

SYSTEM FOR LIFTING A LOAD, IN PARTICULAR FOR LIFTING A LOAD IN THE PRESENCE OF A RELATIVE MOVEMENT DUE TO SWELL

Technical field of the invention

The present invention relates to the technical field of load lifting systems, in particular for lifting a load in the presence of relative movement due to swell.

State of the art

In the field of sea lifting, the main difficulty encountered concerns the relative speeds between the reference frame of the lifting equipment and the reference frame on which the load to be recovered is placed or has to be placed.

Traditionally, offshore lifting systems have high lifting speeds to allow experienced crane operators to follow the movements of the swell by hauling in (or “hoisting”) and paying out (or “lowering”) actions.

The lifting of the load from the bridge is done initially by always leaving slack in the lifting straps, then by taking up the slack during a lifting phase of the load in order to accompany the natural movement of the load imposed by the swell.

To assist crane operators, there are now cranes with active wave compensation that automatically compensate for relative movements between the two reference frames.

This active compensation aims at keeping the cables taut at all times in order to prevent slack and thus avoid a slack-taking shock (“snatch load” or “snap loading”).

However, in practice, this technical solution is cumbersome, expensive and highly dependent on sensors.

Another solution involves shock-absorbing cranes: a shock-absorbing device, usually hydraulic, filters out any force exceeding a certain preset threshold in the most dynamic way possible.

However, this type of solution is not able to recover from significant shocks due to very high relative speeds.

In view of the above, it is worthwhile to propose alternative solutions adapted to the lifting of loads in the presence of relative movement due to swell.

Especially, it would be interesting to propose a solution that does not only aim at treating the effects of shocks but at making them impossible, or at least at limiting them.

Presentation of the invention

In order to offer another solution adapted to the compensation of the swell, the present invention proposes a system for lifting a load, in particular for lifting a load in the presence of a relative movement due to the swell.

The lifting system comprises at least one lifting point which comprises a frame comprising:

- at least one lifting cable associated with:

- a winch, for maneuvering said lifting cable, during hauling in and paying out actions,

- reeving means comprising:

- a fixed block of sheaves, attached to said frame, and

- a movable block of sheaves, cooperating with said frame by means of sliding means defining a degree of freedom in translation perpendicular to the axis of rotation of said sheaves, the distance between said movable block of sheaves and said fixed block of sheaves being variable,

- controlled braking means, cooperating with said mobile block of sheaves and controllable between two bistable configurations:

- an inactive configuration, in which said controlled braking means allow free translation of said moving block of sheave(s) according to said degree of freedom in translation, particularly adapted to passive wave compensation, and

- an active configuration, in which said controlled braking means allow the moving block of sheaves to move in a single direction according to said translational degree of freedom, corresponding to an increase of said distance, and

- control means for operating said winch and said controlled braking means, particularly during the launching or retrieval of said load,

- maneuvering means which cooperate with said mobile block of sheaves and which are configured to restore potential energy, advantageously elastic potential energy or gravitational potential energy, on said mobile block of sheaves so as, in the inactive configuration, to tend to maintain a constant tension in said at least one lifting cable and, in the active configuration, to tend to increase said distance value.

The present invention thus proposes a technical solution using the swell:

- half of the time, the movement imposed on the load by the environment is an upward movement, which facilitates retrieval, and

- the other half of the time is a descent of the load which facilitates launching or depositing on the other reference frame.

This synchronization also has the advantage of reducing the speeds:

- during recovery, this translates into a minimized dynamic amplification coefficient, and

- at launch, or deposits on another reference frame, this limits the accelerations felt by the load.

Instead of managing shocks when the lifting cables are tensioned, the lifting system according to the invention provides passive self-tensioning and, advantageously, load transfer at the wave crest (where the relative speed is, by definition, zero).

The speeds of tracking relative movements are ensured by maneuvering means configured to restore potential energy, which allow taking up or giving slack at speeds which are very high compared to what is available at the winch.

This approach significantly reduces the power required at the winch. This solution is therefore very efficient and economical.

Controlled bistable braking means also offer the advantage of:

- lifting at a very moderate maximum speed compared to other prior art solutions (low power requirement),
- passive compensation of relative movements by keeping the lifting cables taut at a relatively low value, with a high-speed capacity for tracking relative movements.

These controlled bistable braking means advantageously allow switching from one mode to another in a safe and almost instantaneous manner in relation to the phenomena involved.

Other non-limiting and advantageous characteristics of the product according to the invention, taken individually or in all technically possible combinations, are as follows:

- the control means are configured to, on the one hand, prevent a switch from said active configuration to said inactive configuration when the tension on said cable is greater than a determined minimum threshold, in particular when said load is suspended from said cable, and on the other hand, allow a switch from said active configuration to said inactive configuration when the tension on said cable is less than a determined minimum threshold, in particular when said load rests on a reference frame;
 - for lifting a load in the presence of relative movement due to swell, the control means are configured to implement a lifting process comprising the following operations:
 - (i) during an operation to launch said load to a new reference frame:
 - a step of suspending said load from said lifting cable, in which said controlled braking means are in active configuration and the mobile block of sheaves is in an average position centered on an available stroke,
 - a step of lowering said load near the highest wave crests of the swell,
 - when the load is placed on a wave crest, a deflection step, preferably to come tangent to said wave crest,
 - when said load transfers its weight from said lifting cable to said new reference frame, a step of switching said braking means to an inactive configuration so that said lifting system provides passive compensation for swell,
- and/or

(ii) during a recovery operation of said load, starting from an inactive configuration in which said lifting system provides passive wave compensation,

- if said load is in an upward movement, a transition step towards said active configuration so that said mobile block of sheaves continues its movement increasing by said distance value, until a wave crest where said mobile block of sheaves is blocked in translation, or

- if said load is in a downward movement, a step of maintaining the controlled braking means in inactive configuration then a step of switching to said active configuration at the start of said upward movement of said load,

- the sliding means comprise a sliding member which carries the mobile block of sheave(s), which extends coaxially to said degree of freedom in translation and which cooperates with said controlled braking means,

- the maneuvering means, configured to restore elastic potential energy or gravitational potential energy on said moving block of sheave(s), consist of a spring element or a counterweight,

- the control means comprise a centering module which, in the inactive configuration of the controlled braking means, is configured to control said winch so as to position the moving block of sheaves in a centered position, advantageously an average position centered on an available stroke, preferably prior to a lift preceding a launch and/or in the passive wave compensation phase; preferably, said centering module consists of a slow centering module which, in the inactive configuration of the controlled braking means, cooperates with means for instantaneous and averaged measurement of the position of said moving block of sheaves over a period of time and which is configured to control said winch when the average position of said moving block of sheaves reaches an actuation threshold on said translational degree of freedom;

- the control means comprise a safety module at the end of travel which is configured to actuate said winch when said mobile block of sheave(s) reaches an end-of-travel threshold on said degree of freedom in translation, and this in a way to actively push said mobile block of sheave(s) back from said end-of-travel threshold,

- the control means comprise an automatic recovery module and/or an automatic launch module, configured to automatically control said winch and said controlled braking means during recovery operation and/or launch operation of said load, which automatic recovery module and/or automatic launch module is preferably associated with at least one measuring sensor configured to measure the relative vertical distance between a reference frame of said chassis and a destination reference frame, for example in the case where the average distance between the reference frame of said chassis and the destination reference frame is not known or variable;

- the lifting system consists of a crane having one lifting point, the frame of which has a post and a boom, and a gantry having at least two lifting points.

The present invention further relates to a method of lifting a load, especially of lifting a load in the presence of relative movement due to swell, by implementing a lifting system according to the invention.

This lifting method comprises the following operations:

(i) during an operation to launch said load to a new reference frame:

- a step of suspending said load from said lifting cable, in which said controlled braking means are in active configuration and the mobile block of sheaves is in an average position centered on an available stroke,

- a step of lowering said load near the highest wave crests of the swell,

- when the load is placed on a wave crest, a paying out step, preferably to come tangent to said wave crest,

- when said load transfers its weight from said lifting cable to said new reference frame, a step of switching said braking means to an inactive configuration so that said lifting system provides passive compensation for swell,

and/or

(ii) during a recovery operation of said load, starting from an inactive configuration in which said lifting system provides passive wave compensation,

- if said load is in an upward movement, a transition step towards said active configuration so that said mobile block of sheaves continues its movement increasing by said distance value, until a wave crest where said mobile block of sheaves is blocked in translation, or

- if said load is in a downward movement, a step of maintaining the controlled braking means in inactive configuration then a step of switching to said active configuration at the start of said upward movement of said load.

Preferably, in passive swell compensation, said method comprises a step of piloting said winch to tend to maintain the mobile block of sheaves in an average position.

Of course, the different features, variants and embodiments of the invention can be combined with each other in various ways as long as they are not incompatible or mutually exclusive.

Detailed description of the invention

Furthermore, various other features of the invention become apparent from the attached description made with reference to the drawings which illustrate non-limiting embodiments of the invention and where:

[Fig. 1] is a general and perspective view of a lifting system according to the invention, in the form of a crane comprising a lifting point;

[Fig. 2] is a general and perspective view of the lifting system according to Figure 1, in which the chassis is masked;

[Fig. 3] is a general and perspective view of the lifting system according to another embodiment in which the sliding means define a degree of freedom in horizontal translation and the operating means comprise an offset counterweight;

[Fig. 4] is a general and perspective view of a lifting system according to a variant of Figure 3, which differs in the arrangement of the mobile block of sheaves on the sliding member.

It should be noted that, in these figures, the structural and/or functional elements common to the different variants may have the same references.

The present invention thus relates to a lifting system 1 for lifting a load C.

This lifting system 1 is particularly suitable for lifting a load C in the presence of relative movement due to swell, especially for offshore or sea applications.

More generally, the lifting system 1, for example a crane or a gantry, is suitable for handling a load C between two reference frames which have a relative movement due to the swell.

By "swell" we mean the oscillation of the sea surface, particularly due to waves.

Generally, the highest point of a wave is called the crest; the lowest point is called the trough. The size of the wave is determined by the distance between the crest and the trough. The period is the time elapsed between two crests.

As mentioned later, a "highest ridge" advantageously corresponds to the highest ridge over a period of time.

The term "load" encompasses any object (or load) intended to be handled by the lifting system 1. Such a load C can have various shapes and sizes, for example a gondola for transferring people (Figure 1 for example), a container or a boat.

The term "reference frames" advantageously encompasses any surface intended to receive load C, comprising a reference frame of origin and a reference frame of destination, for example a ship, a platform, the surface of the water.

In general, and according to the invention, the lifting system 1 comprises at least one lifting point 1a which comprises a frame 2 comprising:

- at least one lifting cable 3 associated with a winch 4 and reeving means 5,
- controlled braking means 6, cooperating with the reeving means 5,
- control means 7, for piloting the winch 4 and the controlled braking means 6, particularly during the launching or retrieval of load C, and
- maneuvering means 8 which cooperate with reeving means 5 and which are configured to restore potential energy, in particular to ensure passive compensation of swell.

Lifting cable

Lifting cable 3 is classic in itself.

It consists, for example, of a lifting cable made of synthetic material or metallic material.

This lifting cable 3 is capable of withstanding a tensile force which is generated by the load C suspended from said lifting cable 3.

In other words, load C is intended to be suspended from the end of the lifting cable 3. When suspended, this load C is thus intended to exert a tensile effort, or a tensile force, on the lifting cable 3.

By "suspended" we mean a configuration in which load C is located at a height and at a distance from the reference frames.

This lifting cable 3 cooperates with the winch 4 and with the reeving means 5.

Winch

Winch 4 is classic in itself.

This winch 4 is suitable for operating the lifting cable 3:

- in turn, to exert force on the lifting cable 3 by winding it onto the winch 4, and advantageously to generate an upward movement of the load C from a reference frame, and
- deviates from it, to release the effort on the lifting cable 3 by unwinding from the winch 4, and advantageously to generate a descent of the load C towards a reference frame.

Pulling equipment

The reeving means 5 comprise:

- a fixed block of sheaves 51, attached to the frame 2, and
- a mobile block of sheaves 52, cooperating with the frame 2 by means of sliding means 53.

In particular, the mobile block of sheaves 52 preferably comprises a single sheave 52 or several pairs of sheaves 52.

Preferably, the sheaves 51, 52 (also called "pulleys") have respective axes of rotation 51', 52', which extend in parallel planes and which define between them a distance value D.

The distance value D is advantageously measured according to a translational degree of freedom T, described below.

The sliding means 53 define a translational degree of freedom T for the moving block of sheave(s) 52.

This translational degree of freedom T extends perpendicularly with respect to the rotation axis 51', 52' of the sheaves 51, 52.

In general, this translational degree of freedom T can be oriented vertically (especially Figures 1 or 2) or horizontally (especially Figures 3 and 4).

As further developed, the aforementioned distance value D (corresponds to the distance between the rotation axis 52' of the moving block of sheaves 52 and the rotation axis 51' of the fixed block of sheaves 51, measured on the translational degree of freedom T) is variable.

For example, the possible stroke of the mobile block of sheave(s) 52, according to the degree of freedom in translation T, is for example from 1 m to 2 m, for example from 1.5 m (i.e. from 6 m to the hook).

In general, the sliding means 53 comprise for example a sliding member 531 (also called "rod"), forming a slide, which carries the mobile block of sheave(s) 52.

If necessary, the sliding member 531 extends coaxially to the translational degree of freedom T. This sliding member 531 is movable along a direction coaxial with said translational degree of freedom T.

The mobile block of sheaves is advantageously carried at one of the ends 531a, 531b of the sliding member 531.

As developed below, this sliding member 531 cooperates with the controlled braking means 6, so as to control the path of the mobile block of sheaves 52.

Controlled braking means

The controlled braking means 6 cooperate with the mobile block of sheaves 52, where appropriate via the sliding member 531.

These controlled braking means 6 can be controlled between two bistable configurations: an inactive configuration and an active configuration.

According to the inactive configuration, the controlled braking means 6 allow free translation of the mobile block of sheaves 52 according to the translational degree of freedom T.

As further developed, such an inactive configuration is particularly suited to passive wave compensation. In this case, the movable block of sheaves 52 (and possibly the associated sliding member 531) can passively oscillate, notably as a function of the relative motion between the two reference frames.

According to the active configuration, the controlled braking means 6 allow the mobile block of sheaves 52 to move in a single direction according to the translational degree of freedom T, corresponding to an increase in the aforementioned distance value D.

In other words, the controlled braking means 6 are structured to:

- allow the mobile block of sheave(s) 52 to move in a first direction according to the translational degree of freedom T, corresponding to an increase in the distance value D, and
- prevent the mobile block of sheave(s) 52 from moving in a second direction according to the translational degree of freedom T, corresponding to a decrease in the distance value D.

Such an active configuration is particularly interesting for allowing the continuation of a movement increasing in the distance value D, for example when the load C follows an upward trajectory up to a wave crest.

For example, the controlled braking means 6 comprise mechanical, mobile means cooperating with the sliding side member 531 so as to define the active and inactive configurations.

Control means

The control means 7 are configured for the control of the winch 4 and the controlled braking means 6, especially during the launching or recovery operation of load C.

Such control means 7 comprise, for example, a computer program implemented by a computer, for example in the form of a programmable logic controller (PLC). This computer program advantageously comprises instructions which, when the program is executed by a computer, cause the computer to control the winch 4 and/or the controlled braking means 6 (preferably according to an algorithm).

According to a preferred embodiment, the control means 7 are configured to prevent a switchover of the piloted braking means 6, from the active configuration to the inactive configuration, when the traction on the lifting cable 3 is greater than a determined minimum threshold.

In this sense, preferably, the control means 7 are configured to prevent a switchover of the controlled braking means 6, from the active configuration to the inactive configuration, when this load C is suspended from said cable.

According to this preferred embodiment, the control means 7 are configured to allow a switchover of the controlled braking means 6, from the active configuration to the inactive configuration, when the traction on said cable is less than a determined minimum threshold.

In this sense, preferably, the control means 7 are configured to allow a switchover of the controlled braking means 6, to the inactive configuration, when the load C rests on a reference frame.

By "minimum threshold" we mean, for example, a tensile force on the lifting cable 3 which is greater than the maximum force exerted by the lifting system 1, for the slack take-up.

According to one definition, the minimum threshold advantageously corresponds to a traction value exerted by the lifting cable 3 when the load C rests on a reference frame.

More generally, for lifting a load C in the presence of relative movement due to swell and during an operation to launch the load C towards a new reference frame, the control means 7 are configured to implement a lifting method which comprises the following operations:

- a step of suspending the load C from the lifting cable 3, in which the controlled braking means 6 are in an active configuration and the mobile block of sheaves 52 is in an average position centered on an available stroke,
- a descent step of load C near the highest wave crests of the swell,

- when load C is placed on a wave crest, a paying out step, preferably to come tangent to said wave crest,

- when said load C transfers its weight from the lifting cable 3 to the new reference frame, a step of switching the controlled braking means 6 to an inactive configuration so that the lifting system 1 provides passive compensation for the swell.

For lifting a load C in the presence of relative movement due to swell and starting from an inactive configuration in which said lifting system 1 provides passive compensation for the swell, the control means 7 are configured to implement a lifting process which comprises the following operations:

- if said load C is in an upward movement, a step of transition of the controlled braking means 6 to said active configuration so that said mobile block of sheaves 52 continues its movement increasing by said distance value D, up to a wave crest where said mobile block of sheaves 52 is blocked in translation, or

- if said load C is in a downward movement, a step of maintaining the controlled braking means 6 in said inactive configuration, then a step of switching to said active configuration at the start of an upward movement of said load C and an increase in said distance value D.

Further, according to the invention, the control means 7 advantageously comprise a centering module 71 which, in the inactive configuration of the controlled braking means 6, is configured to control the winch 4 so as to position the mobile block of sheaves 52 in a centered position, advantageously an average position centered on an available stroke.

This centering module 71 advantageously comprises a module 71a for an initial centering, which aims at positioning the mobile block of sheaves 52 in a centered position prior to a launch operation of the load C from a reference frame.

The centering module 71 advantageously further comprises a module 71b for slow centering which is configured so as, in inactive configuration of the controlled braking means 6, to tend to maintain the mobile block of sheaves 52 in a centered position, advantageously an average position centered on an available stroke.

Preferably, the slow centering module 71b cooperates with means for instantaneous and averaged measurement of the position of the moving block of sheaves 52 over a period of time (period of 30 s to 90 s for example), in particular when the controlled braking means 6 are in inactive configuration.

The means for instantaneous and averaged measurement of the position of the mobile block of sheaves 52 consist for example of a cable or laser position sensor.

This slow centering module 71b is configured to drive the winch 4 (in hauling in and in paying out) when the average position of said mobile block of sheave(s) 52 reaches an actuation threshold according to the translational degree of freedom T.

For example, the actuation threshold is 3% to 7%, in length relative to the total stroke, depending on the translational degree of freedom T.

In general, the control means 7 advantageously comprise a safety module at the end of travel 72 (also called a dynamic end-of-travel avoidance module).

This safety module at the end of travel 72 is configured to actuate the winch 4 (in turn and turn) when the mobile block of sheaves 52 reaches an end-of-travel threshold on the translational degree of freedom T, so as to actively push back said mobile block of sheaves 52 with respect to said end-of-travel threshold.

The purpose of this safety module at the end of travel 72 is to prevent the mobile block of sheaves 52 from arriving in a mechanical end-of-travel position.

For example, this end-of-stroke threshold is 5 to 15 %, relative to the total stroke.

Preferably, an increasing speed order is imposed by this safety module at the end of travel 72 to prevent the mobile block of sheaves 52 from reaching the end of travel. Preferably, this speed increases towards the maximum available speed, under the action of the motor and its frequency inverter.

According to the invention, the control means 7 advantageously comprise an automatic recovery module 73 and/or an automatic launch module 74, configured to automatically control the winch 4 and the controlled braking means 6 during recovery and/or launch operation of the load C.

The automatic recovery module 73 and/or the automatic launch module 74 is preferably associated with at least one measuring sensor 75 (for example a laser or a radar, illustrated in Figure 1) configured to measure the relative vertical distance between a frame reference 2 and a destination reference, for example in the case where the average distance between the reference of frame 2 and the destination reference is not known or is variable.

Preferably, said at least one measuring sensor 75 allows the relative vertical position of the destination reference frame with respect to the lifting system 1 to be measured, among:

- the average position,
- the highest position,
- the lowest position.

From these measurements, it is possible to determine:

- the instantaneous vertical velocity (by derivation $\Delta U/\Delta t$),
- the maximum speed uphill and downhill (over the last 1 to 5 minutes, for example),
- the average absolute speed (over the last 1 to 5 minutes, for example),
- the length to be turned by the winch 4 to obtain the center of the mobile block of sheave(s)

52 in the theoretical centered position.

In practice, the automatic launch module 74 is advantageously executed at the most opportune time, for example so that load C is deposited on a wave crest, at the beginning of the descent, to minimize the acceleration of load transfer felt by load C.

Preferably, the automatic launch module 74 is executed in the middle of the wave rise.

The automatic recovery module 73 can be executed at any time. In particular, the automatic recovery module 73 waits for the start of a rising edge to transmit the control command for the controlled braking means 6 in active configuration.

Maneuvering means

The maneuvering means 8 cooperate with said mobile block of sheaves 52.

These maneuvering means 8 are configured to restore potential energy to the mobile block of sheaves 52 in order:

- in an inactive configuration, to tend to maintain a constant tension in said at least one lifting cable, and
- in an active configuration, to tend to increase the distance value D.

More specifically, these maneuvering means 8 are configured to accumulate potential energy from the mobile block of sheaves 52 when the distance value D decreases.

In other words, the maneuvering means 8 are intended to restore a restoring force, corresponding to the potential energy restored.

The maneuvering means 8 are adapted to maintain sufficient tension to tension said at least one lifting cable 3, in the inactive configuration and in the active configuration of the controlled braking means 6.

Without being limiting, this tension advantageously depends on the maximum length of said at least one lifting cable 3 which hangs during the passive compensation of the waves, on the linear density of said at least one lifting cable 3 and on the value of the destabilizing forces (for example winds, accelerations of the reference frames) which tend to make said at least one lifting cable 3 move out of relation to its/their ideal natural position(s) of straightness between the sheaves 51, 52 and the fixed points.

Preferably, this tension should also be greater than the force exerted by the controlled braking means 6 in the active configuration, in the direction of increasing the distance value D.

The term "potential energy" preferably encompasses:

- an elastic potential energy, for example in the form of a spring element (not shown), advantageously mechanical or pneumatic, and/or
- gravitational potential energy, for example in the form of a counterweight.

For example, a spring element accumulates elastic potential energy (for example by putting it under stress) when the distance value D decreases.

For example, a counterweight accumulates gravitational potential energy (e.g., by its vertical displacement) when the distance value D decreases.

In general, the counterweight can potentially be formed by:

- the sliding member 531, directly, particularly in the case of a vertical translational degree of freedom T (figure 2), and/or
- an offset counterweight 85, suspended from one end of the sliding member 531 (for example at a proximal end 531b, on the winch side 4), for example via a cable/pulley assembly, and advantageously exerting a pulling force on the sliding member 531.

Conversely, the potential energy is restored here in the form of a restoring force, by increasing the distance D .

In general, and taking into account the maneuvering means 8 exerting potential energy on the mobile block of sheaves 52, the distance value D is notably variable depending on the tensile force exerted by the load C via the lifting cable 3:

- the distance value D tends to increase when the tensile force exerted by the load C decreases, and
- the distance value D tends to decrease when the tensile force exerted by the load C increases.

In other words, the movements of the moving block of sheave(s) 52 are determined by:

- the tensile force exerted by the load C on lifting cable 3,
- the restoring force corresponding to the potential energy restored by the maneuvering means 8, and
- and where applicable, the maneuvers in hauling in and in paying out exerted on the lifting cable 3 via the winch 4.

Embodiments

In the present case, as illustrated in the figures, the lifting system 1 consists here of a crane comprising a lifting point 1a.

In this case, the frame 2 has a post 2a and a boom 2b.

In general, the winch 4, the reeving means 5, the controlled braking system 6 and the maneuvering means 8 are advantageously supported by the frame 2.

According to the embodiment illustrated in Figures 1 and 2, the winch 4 and the reeving means 5 are supported by the post 2a. In particular, the sliding means 53 define a degree of freedom in vertical translation T , along this post 2a.

The maneuvering means 8, cooperating with said mobile block of sheaves 52, consist here of a gravitational potential energy, for example in the form of a counterweight formed directly by the vertically oriented sliding member 531 whose upper end carries the mobile block of sheaves 52.

The sliding member 531 cooperates with the controlled braking means 6 which are carried by the post 2a.

The maneuvering means 8 may also comprise an offset counterweight (not shown), exerting a downward pull on the sliding member 531.

According to embodiments illustrated in Figures 3 and 4, the winch 4 and the reeving means 5 are carried by the boom 2b. In particular, the sliding means 53 define a horizontal translational degree of freedom T, along the boom 2b.

The maneuvering means 8, cooperating with said mobile block of sheaves 52, consist here of a gravitational potential energy, for example in the form of an offset counterweight 85 intended to exert a traction force on the horizontally oriented sliding member 531, one of whose ends 531a, 531b carries the mobile block of sheaves 52.

The sliding member 531 cooperates with the controlled braking means 6 which are carried by the boom 2b.

The embodiments illustrated in Figures 3 and 4 differ especially in the arrangement of the mobile block of sheaves 52 on the sliding member 531.

According to the embodiment illustrated in Figure 3, the mobile block of sheaves 52 is carried by a distal end 531a of the sliding member 531 (at a distance from the winch 4) and the offset counterweight 85 is secured with a proximal end 531b of the sliding member 531 (on the winch 4 side).

In other words, the mobile block of sheaves 52 and the offset counterweight 85 are secured with ends 531a, 531b of the sliding member 531 which are located on either side of the controlled braking means 6.

Alternatively, according to the embodiment illustrated in Figure 4, the mobile block of sheaves 52 and the offset counterweight 85 are secured to the same proximal end 531b of the sliding member 531 (on the winch side 4).

In other words, the mobile block of sheaves 52 and the offset counterweight 85 are secured to the same end 531b of the sliding member 531, which is located on only one side of the controlled braking means 6.

This last embodiment, according to Figure 4, has the advantage of being relatively compact.

Alternatively, and not shown, the lifting system 1 may also consist of a gantry having at least two lifting points 1a according to the invention.

Lifting method

In general, for passive wave compensation, the controlled braking means 6 are in an inactive configuration. The lifting system 1 and the load C are based on two different reference frames.

The moving block of sheave(s) 52 is then subjected to two opposing forces:

- the tensile force exerted by load C via lifting cable 3, and
- the restoring force corresponding to the potential energy restored by the maneuvering means 8.

In this case, if the difference in height between the reference frames decreases (for example a wave raises the load C), the tension in the lifting cable 3 decreases and, naturally, the distance value D increases under the action of the maneuvering means 8.

Conversely, if the difference in height between the reference frames increases (for example a wave causes load C to descend), the tension in the lifting cable 3 increases and, naturally, the distance value D decreases.

Passively, the lifting cable 3 is advantageously maintained at an average tension (namely preferably a force exerted by the maneuvering means 8 divided by the number of strands of the reeving means 5).

More generally, in passive swell compensation, the process comprises a winch piloting step 4 to tend to maintain the mobile block of sheaves 52 in an average position.

This centering of the mobile block of sheaves 52 is ensured here by the aforementioned slow-centering module 71b.

In practice, if an actuation threshold is reached by increasing the distance value D, the slow centering module 71b drives the winch 4 in a hauling in mode so as to tend to bring the mobile block of sheaves 52, advantageously on average, into a central position.

Conversely, if an actuation threshold is reached by decreasing the distance value D, the slow centering module 71b drives the winch 4 in a paying out mode so as to tend to bring the mobile block of sheaves 52 into a central position, advantageously on average.

In general, if an end-of-stroke threshold is reached, the end-of-stroke safety module 72 is executed to actuate the winch 4, in a hauling in mode or in a paying out mode, as appropriate, so as to actively push back the mobile block of sheaves 52 relative to said end-of-stroke threshold.

The present invention further relates to the method of lifting a load C, especially of lifting a load C in the presence of relative movement due to swell, by implementing a lifting system 1 according to the invention.

During a launch operation of load C towards a new reference frame, the lifting method advantageously comprises the following operations:

- a step of suspending the load C from the lifting cable 3, in which the controlled braking means 6 are in active configuration and the mobile block of sheaves 52 is in an average position centered on an available stroke,
- a descent step of load C near the highest wave crests of the swell,
- when load C is placed on a wave crest, a paying out step, preferably to come tangent to said wave crest,

- when said load C transfers its weight from the lifting cable 3 to the new reference frame, a step of switching the controlled braking means 6 to an inactive configuration so that said lifting system 1 provides passive compensation for the swell.

This launch operation can be ensured by the automatic launch module 74.

Preferably, before the launch operation (while the load is still on the initial reference frame), the initial centering module 71a centers the mobile block of sheaves 52 to provide a safety margin. This procedure ensures self-centering of the mobile block of sheaves 52 before the launch operations.

To achieve this, the following operations are advantageously implemented:

- switching the controlled braking means 6 to an inactive configuration,
- impose a hauling in or paying out command on winch 4, until it reaches the middle position.
- switching of the controlled braking means 6 into an active configuration.

Following this centering, if the operator lifts load C, the mobile block of sheaves 52 is centered for safe launching.

During a recovery operation of said load C, starting from an inactive configuration in which said lifting system 1 provides passive compensation for the swell, the lifting method advantageously comprises a step of transitioning to the active configuration.

This recovery operation can be ensured by the automatic recovery module 73.

If the load C is in an upward movement, the mobile block of sheaves 52 continues its movement increasing the distance value D, up to a wave crest where the mobile block of sheaves 52 is blocked in translation.

Once at the crest of the wave, the controlled braking means 6 prevent the reduction of the distance value D. The beginning of the descent of the next wave then gradually deposits the load C on the lifting cable 3.

Conversely, if said load C is in a downward movement, the method comprises a step of maintaining the controlled braking means 6 in an inactive configuration, before a step of switching to said active configuration at the start of an upward movement of load C.

At the end of these operations, load C hangs from the end of the lifting cable 3, above and at a distance from a reference frame.

If a wave crest arrives later, load C rises again and gets stuck at a new maximum level.

When the controlled braking means 6 are in an active configuration, an operator can turn to begin extracting load C from its original reference frame.

Advantageously, in the event of a power outage:

- in compensation for the swell: the lifting system 1 being passive, it continues to function normally,

- in lifting: if load C is near a reference frame and if this reference frame comes back into contact with load C, then the latter rises to the new highest point.

Of course, various other modifications can be made to the invention within the scope of the attached claims.

Claims

[Claim 1] Lifting system (1) for a load (C), especially for lifting a load (C) in the presence of relative movement due to swell,

which lifting system (1) comprises at least one lifting point (1a) which comprises a frame (2) comprising:

- at least one lifting cable (3) associated with:
 - a winch (4), for maneuvering said lifting cable (3), in hauling in and in paying out,
 - reeving means (5) comprising:
 - a fixed block of sheaves (51), secured to said frame (2), and
 - a movable block of sheaves (52), cooperating with said frame (2) by means of sliding means (53) defining a degree of freedom in translation (T) perpendicular to the axis of rotation of said sheave blocks (51, 52), the distance value (D) of said movable block of sheaves (52) with respect to said fixed block of sheaves (51) being variable,
 - controlled braking means (6), cooperating with said mobile block of sheaves (52) and controllable between two bistable configurations:
 - an inactive configuration, in which said controlled braking means (6) allow free translation of said moving block of sheaves (52) according to said translational degree of freedom (T), particularly adapted to passive wave compensation, and
 - an active configuration, in which said controlled braking means (6) allow the moving block of sheaves (52) to move in a single direction along said translational degree of freedom (T), corresponding to an increase in said distance value (D), and
 - control means (7), for controlling said winch (4) and said controlled braking means (6), particularly during launching or retrieval operations for said load (C),
 - maneuvering means (8) which cooperate with said mobile block of sheaves (52) and which are configured to restore potential energy on said mobile block of sheaves (52) so as, in an inactive configuration, to tend to maintain a constant tension in said at least one lifting cable (3) and, in an active configuration, to tend to increase said distance value (D).

[Claim 2] Lifting system (1), according to claim 1, characterized in that the control means (7) are configured to:

- prevent a switch from said active configuration to said inactive configuration when the tension on said lifting cable (3) exceeds a determined minimum threshold, especially when said load (C) is suspended from said lifting cable (3), and

- allow a switch from said active configuration to said inactive configuration when the traction on said lifting cable (3) is less than a determined minimum threshold, especially when said load (C) rests on a reference frame.

[Claim 3] Lifting system (1), according to any one of claims 1 or 2, especially for lifting a load (C) in the presence of relative movement due to swell, characterized in that the control means (7) are configured to implement a lifting method which comprises the following operations:

(i) during an operation to launch said load (C) to a new reference frame:

- a step of suspending said load (C) from said lifting cable (3), in which said controlled braking means (6) are in active configuration and the mobile block of sheaves (52) is in an average position centered on an available stroke,
- a step of lowering said load (C) near the highest wave crests of the swell,
- when the load (C) is placed on a wave crest, a paying out step, preferably to come tangent to said wave crest,
- when said load (C) transfers its weight from said lifting cable (3) to said new reference frame, a step of switching said controlled braking means (6) to an inactive configuration so that said lifting system (1) provides passive wave compensation,

and/or

(ii) during a recovery operation of said load (C), starting from an inactive configuration in which said lifting system (1) provides passive wave compensation:

- if said load (C) is in an upward movement, a transition step towards said active configuration so that said mobile block of sheaves (52) continues its movement increasing by said distance value (D), up to a wave crest where said mobile block of sheaves (52) is blocked in translation, or
- if said load (C) is in a downward movement, a step of maintaining the controlled braking means (6) in the inactive configuration, then a step of switching to said active configuration at the start of said upward movement of said load (C).

[Claim 4] Lifting system (1), according to any one of claims 1 to 3, characterized in that the sliding means (53) comprise a sliding member (531) which carries the movable block of sheaves (52), which extends coaxially over said degree of freedom in translation (T) and which cooperates with said controlled braking means (6).

[Claim 5] Lifting system (1), according to any one of claims 1 to 4, characterized in that the maneuvering means (8), configured to restore elastic potential energy or gravitational potential energy on said moving block of sheave(s) (52), consist of a spring element or a counterweight (85).

[Claim 6] Lifting system (1), according to any one of claims 1 to 5, characterized in that the control means (7) comprise a centering module (71) which, in the inactive configuration of the controlled braking means (6), is configured to control said winch (4) so as to position the mobile block of sheaves (52) in a centered position, advantageously an average centered position over an available stroke, preferably prior to a load launch operation from a reference frame and/or in the passive wave compensation phase.

[Claim 7] Lifting system (1), according to claim 6, characterized in that said centering module (71) consists of a slow centering module (71b) which, in the inactive configuration of the controlled braking means (6), cooperates with means for instantaneous and averaged measurement of the position of said moving block of sheaves (52) over a period of time and which is configured to control said winch (4) when the average position of said mobile block of sheave(s) (52) reaches an actuation threshold on said translational degree of freedom (T).

[Claim 8] Lifting system (1), according to any one of claims 1 to 7, characterized in that the control means (7) comprise a safety end-of-stroke module (72) which is configured to actuate said winch (4) when said moving block of sheaves (52) reaches an end-of-stroke threshold on said translational degree of freedom (T), so as to actively push said moving block of sheaves (52) away from said end-of-stroke threshold.

[Claim 9] Lifting system (1), according to any one of claims 1 to 8, characterized in that the control means (7) comprise an automatic recovery module (73) and/or an automatic launching module (74), configured to automatically control said winch (4) and said controlled braking means (6) during recovery operation and/or launching operation of said load (C),

which automatic recovery module (73) and/or automatic launch module (74) is preferably associated with at least one measuring sensor (75) configured to measure the relative vertical distance between a reference frame of said frame (2) and a destination reference frame, for example in the case where the average distance between the reference frame of said frame (2) and the destination reference frame is not known or is variable.

[Claim 10] Lifting system (1), according to any one of claims 1 to 9, characterized in that it consists of:

- a crane comprising a lifting point (1a), the frame (2) of which comprises a post (2a) and a boom (2b), or
- a gantry with at least two lifting points (1a).

[Claim 11] Method of lifting a load (C), especially for lifting a load (C) in the presence of relative movement due to swell, by implementing a lifting system (1) according to any one of claims 1 to 10,

which lifting method comprises the following operations:

(i) during an operation to launch said load (C) to a new reference frame:

- a step of suspending said load (C) from said lifting cable (3), in which said controlled braking means (6) are in an active configuration and said mobile block of sheaves (52) is in an average position centered on an available stroke,
- a step of lowering said load (C) near the highest wave crests of the swell,
- when the load (C) is placed on a wave crest, a paying out step, preferably to come tangent to said wave crest,
- when said load (C) transfers its weight from said lifting cable (3) to said new reference frame, a step of switching said braking means to an inactive configuration so that said lifting system (1) provides passive wave compensation,

and/or

(ii) during a recovery operation of said load (C), starting from an inactive configuration in which said lifting system (1) provides passive wave compensation,

- if said load (C) is in an upward movement, a transition step towards said active configuration so that said mobile block of sheaves (52) continues its movement increasing by said distance value (D), up to a wave crest where said mobile block of sheaves (52) is blocked in translation, or
- if said load (C) is in a downward movement, a step of maintaining the controlled braking means (6) in the inactive configuration, then a step of switching to said active configuration at the start of said upward movement of said load (C).

[Claim 12] Method of lifting a load (C), according to claim 11, characterized in that, in passive compensation of the swell, said method comprises a piloting step of said winch (4) to tend to maintain the mobile block of sheaves (52) in an average position.