situation acquired in Step S11.

[0067] Next, in Step S13, the arithmetic portion recalculates and corrects the width Aw of the adhesive 30, based on the corrected safety factor Q using Equation (1) described above. The calculation method is the same as in Step S4 in the flowchart illustrated in FIG. 5.

[0068] Next, in Step S14, the arithmetic portion corrects the safety factor S of the number Gn of gels 20 according to Tables 6 and 2 to 4 described above, based on the operating situation acquired in Step S11.

[0069] Next, in Step S15, the arithmetic portion recalculates and corrects the number Gn of gels 20 to be installed between the base 10 and the floor surface Gr, based on the corrected safety factor S using Equation (5) described above. The calculation method is the same as in Step S8 in the flowchart illustrated in FIG. 5.

[0070] Next, in Step S16, the arrangement of the gels is corrected based on the corrected number Gn of gels. The method of determining the arrangement of the gels is the same as in Step S9 in the flowchart illustrated in FIG. 5. The method of reapplying the adhesive 30 and the gel 20 is determined as above, and the processing of the flowchart illustrated in FIG. 8 is ended.

[0071] <Method of Predicting Reapplication Time>

In the present embodiment, a reapplication time may be predicted using machine learning. For example, data in which the safety factors Q and S during application, the actual operating situation, and the operating time from the application to the reapplication are correlated is accumulated for machine learning to make a prediction using the machine learning. In addition, the replacement time data predicted by machine learning and the data accumulated in each factory, such as results of the collation with the past reapplication records, may be managed by the management device or remote monitoring at further upstream of the management device to improve the prediction accuracy.

[0072] (Functions and Effects of Embodiments)

The application method described in the embodiments is understood as follows, for example.

[0073] An application method according to a first aspect is an application method of applying, in a state where a movable device 40 that is at least partially movable with

respect to a base 10 is fixed to the base 10, a gel-like support member (gel 20) that is interposed between the base 10 and a floor surface Gr and supports the base 10, and an adhesive 30 that is interposed between the base 10 and the floor surface Gr and adheres the base 10 to the floor surface Gr, including calculating a required adhesion area As_0 based on design values of the base 10 and the movable device 40 and a tensile strength Af of the adhesive 30, determining a safety factor Q of an application area As of the adhesive 30 according to a load level estimated based on operating conditions including a speed, an operating rate, an installation environment, and a weight of the movable device 40, and calculating a width Aw of the adhesive 30 to be applied based on the safety factor Q, the required adhesion area As_0, and a length Al over which the adhesive 30 is to be applied.

[0074] In the application method according to the first aspect, the load applied from the base 10 is supported by the support member (gel 20), and the base 10 and the floor surface Gr are fixed together by the adhesive 30. Such an application method does not require work for the floor surface Gr and allows relocation, compared to fixing by anchor bolts. In addition, since the safety factor Q is determined according to the load level estimated based on the operating conditions of the movable device 40 and the width Aw of the adhesive 30 to be applied is calculated in consideration of the safety factor Q, the adhesive 30 can be applied with an appropriate application area As, and the operating time (number of times of conveyance) of the movable device 40 from the application to the reapplication can be sufficiently ensured.

[0075] An application method according to a second aspect is the application method according to the first aspect, including acquiring an actual operating situation including a speed, an operating rate, an installation environment, and a weight of the movable device 40, correcting the safety factor Q based on the actual operating situation, and calculating a width Aw of the adhesive 30 to be reapplied based on the corrected safety factor Q.

[0076] In the application method according to the second aspect, since the safety factor Q is corrected based on the actual operating situation, the adhesive 30 can be applied with a more appropriate application area As in second and subsequent application operations.

[0077] An application method according to a third aspect is the application method

according to the second aspect, including accumulating data in which the safety factor Q used during application of the adhesive 30, the actual operating situation, and an operating time of the movable device 40 from application to reapplication are correlated to subject the data to machine learning, and predicting a reapplication time of the adhesive 30 using the machine learning.

[0078] In the application method according to the third aspect, even when there is a large difference between the safety factor Q used during application and the safety factor Q calculated based on the actual operating situation, the reapplication can be performed by predicting the reapplication time before the amount of shift of the base 10 caused by the deterioration of the adhesive 30 exceeds an allowable value.

[0079] An application method according to a fourth aspect is the application method according to any one of the first to third aspects, further including calculating a number of required support members to be applied (number Gn_0 of required gels), based on a total weight W of a target to be supported by the support members (gels 20) and a load capacity Gf per support member, determining a safety factor S of a number of the support members to be applied (number Gn of gels) according to a load level estimated based on operating conditions including a speed, an operating rate, and a weight of the movable device 40, and calculating the number of the support members to be applied (number Gn of gels), based on the safety factor S and the number of required support members to be applied (number Gn_0 of required gels).

[0080] In the application method according to the fourth aspect, the safety factor S is determined according to the load level estimated based on the operating conditions of the movable device 40, and the number of the support members (gels 20) to be applied (number Gn of gels) is calculated in consideration of the safety factor S. Therefore, an appropriate number of the support members (number Gn of gels) can be applied, and the operating time (number of times of conveyance) of the movable device 40 from the application to the reapplication can be sufficiently ensured.

[0081] An application method according to a fifth aspect is the application method according to the fourth aspect, including acquiring an actual operating situation including a speed, an operating rate, and a weight of the movable device 40, correcting the safety factor S based on the actual operating situation, and calculating a number of the support members (gels 20) to be reapplied (number Gn of gels) based on the

corrected safety factor S.

[0082] In the application method according to the fifth aspect, since the safety factor S is corrected based on the actual operating situation, a more appropriate number of the support members (gels 20) (number Gn of gels) can be applied in second and subsequent application operations.

[0083] An application method according to a sixth aspect is the application method according to the fifth aspect, including accumulating data in which the safety factor S used during application of the support member (gel 20), the actual operating situation, and an operating time of the movable device 40 from application to reapplication are correlated to subject the data to machine learning, and predicting a reapplication time of the support member using the machine learning.

[0084] In the application method according to the sixth aspect, even when there is a large difference between the safety factor S used during application and the safety factor S calculated based on the actual operating situation, the reapplication can be performed by predicting the reapplication time before the amount of shift of the base 10 caused by the deterioration of the support member (gel 20) exceeds an allowable value.

[0085] Although the embodiments of the present disclosure have been described above, the embodiments are not limited by those described in the embodiments.

Reference Signs List

[0086] 1 CONVEYANCE DEVICE
10, 10A, 10B BASE
10-1, 10-2, 10-3, 10-4 AREA
20 GEL (SUPPORT MEMBER)
30 ADHESIVE
40 MOVABLE DEVICE
42 ROBOT PEDESTAL
421 LEG PORTION
422 ANCHOR BOLT
44 ARM
441 JOINT
442 LINK
46 END EFFECTOR

Al PERIPHERAL LENGTH

Aw WIDTH

Gr FLOOR SURFACE

P1, P2 PALLET

Q, S SAFETY FACTOR

R ITEM

CLAIMS

[Claim 1]

An application method of applying, in a state where a movable device that is at least partially movable with respect to a base is fixed to the base, a gel-like support member that is interposed between the base and a floor surface to support the base, and an adhesive that is interposed between the base and the floor surface to adhere the base to the floor surface, the application method comprising:

calculating a required adhesion area based on design values of the base and the movable device and a tensile strength of the adhesive;

determining an adhesive safety factor of an application area of the adhesive according to a load level estimated based on operating conditions including a speed, an operating rate, an installation environment, and a weight of the movable device; and

calculating a width of the adhesive to be applied based on the adhesive safety factor, the required adhesion area, and a length over which the adhesive is to be applied.

[Claim 2]

The application method according to claim 1, comprising:

acquiring an actual operating situation including a speed, an operating rate, an installation environment, and a weight of the movable device;

correcting the adhesive safety factor based on the actual operating situation; and

calculating a width of the adhesive to be reapplied based on the corrected adhesive safety factor.

[Claim 3]

The application method according to claim 2, comprising:

accumulating data in which the adhesive safety factor used during application of the adhesive, the actual operating situation, and an operating time of the movable device from application to reapplication are correlated to subject the data to machine learning; and

predicting a reapplication time of the adhesive using the machine learning.

[Claim 4]

The application method according to any one of claims 1 to 3, further comprising:

calculating a number of required support members to be applied, based on a total weight of a target to be supported by the support members and a load capacity per support member;

determining a support member safety factor of a number of the support members to be applied according to a load level estimated based on operating conditions including a speed, an operating rate, and a weight of the movable device; and

calculating the number of the support members to be applied, based on the support member safety factor and the number of required support members to be applied.

[Claim 5]

The application method according to claim 4, comprising:

acquiring an actual operating situation including a speed, an operating rate, and a weight of the movable device;

correcting the support member safety factor based on the actual operating situation; and

calculating a number of the support members to be reapplied based on the corrected support member safety factor.

[Claim 6]

The application method according to claim 5, comprising:

accumulating data in which the support member safety factor used during application of the support member, the actual operating situation, and an operating time of the movable device from application to reapplication are correlated to subject the data to machine learning; and

predicting a reapplication time of the support member using the machine learning.