

DESCRIPTION

ELEVATOR

TECHNICAL FIELD

[0001] The present invention relates to an elevator which has a brake device, and which is suitable when it is desired to forcibly stop an elevator car by the brake device, in particular in, in an emergency or upon maintenance.

5 BACKGROUND ART

[0002] In inspection of an elevator, an emergency brake test is conducted by detecting an abnormal increase in the speed of an elevator car and by forcibly stopping the elevator car with use of a brake device having a hoist.

10 [0003] In order to reduce a shock to an elevator car in an emergency and to shorten the brake distance of the elevator car, it is so far known to apply a full brake force to a drive sheave upon emergent braking and then to apply a brake force smaller than the full brake force to the drive sheave thereafter, and finally to apply the full brake force to the drive sheave when the absolute value of an acceleration of the elevator car becomes smaller than a predetermined value, as disclosed, for example, in Patent Literature 1.

15 [0004] In an elevator using a main rope coated with a resin, in order to suppress the deceleration speed of an elevator car in an emergency or upon quick stoppage to a suitable value, it is also known, when an electromagnetic brake device is activated, to make rising of a brake force slow by connecting a small resistor in parallel to an electromagnetic brake coil, as disclosed in Patent Literature 2.

20 CITATION LIST

Patent Literatures

[0005] Patent Literature 1: JP-A-2006-8333

Patent Literature 2: JP-A-2003-221171

SUMMARY OF INVENTION

25 TECHNICAL PROBLEM

[0006] In both of the aforementioned prior arts, the stoppage shock of the elevator car is made merely soft and no consideration is paid to damage on the surface of the rope. In other

words, when the location or area of damage on the rope is where the sheave or pulley often passes therethrough many times, the damage may possibly become more serious. When the diameter of the hoist sheave is reduced using a rope of a highly flexible material such as a fiber or a belt, this requires more prevention of the damage on the surface of the rope.

- 5 [0007] It is therefore an object of the present invention to solve problems in the aforementioned prior arts and to reduce damage on the surface of a rope. Another object of the invention is to provide an elevator which can be made compact in size and have an improved space saving by making smaller the diameter of a hoist sheave of the elevator.

SOLUTION TO PROBLEM

- 10 [0008] The above objects can be attained by providing an elevator which includes an elevator car lifted up and down by winding up and down a rope by a sheave; a rotational speed detection means for the sheave; a brake device for applying a brake torque to the sheave, the brake device being activated when the speed of the rope is higher than a predetermined level; and a calculation section for a slip speed between the rope and the sheave on the basis of the
15 rotational speed of the sheave and the speed of the rope, wherein the brake torque after activation of the brake device is determined by the value of the calculated slip speed.

ADVANTAGEOUS EFFECTS OF INVENTION

- [0009] In accordance with the present invention, the brake device is activated when the speed of the rope is higher than the predetermined level, and then the brake torque is determined
20 by the value of a slip speed between the rope and the sheave. Thus a slip distance can be minimized and damage on the surface of the rope can be reduced.

The other objects, features and advantages of the present invention will become clear from the following description of embodiments of the present invention relating to the attached drawings.

25 BRIEF DESCRIPTION OF DRAWINGS

- [0010] [FIG. 1] FIG. 1 shows a side view of an elevator in accordance with an embodiment of the present invention.

[FIG. 2] FIG. 2 shows a side view of an elevator in accordance with another embodiment of the present invention.

- 30 [FIG. 3] FIG. 3 is a graph showing a change in each factor with time upon emergency braking in each of the embodiments.

[FIG. 4] FIG. 4 is a graph showing a relationship between a slip speed and a frictional coefficient.

[FIG. 5] FIG. 5 shows a front view of a hoist according to one embodiment.

[FIG. 6] FIG. 6 is a graph showing changes in various signals with time upon
5 braking in one embodiment.

DESCRIPTION OF EMBODIMENTS

[0011] An elevator includes a hoist for lifting up and down an elevator car, a governor device for detecting an increase in speed of the elevator car in an abnormal situation, a brake device for braking the elevator car on the basis of a signal from the governor device, and an
10 emergency stoppage device mounted to the elevator car for gripping and holding a rail.

[0012] In an elevator inspection, for the purpose of confirming emergency braking operation, an emergency braking test is conducted. The word "emergency braking" means to detect an abnormal increase in the speed of the elevator car and to forcibly stop the elevator car using the brake device provided to the hoist. In the emergency braking, a slip is generated
15 between the rope and the sheave due to the braking, and the surface of the rope may be damaged in some cases. When the location of the damage on the rope coincides with where the sheave or the pulley often passes therethrough many times, the damage may possibly become more serious.

[0013] In these years, the diameter of the hoist sheave is made smaller using a rope of a
20 highly flexible material such as a fiber or a belt. In order to prevent the surface damage of the rope, it is required to minimize a slip between the rope and the sheave.

[0014] Explanation will be made in connection with an embodiment of the present invention by referring to the drawings. FIG. 1 shows a general arrangement of an elevator. An elevator car 1 for carrying passengers in the car is lifted up and down by winding up a rope 6
25 by a hoist 7. The hoist 7 has a brake drum which is rotated by the same turns as a sheave 2, a pair of brake devices, and an encoder 9 for detecting a rotation in the sheave. The brake devices have brake shoes 3a, 3b, brake springs 31a, 31b for pushing the shoes against a brake surface, and electromagnetic coils 33a, 33b for releasing these springs from the brake surface.

[0015] When the elevator car is stopped, no current flows through the electromagnetic
30 coils 33a, 33b, the brake shoes 3a, 3b are pushed against a drum by the brake springs 31a, 31b, the sheave 2 is not rotated, thus the elevator car is put in its stopped state.

[0016] When the lifting up or down of the elevator car 1 is started, currents flow through the electromagnetic coils 33a, 33b to release the brake shoes 3a, 3b from the brake surface.

This fundamental operation holds true even for a disk brake system of a combination of a brake disk and an electromagnetic coil.

[0017] When the speed of the elevator car 1 is abnormally increased, the elevator car 1 has to be stopped safely and quickly to insure the safety of passengers in the car. As a means for detecting such an abnormal speed, a governor pulley 4 is located in a hoistway. The abnormality detecting means has a governor rope 5 coupled to the elevator car 1, a governor pulley having the governor rope 5 wound therearound, and a trigger mechanism (not illustrated) for detecting a speed exceeding a predetermined rotational speed of the pulley.

[0018] When the governor device detects an abnormal speed in the elevator car, passage of currents flowing through the electromagnetic coils is cut off, and the brake shoes 3a, 3b are forcibly pushed against the brake surface. At this time, it is necessary to active the brake device in such a manner that the accelerating speed is lowered down to a constant value or a smaller value.

[0019] When a friction between the rope 6 and the sheave 2 is small, the rope 6 slips on the sheave 2. Thus damage on the surface of the rope 6 takes place because an impression (indentation) is formed in the surface of a rope strand. In particular, the larger the speed of the elevator car 1 is, the more serious the damage level is. For this reason, when the damaged portion or area of the rope 6 highly frequently passes on the sheave 2 in a normal operation of the elevator after the emergency braking operation, the damage may possibly become more serious.

[0020] The damage on the surface of the rope 6 is caused not only for a steel-wire rope. When a belt or twisted rope of a rope strand or a group of strands coated with a resin such as urethane or rubber is employed, the resin surface may be damaged more badly, and particularly so under the condition that the resin has a low hardness.

[0021] The speed of the rope 6 is detected using the governor rope 5 moving identically with the elevator car 1, that is, using the output of the governor pulley 4. At the same time, a rotation in the sheave 2 is detected in the form of a rotational speed of the encoder 9 which is directly coupled to the sheave. From these values, a relative slip speed ΔV between the sheave 2 and rope 6 is found by an expression of $(r_s \times \omega_s) - (r_e \times \omega_e)$. In the expression, r_s and r_e denote radii of the sheave 2 and governor pulley respectively; and ω_s and ω_e denote rotational angular velocities of the sheave 2 and governor pulley respectively.

[0022] Upon emergency braking operation, it is preferable to stepwise (or intermittently) change the timing of turning the current off (brake application) of the electromagnetic coils or the brake torques in such a manner that a relative speed or slip speed between the rope and

sheave become small. More concretely, the slip speed between the rope and sheave is calculated by a calculation section on the basis of the rotational speed of the sheave and the speed of the rope, and a brake torque after the activation of the brake device is determined on the basis of the value of the calculated slip speed.

5 [0023] When the slip speed is larger than a predetermined value, the brake torque is reduced or the brake is released by turning the conduction of current off. Thereafter, when the slip speed becomes smaller than the predetermined value, the brake torque is increased or the current conduction is turned off (released) to thereby apply the brake.

[0024] When a large brake torque is applied at an initial stage, the sheave 2 is abruptly
10 stopped. This is compared with such a situation that the tires of an auto vehicle are put in its locked state. This means that the rope 6 slips on the sheave 2. When the brake torque of the sheave 2 is applied gradually or stepwise (intermittently), the slip of the rope 6 can be made small.

[0025] Since a signal output of the encoder mounted to the governor pulley 4 and a signal
15 output of the encoder 9 mounted to the hoist are both usually of a pulse type, these output signals are converted to continuous signals. Since the diameter of the sheave 2 is different from the diameter of the governor pulley 4, the both signals are converted to a slip speed to be used to control the off timing or the like of current conduction in a controller 10.

[0026] Explanation will next be made as to another embodiment by using FIG. 2.
20 A speed detector 19 such as a Doppler type speed sensor is mounted to the elevator car 1. In the case of this type of speed sensor, the governor rope 5 moving in synchronism with the elevator car 1 becomes unnecessary, whereby the cross-sectional area of the hoistway of the elevator can be reduced. In this connection, when power supply to the speed detector 19 is stopped in an emergency braking mode, a signal output for control becomes
25 null. In order to prevent such a situation, an emergency power 32 is mounted to the elevator car 1. Even with such an arrangement, similarly to the first embodiment, the brake torque of the brake device is controlled by comparing the output of the speed detector 19 of the elevator car 1 with the output of the encoder 9 of the hoist 7.

[0027] The above explanation has been made in connection with the example of how to
30 control the brake torque in the emergency brake mode. However, even in an operational mode such as a maintenance mode where the elevator car 1 is braked by the brake devices, the invention can obtain an effect of preventing damage of the rope 6 caused by slip.

[0028] The elevator car 1 of the elevator is usually required to be stopped accurately at the floor level of a building. To this end, the hoist 7 is controlled by detecting a shield plate (17

in FIG. 1) installed to a car-side rail 15a with use of a position detector (16 in FIG. 1) provided to the elevator car 1. In this embodiment, the shield plate can be removed, and the elevator car 1 can be stopped at the floor level by using both of motor encoder information and information about the slip speed between the rope and sheave.

5 [0029] FIG. 3 shows time history waveforms of signals after and before emergency braking operation is carried out in the respective embodiments. The condition at this time shows that mass unbalance between the elevator car 1 and a balancing weight 20 is great.

[0030] In the drawing, a signal a shown at the uppermost part of the drawing is an emergency braking trigger signal and subsequently shown are a brake application current, a
10 sheave speed, an elevator car speed, and a slip speed between the rope and sheave in this order sequentially from the upper part of the drawing toward the lower part. Application of the emergency braking trigger signal causes the motor current and the current conduction of the brake devices to be cut off. Since two brake devices are provided, a time difference is provided in current conduction off timing (application current cut-off timing) between the brake devices in
15 this embodiment (as shown by b1 and b2 in the drawing). When the current conduction to the brake devices is turned off, the brake springs cause a brake torque to take place in the sheave 2 and the speed of the sheave 2 to become gradually small. In the illustrated example, the speeds of the sheave 2 and elevator car 1 are increased only during a period La immediately after the emergency brake trigger. This is because the unbalance between the elevator car 1 and the
20 balancing weight 20 causes the elevator car 1 to be put in its free-running state.

[0031] Since the braking timings of the brake devices are controlled, the sheave 2 is stopped (c2 in the drawing) more gradually than a waveform (c1 in the drawing) when no control is made. When the brake devices are not controlled, even after the sheave 2 is stopped, the rope 6 slips on the sheave 2 until it finally stops.

25 [0032] A speed difference, i.e., a slip speed between the sheave 2 and the elevator car 1 is shown at the lowest part of the drawing. Although shown thereat is the slip speed when the brake devices are not controlled, control of the brake devices enables the slip speed (or slip quantity) between the sheave 2 and the rope 6 to be set no larger than a predetermined value or to be set null.

30 [0033] FIG. 4 shows a general relationship between slip speed and frictional coefficient. When the slip speed is small, the frictional coefficient is small. The larger the speed is, the larger the friction coefficient is. Accordingly, when a relative speed between the sheave 2 and the rope 6 is reduced by controlling the brake devices stepwise, a high frictional coefficient continues to be maintained between the both and less slip takes place between the both. This

principle is the same as ABS control or pumping break operation in automobiles.

[0034] FIG. 5 shows an example of the hoist, wherein the sheave 2 is formed integrally with a rotor 21, and an outer rotor type motor is provided with an outer peripheral surface of the rotor 21 used as a braking surface 22. The brake shoes 3a, 3b are brought into contact with the
5 braking surface 22 to apply a brake torque to the sheave 2. Since the electromagnetic coils 33a, 33b are provided in pair, the electromagnetic coils can be controlled independently of each other by two power supply circuits.

[0035] FIG. 6 shows an example of a method of controlling the two electromagnetic coils 33a, 33b. The numbers of coil turns of coil windings 34a, 34b of the two electromagnetic coils
10 33a, 33b are set to be different from each other. In illustrated brake application torque graphs, the upper graph shows the case where the number of coil winding turns is small, whereas the lower graph shows the case where the number of coil winding turns is large, which indicates that the larger the winding turns is, the longer a time constant is and the longer a time $\Delta T1$ until release is. Thus, a time difference between the two coils in a time from the turning off of
15 current passage until the completion of release of the two coils can be provided to the coils.

[0036] When gaps ($\delta 1$ and $\delta 2$ in FIG. 5) between the braking surface 22 and the brake shoes 3a, 3b are set to different values from each other, a time difference of $\Delta T2$ can be similarly provided even between timings of starting to release the electromagnetic coils 33a and 33b.

With such an arrangement, even when the electromagnetic coils have the same timing of turning
20 off their current conduction, the times until the two brake shoes 3a, 3b are brought into contact with the braking surface (22 in FIG. 5) can be changed and thus the brake torque can be changed.

[0037] With the aforementioned arrangement, since the timing of turning off the current conduction is optimized while the relative slip speed between the rope 6 and the sheave 2 is observed or monitored, the sheave 2 can be slowly or gradually stopped. As a result, the slip
25 speed (or slip distance) between the rope 6 and the sheave 2 can be reduced and rope damage can be reduced.

Although the above explanation has been made in connection with some embodiments, the present invention is not limited to the illustrated examples, but can include various modifications and alterations within the spirit of the invention and the scope of appended
30 claims, which will be obvious to those skilled in the art.

REFERENCE SIGNS LIST

[0038] 1: elevator car
2: sheave

	3a, 3b: brake shoes
	4: governor pulley
	5: governor rope
	6: rope
5	7: hoist
	8a, 8b: balancing weight side rails
	9: encoder
	10: controller
	11a, 11b: buffers
10	12: brake driving circuit
	13: power converter
	14: power supply
	15a, 15b: car side rails
	16: position detector
15	17: shield plate
	18: rotation detector
	19: speed detector
	20: balancing weight
	21: rotor
20	22: braking surface
	23a, 23b: brake arms
	25a, 25b: arm fulcrums (supporting point)
	31a, 31b: brake spring
	32: emergency power supply
25	33a, 33b: electromagnetic coils
	34a, 34b: windings
	$\delta 1$: gap between braking surface and brake shoe (left side)
	$\delta 2$: gap between braking surface and brake shoe (right side)
	$\Delta T1$: time difference caused by changing the numbers of turns of coil windings
30	$\Delta T2$; time difference caused by changing shoe gaps

CLAIMS

- [CLAIM 1] An elevator comprising:
an elevator car lifted up and down by winding up and down a rope by a sheave;
a rotational speed detection means for the sheave;
a brake device for applying a brake torque to the sheave;
the brake device being activated when the speed of the rope becomes higher than a predetermined value; and
a calculation section for a slip speed between the rope and the sheave on the basis of the rotational speed of the sheave and the speed of the rope,
wherein the brake torque after the activation of the brake device is determined by the value of the calculated slip speed.
- [CLAIM 2] An elevator according to claim 1, wherein the brake torque of the brake device is reduced when the calculated slip speed becomes larger than a predetermined value after the activation of the brake device.
- [CLAIM 3] An elevator according to claim 1, wherein the brake torque of the brake device is reduced by releasing the braking of the brake device when the calculated slip speed becomes larger than a predetermined value after the activation of the brake device.
- [CLAIM 4] An elevator according to claim 1, comprises a governor rope moved in synchronism with the elevator car and a governor pulley having the governor rope wound therearound, and the speed of the rope is detected by detecting a rotational speed of the governor pulley.
- [CLAIM 5] An elevator according to claim 1, wherein the speed of the rope is detected by detecting a speed of the elevator car.
- [CLAIM 6] An elevator according to claim 1, wherein the brake device has two brake shoes to be contacted with the braking surface for applying brake torques to the sheave and also has electromagnetic coils for driving the respective brake shoes, and a time difference is provided between the electromagnetic coils in timing of turning off current conduction through the electromagnetic coils.
- [CLAIM 7] An elevator according to claim 1, wherein the brake device has two brake shoes to be contacted with a braking surface for applying a brake torque to the sheave and also has electromagnetic coils for driving the respective brake shoes, and gaps between the braking surface and the respective brake shoes have different values.
- [CLAIM 8] An elevator according to claim 1, wherein the brake torque after the activation of the brake device is stepwise provided.