

ELEVATOR

BACKGROUND OF THE INVENTION

The present invention relates to an elevator with a machine for moving an elevator car up or down.

5 An elevator in general has a counterweight connected to an elevator car through a rope, the counterweight having a weight that balances with about half a rated carrying capacity of the elevator car. As the rope is wound up on a machine sheave which is directly coupled to a motor, the elevator car and the counterweight travel up or down a hoistway like a well bucket.

The machine employs a so-called traction drive system in which a torque is conveyed to the rope through a frictional force between the sheave and the rope wound on the
10 sheave.

In recent years, an elevator that has its machine installed inside the hoistway to eliminate a machine room for a reduced volume of the elevator is becoming a mainstream.

To make the machine compact, this type of elevator adopts a 2:1 roping scheme in which the length of rope wound up by the machine is two times the distance the elevator car
15 travels.

This roping scheme also allows the motor to be reduced in size since the torque required by the machine is only half that of a 1:1 roping scheme.

Further, for a size reduction of the machine, a construction designed to reduce the diameter of the machine sheave has been proposed, as in JP-A-2004-106984.

20 SUMMARY OF THE INVENTION

In recent years, as rare earths including neodymium, a material for a magnet used in the elevator machine, are soaring in price, studies are being conducted to reduce a diameter of the sheave as part of an effort to realize a rare earth magnet motor.

The elevator machine described in JP-A-2004-106984, however, does not have
25 any provision to realize the rare earth magnet motor, giving rise to a concern over a possible substantial increase in cost as the price of rare earths continues to rise.

The present invention has been accomplished in light of these problems and its objective is to provide an elevator equipped with a machine having a rare-earthless magnet motor and also designed to prevent an increase in the volume of a hoistway.

30 To achieve the above objective, the present invention provides an elevator

comprising: a machine 30 having a cubicle, a motor 4 having a stator 24 and a rotor 22 accommodated in the cubicle and a sheave 5 coupled to a rotating shaft of the motor for rotation and having a rope 3 wrapped therearound; and an elevator car 1 and a counterweight 2, both moving up or down like a well bucket when applied a drive force through the rope 3; wherein the sheave 5 of the machine 30 is reduced in diameter without changing a width W of the cubicle; wherein the machine 30 includes a tension pulley 23 that engages the rope 3 wrapped around the reduced-diameter sheave 5 and guides it to near the position that the rope 3 occupied before the sheave 5 has been reduced in diameter.

This invention therefore can provide an elevator equipped with a machine having a rare-earthless magnet motor and capable of reducing the volume of the hoistway.

Other objects, features and advantages of the invention will become apparent from the following description of the embodiments of the invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a perspective view of a machine in an elevator of this invention.
Fig. 2 shows a front view of the machine in the elevator of this invention.
Fig. 3 shows a side view of the machine in the elevator of this invention.
Fig. 4 shows a front view of a machine as a second embodiment of this invention.
Fig. 5 shows a perspective view of an elevator as a third embodiment of this invention.
Fig. 6 shows a perspective view of a machine-roomless elevator in this invention.
Fig. 7 shows a cross-sectional plan view of a hoistway in the machine-roomless elevator of this invention.

DESCRIPTION OF THE EMBODIMENTS

Now one embodiment of this invention will be described by referring to the accompanying drawings.

First, an overall construction of the machine-roomless elevator of this invention will be explained by referring to Fig. 6 and Fig. 7.

Fig. 6 is an overall perspective view of the machine-roomless elevator of this invention, and Fig. 7 is a plan view of the machine-roomless elevator of this invention (cross-sectional plan view of the hoistway).

As shown in Fig. 6, this elevator has a machine 30 mounted in the hoistway, with

a counterweight 2 suspended in a space behind an elevator car 1.

The machine 30 comprises a motor 4 and a sheave 5 and, for its size reduction, employs a 2:1 roping scheme in which the machine takes up a length of rope two times the distance the car 1 travels.

5 For improved quietness, the motor 4 uses a permanent magnet gearless motor.

In the machine-roomless elevator, under-car pulleys 6a, 6b for lifting the elevator car 1 are installed below the car to reduce the size of a dead space above the car.

One end of a rope 3 of the machine-roomless elevator is secured through a spring 42 to a beam, not shown, provided at the top of the hoistway.

10 The rope 3 hanging from this fixed end is wrapped around a counterweight pulley 8 of the counterweight 2, then led upward to wrap around a top pulley 7c secured to the beam before being led downward.

The rope 3 at the opposite end is secured to the beam mounted at the top of the hoistway not shown through a spring 41. The rope 3 on this side is wrapped around the under-car
15 pulleys 6b, 6a and then runs upward and is wound on top pulleys 7a, 7b secured to the beam before running downward to wrap around the sheave 5.

As shown in Fig. 7, the elevator of this invention has the machine 30 mounted in a rear space in the hoistway (behind the elevator car 1), with the sheave 5 facing the wall surface of the hoistway 45.

20 The rope 3 that has passed the top pulleys 7a, 7b is arranged to run from an end 43 of the pulley 7b toward an end 44 of the sheave 5.

Next, the construction of the machine used in the elevator of this invention will be explained by referring to Fig. 1 to Fig. 3.

Here, Fig. 1 is a perspective view of the machine used in the elevator of this
25 invention, Fig. 2 a front view of the machine and Fig. 3 a side view of the machine.

As shown in Fig. 1 and Fig. 2, the machine 30 of the elevator comprises a motor 4, a sheave 5 coupled to and driven by a drive shaft of the motor 4 and wrapped around by the rope, and a tension pulley 23 arranged to cover a vertically projected shape of the sheave 5 and engage with the rope 3.

30 The motor 4 comprises a rotor 22 and a stator 24, arranged in an inner rotor construction in which the rotor 22 rotates inside the stator 24.

The stator 24 is constructed of a plurality of slotted electromagnetic steel plates laminated together, which are wound with a coil 25 of a copper wire.

The motor 4 of the elevator is of a gearless permanent magnetic type, a current

mainstream construction, to meet the requirements of large torques at low speeds and of quietness.

To meet the requirements the motor uses a neodymium magnet that has a high magnetically attractive force.

5 In recent years, however, as rare earths such as neodymium and dysprosium soar in price, rare-earthless magnet motors using ferrite magnets to obviate the need for rare earths are being called for.

So, if the same level of attractive force as that of the neodymium magnet is to be produced by a motor using the ferrite magnet which has less attractive force, a large ferrite
10 magnet will be required. This will cause the motor to increase in size, which in turn results in the machine, including the motor, becoming too large in its entire width W to fit in the hoistway or the hoistway dimensions being required to be expanded according to the increased size of the motor.

With one embodiment of this invention, the sheave diameter D_s and the entire
15 width W of the machine can be designed as independent parameters (conventionally, the full width of the machine is uniquely determined by the sheave diameter D_s).

For this reason, an allowable full width W of the machine is first determined from the cross-sectional area of the hoistway. Then, from this frame dimension W (width of a cubicle accommodating the motor), a torque that can be produced by the ferrite magnet is calculated. At
20 a last step, a dimension of the sheave 5 is determined. With these steps taken, the machine can be designed.

In other words, even when the ferrite magnet is reduced in volume, the motor torque generated can be kept from becoming smaller by reducing the diameter of the sheave 5. This allows for a size reduction of the machine even with a rare-earthless magnet motor using
25 the ferrite magnet.

That is, as shown in Fig. 1, the diameter D_p of the tension pulley 23 is determined by the layout of the hoistway. Let us assume, for example, the allowable width of the machine that can be mounted in the hoistway (full width of the machine) $W = 680$ mm, the sheave diameter $D_s = 240$ mm and the tension pulley diameter $D_p = 400$ -420 mm.

30 If the tension pulley diameter is set at $D_p = 400$ mm, the same layout as the one used for the sheave diameter $D_s = 400$ mm can make the amount of magnet used smaller in proportion as the sheave 5 is reduced in diameter.

This advantageous effect increases as the sheave 5 becomes smaller in diameter.

If the sheave diameter is set at $D_s = 150$ -240 mm and the tension pulley diameter

at $D_p = 400$ mm, then D_p/D_s will be between 1.67 and 2.67.

Further, if the sheave is made smaller in diameter and a reduced diameter rope used, the torque required by the machine can be reduced.

For small-diameter ropes 6 mm and 8 mm in diameter, the sheave diameters D_s are more than 240 mm and 320 mm, respectively.

If we let the diameter of the sheave 5 be D_s and the entire width of the machine (width of the cubicle accommodating the motor) be W as shown in Fig. 7, the distance between a sheave end 44 and the end of the machine 30, W_1 , is given by $(W - D_s)/2$.

The end portion of the thin type machine protruding from the sheave 5 is the most protruding portion when viewed in the direction of width of the hoistway.

Here, to reduce the out-of-plane angle of incidence of the rope 3 between the top pulley 7b and the sheave 5 (generally called a fleet angle), if the end 43 of the top pulley 7b and the sheave end 44 are made to agree with each other in the cross-sectional plane, the distance W_1 can be reduced minimizing the protruding portion W_1 .

In other words, when the distance W_1 is large, the machine protrudes on the left side in the X direction, increasing the width of the hoistway W_h .

As the diameter D_s of the sheave 5 is reduced, the distance W_1 increases, as the aforementioned formula indicates, increasing the hoistway width W_h .

To deal with this problem, the embodiment of this invention has the tension pulley 23 arranged above the sheave 5, as shown in Fig. 1 to Fig. 3.

Since the rope 3 is wrapped around both the sheave 5 and the tension pulley 23, the leaving position of the rope 3 is determined by the diameter D_p of the tension pulley 23.

So, even when the sheave 5 is made smaller in diameter, because the end 43 and the sheave end 44 are brought closer together by the tension pulley 23 (which can guide the rope 3 to near the position that it occupied before the reduction of sheave diameter), the dimension D_1 identical to the protruding portion can be reduced even if the distance W_1 has increased.

That is, even when the sheave 5 is made smaller in diameter, this arrangement can prevent the machine 30 from protruding and thereby solve the problem of an increased hoistway width W_h which would otherwise result.

Further, since the reduction of the diameter of the sheave 5 results in an increased number of revolutions of the sheave 5, the motor temperature is likely to rise.

To deal with this problem, as shown in Fig. 1 and Fig. 2, this invention provides the tension pulley 23 with a fan 29 that disturbs ambient air. This can produce an air flow from left to right in Fig. 3, which in turn minimizes temperature rises of the motor.

It should be noted that the thickness of the motor cubicle (thickness of the machine) L and the dimension of components of the sheave 5, such as shaft, are independent of the diameter reduction of the sheave 5. So, as long as the suspension load determined by the dead weight of the elevator car and the load carried remains unchanged, these dimensions cannot be reduced, indicating that it is generally not easy to reduce the entire width of the machine (width of the cubicle accommodating the motor) W.

Therefore, if the motor 4 is arranged to have a large diameter rotor 22 which has an alleviated reduction ratio when compared to that for the reduced diameter of the sheave 5 (the rotor diameter is set greater than its original diameter used before the sheave's diameter is reduced) and if the frame dimension (width of the cubicle accommodating the motor 4) W is not reduced but allowed some margins, the rotor 2 can take a large gap radius thus realizing an increased torque of the motor 4.

Further, in this embodiment, a combination of reducing the diameter of the sheave 5 and giving some margins to the width of the motor 4 (width of the cubicle accommodating the motor 4) W, rather than reducing it to the limit, in designing a magnetic circuit allows the air gap (rotor) diameter Dr1 to be increased. This in turn can help reduce the amount of ferrite magnet used and therefore the size of the rare-earthless motor.

As shown in Fig. 3, the rotor 22 has a magnet 26 bonded to its surface. A brake is mounted inside the rotor 22 with its inner surface used as a brake drum.

This brake has brake shoes 20a, 20b arranged to come into contact with the brake drum, magnet coils 21a, 21b to attract and release the brake shoes, and a pair of left and right brake springs, not shown, to press the shoes against the rotor 22.

When the elevator car is at rest, the magnet coils 21a, 21b are open, causing the brake springs to press the brake shoes 20a, 20b against the brake drum. When the elevator car starts to move up or down, the magnet coils 21a, 21b are energized to cause the brake shoes 20a, 20b to part from the brake drum.

With this embodiment of the invention, the reduction of the diameter of the sheave 5 and the introduction of the tension pulley 23 combine to increase the rotor diameter Dr1, reducing the force with which the brake is required to press, through the spring, against the brake drum.

This allows the brake shoes 20a, 20b to be driven by the magnet coils 21a, 21b with a reduced attractive force. This in turn enables the brake to be mounted inside the rotor 22.

As to the wrap angle of the rope 3 around the sheave 5, it is approximately 180° when the tension pulley 23 is not used. As shown in Fig. 1 and Fig. 2, however, with the

introduction of the tension pulley 23 this embodiment can reduce the wrap angle of the rope 3 around the sheave 5 by a corresponding amount.

The reduced wrap angle results in a reduction in transmittable traction. It is therefore advisable to use a rope coated with resin over its circumferential surface.

5 The friction coefficient between resin and steel is large compared to the one between the steels and therefore, even when the wrap angle is reduced, can secure a traction equal to or greater than that produced by the conventional wrap angle of 180° .

For the same reason, the tension pulley 23 is preferably made of resin in terms of securing an enough traction.

10 The rope 3 coated with resin over its circumferential surface is not in direct contact with a groove of the sheave 5. The absence of wear due to the direct contact allows wires of the rope to be reduced in diameter, making the rope more flexible with an excellent bending ability.

As a result, the ratio of D_s/D_r , where D_s is a sheave diameter and D_r is a rope
15 diameter, can be set at 20 or lower (ordinary steel ropes have 40 or higher).

Further, forming the tension pulley 23 from resin can minimize the scraping friction of wires lying on the surface of the rope 3, thus preventing a possible shortening of the rope life.

Another advantage of this construction is that because there is no need to generate
20 a traction between the rope 3 and the tension pulley 23, the wrap angle can be set shallow and the pressure low, which in turn minimizes damages to the groove of the tension pulley 23.

Further, an encoder 27 for measuring the rotation angle of the sheave 5, though normally mounted on the same axis of the sheave 5, is in this embodiment provided on the same axis as the tension pulley 23, as shown in Fig. 3.

25 With this arrangement, the encoder 27, an electronic component, can be placed remote from a high-temperature portion that is subjected to heat from the motor 4. This arrangement assures a highly reliable operation of the encoder.

A second embodiment of this invention will be described by referring to Fig. 4 that shows a front view of the machine.

30 In this embodiment, the tension pulley diameter D_p is set smaller than the sheave diameter D_s , with the tension pulley mounted at a position offset from the center of the machine 30.

By placing the tension pulley 23 only on that wall side of the hoistway 45 to which the machine 30 is to be arranged close, it is possible to change the leaving position of the

rope 3, as in the construction of Fig. 2.

The tension pulley 23 is mounted on the body of the machine 30, and a base of the mounting portion is subjected to a horizontal component of the tensile force of the rope 3.

The base needs to be constructed strong enough to bear this force. When
5 compared with the first embodiment, the second embodiment can reduce the overall height, making the machine more compact.

Therefore, even when the sheave 5 is reduced in diameter, this embodiment, too, can bring the end 43 of pulley 7b and the sheave end 44 closer together by the tension pulley 23 which is formed to have a smaller diameter than that of the reduced sheave 5. This enables the
10 dimension D1 corresponding to the protruding portion to be minimized even if the distance W1 increases.

That is, if the sheave 5 is reduced in diameter, the machine 30 can be prevented from protruding and therefore the width Wh of the hoistway from increasing.

Lastly, a third embodiment of this invention will be described by referring to Fig.
15 5, a schematic view showing a whole machine-roomless elevator.

This elevator has a layout in which the machine 30 is mounted at the top of the hoistway, with the counterweight 2 arranged on the side of the elevator car 1.

While the number of pulleys is smaller than in Fig. 6, the rope 3 passes the upper side of the sheave 5 before leaving the machine to run vertically downward.

20 In this layout, if the tension pulley 23 is arranged below the sheave 5, the similar advantageous effect to that of the first embodiment can be produced, making it easy to avoid the tension pulley interfering with rails (not shown) installed on each side of the elevator car 1 and enhancing the freedom of arrangement of the machine 30 in the hoistway.

As described above, the present invention can provide an elevator equipped with
25 the machine 30 that uses a reduced amount of rare-earthless magnet (ferrite magnet) and which does not increase the volume of the hoistway.

It should be further understood by those skilled in the art that although the foregoing description has been made on embodiments of the invention, the invention is not limited thereto and various changes and modifications may be made without departing from the
30 spirit of the invention and the scope of the appended claims.

CLAIMS:

1. An elevator comprising:
 a machine (30) having a cubicle, a motor (4) having a stator (24) and a rotor (22) accommodated in the cubicle and a sheave (5) coupled to a rotating shaft of the motor for rotation and having a rope (3) wrapped therearound; and
 an elevator car (1) and a counterweight (2), both moving up or down like a well bucket when applied a drive force through the rope (3);
 wherein the sheave (5) of the machine (30) is reduced in diameter without changing a width W of the cubicle;
 wherein the machine (30) includes a tension pulley (23) that engages the rope (3) wrapped around the reduced-diameter sheave (5) and guides it to near the position that the rope (3) occupied before the sheave (5) has been reduced in diameter.
2. The elevator according to claim 1, wherein the tension pulley (23) has a fan (29) mounted coaxially with the rotating shaft thereof so that the fan (29) can be rotated as the tension pulley (23) rotates, to generate an air flow toward the motor (4).
3. The elevator according to claim 1, wherein the machine (30) uses the rotor (22) that is made larger than its original diameter used before the sheave (5) has been reduced in diameter.
4. The elevator according to claim 1, wherein the tension pulley (23) is formed to have a smaller diameter than that of the reduced-diameter sheave (5).
5. The elevator according to claim 1, wherein at least a sheave groove of the reduced-diameter sheave (5) or an outer circumferential surface of the rope (3) is coated with resin.
6. The elevator according to claim 1, wherein an encoder (27) of the rotor (22) is mounted on the same axis of the tension pulley (23).
7. The elevator according to claim 2, wherein at least a sheave groove of the reduced-diameter sheave (5) or an outer circumferential surface of the rope (3) is coated with resin.
8. The elevator according to claim 3, wherein at least a sheave groove of the reduced-diameter sheave (5) or an outer circumferential surface of the rope (3) is coated with resin.
9. The elevator according to claim 4, wherein at least a sheave groove of the reduced-diameter sheave (5) or an outer circumferential surface of the rope (3) is coated with resin.

10. The elevator according to claim 2, wherein an encoder (27) of the rotor (22) is mounted on the same axis of the tension pulley (23).
11. The elevator according to claim 3, wherein an encoder (27) of the rotor (22) is mounted on the same axis of the tension pulley (23).
12. The elevator according to claim 4, wherein an encoder (27) of the rotor (22) is mounted on the same axis of the tension pulley (23).