

WINCH AND A METHOD FOR DRIVING THE SAME

FIELD OF INVENTION

- 5 The invention relates to a winch and a method for driving the same, In particular (but not exclusively), the winch is suitable for use in floating production storage and off-loading units or vessels where high pull loads are needed.

BACKGROUND TO THE INVENTION

- 10 The following discussion of the background to the invention is intended to facilitate an understanding of the present invention. However, it should be appreciated that the discussion is not an acknowledgment or admission that any of the material referred to was published, known or part of the common general knowledge in any jurisdiction as at the priority date of the application.

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- Presently, floating production storage and offloading (FPSO) vessels employ conventional heavy duty anchor handling/towing winches to lower and retrieve their anchors or tow lines. Such conventional winches typically consist of a brake arrangement and a drive arrangement. During operation, the winch can either be
- 20 used in the brake mode or the drive mode. Pull is performed by connecting the drive and pay-out is performed by disconnecting the drive and varying the brake force. Changes from the brake mode to the drive mode and vice versa are however limited by manual control, start-up time and may involve operational errors. Further, the maximum pull load capacity of such conventional winches is
- 25 about 150 tonnes at full drum.

Another type of winch commonly employed is the self-tensioning (also called constant tensioning) winch. The self-tensioning winch is continuously operated in the drive mode. Both pull and pay-out are performed by connecting the drive mode. The maximum pull and release speed is however limited by the maximum speed of the motor. Due to the continuous use of the connected drive, relative large components are needed to achieve the full pull and the maximum speed is often limited. Further, the maximum pull load capacity of such conventional self-tensioning winches is about 150 tonnes at full drum.

It is desirable to provide a winch that alleviates the above limitations.

SUMMARY OF THE INVENTION

Throughout this document, unless otherwise indicated to the contrary, the terms “comprising”, “consisting of”, and the like, are to be construed as non-exhaustive, or in other words, as meaning “including, but not limited to”.

In a first aspect of the present invention, there is provided a winch which is suitable for use in floating production storage and off-loading units or vessels where high pull loads are needed. The winch comprises a winch wheel, a main cylinder, a positioning cylinder, a pawl cylinder, and a pawl.

The winch comprises:

- a winch wheel;

- a main cylinder adapted to rotate the winch wheel in a first direction;
- a positioning cylinder connected to the main cylinder, the positioning cylinder operable to move the main cylinder between a first position whereby the main cylinder rotates the winch wheel in the first direction and a second position whereby the main cylinder does not rotate the winch wheel;
- a pawl adapted to engage the winch wheel to thereby restrict the rotation of the winch wheel in a second direction; and
- a pawl cylinder connected to the pawl, the pawl cylinder operable to move the pawl between a third position whereby the pawl engages the winch wheel and a fourth position whereby the pawl does not engage the winch wheel.

Advantageously, the winch allows a pull load capacity of at least 450 tonnes at full drum. Preferably, the winch allows a pull load capacity of 600 tonnes at full drum. Preferably the second direction of rotation of the winch wheel is in the reverse direction relative to the first direction of rotation of the winch wheel.

Preferably the winch wheel is a ratchet winch wheel comprising a gear with a plurality of teeth. The advantage of using a ratchet winch wheel is that it allows continuous rotary motion only in one direction while preventing motion in the opposite direction.

Preferably, each of the plurality of teeth is uniform but asymmetrical, with each tooth having a gentle slope on one edge and a steep slope on the other edge.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be illustrated, by way of example only, embodiments of the present invention with the accompanying drawings, where:

Figure 1 illustrates a winch at a pre-start 'home' position according to an embodiment of the invention.

Figures 2 and 3 illustrate a winch according to an embodiment of the invention at the pull mode;

Figure 4 illustrates the winch according to an embodiment of the invention at the end of the pull mode, wherein the piston rod of the main cylinder retracts from an extended position towards the 'home' position; and

Figures 5 to 7 illustrate the control flow chart of the winch in various operating modes as seen from an operator's point of view.

Other arrangements of the invention are possible and, consequently, the accompanying drawings are not to be understood as superseding the generality of the preceding description of the invention.

DETAILED DESCRIPTION

The invention relates to a winch, and in particular, a winch suitable for use in floating production storage and off-loading units or vessels where high pull loads are needed.

In accordance with an embodiment of the invention, there is provided a winch **10** which is suitable for use in floating production storage and off-loading (FPSO) units or vessels where high pull loads are needed. The winch **10** comprises a winch wheel **12**, a main cylinder **14**, a positioning cylinder **16**, a pawl cylinder **18**, and a pawl **20**.

The winch **10** comprises:

- a winch wheel **12**;
- a main cylinder **14** adapted to rotate the winch wheel in a first direction;
- 5 – a positioning cylinder **16** connected to the main cylinder **14**, the
 positioning cylinder **16** operable to move the main cylinder **14** between
 a first position whereby the main cylinder rotates the winch wheel in the
 first direction and a second position whereby the main cylinder **14** does
 not rotate the winch wheel;
- 10 – a pawl **20** adapted to engage the winch wheel **12** to thereby restrict the
 rotation of the winch wheel **12** in a second direction; and
- a pawl cylinder **18** connected to the pawl **20**, the pawl cylinder **18**
 operable to move the pawl **20** between a third position whereby the
 pawl engages the winch wheel **12** and a fourth position whereby the
15 pawl does not engage the winch wheel **12**.

FIGURES 1-4 show side views of the winch **10** in various modes of operation in
accordance with an embodiment of the invention. The winch **10** comprises a winch
20 wheel **12**, a main cylinder **14**, a positioning cylinder **16**, a pawl cylinder **18**, and a
pawl **20**.

In this embodiment, the winch wheel **12** is preferably a ratchet winch wheel
consisting of a gear with a plurality of teeth **24**. The teeth **24** may be uniform but
25 asymmetrical, with each tooth **24** having a gentle slope **24a** on one edge and a

steep slope **24b** on the other edge as shown in **FIGURES 1-4**. The space **26** between adjacent teeth where the gentle slope **24a** meets the steep slope **24b** is defined as a **tooth space**. The advantage of using a ratchet winch wheel is that it allows continuous rotary motion in only one direction while preventing motion in the opposite direction, the operating mechanism of which will be described with further details in paragraphs to follow.

Each of the main cylinder **14**, positioning cylinder **16**, and pawl cylinder **18** preferably comprises a cylindrical hollow body having a closed end at the base of the respective cylinder and an open end at the head of the respective cylinder. A piston rod is housed in the hollow body. Preferably, the piston is a hydraulic piston. The head of the piston rod is defined as the leading edge of the piston when the piston rod is extending from the hollow body. The piston rod may be fully or partially retracted in the hollow body, or may be fully or partially extended from the hollow body, depending on the desired position of the respective cylinder. During extension, the head of the piston rod emerges from the hollow body and moves in a direction away from the base of the cylinder. During retraction, the head of the piston rod moves towards the direction of the base of the cylinder.

At the closed end of the respective cylinder, the base of each of the main cylinder **14**, positioning cylinder **16**, and pawl cylinder **18** is securely connected to the flooring of the winch so that movement of the respective cylinder in the horizontal plane parallel to the flooring plane is restricted.

The head of the piston rod of the positioning cylinder **16** is securely connected to the main cylinder **14** at a position preferably midway between the head and the base of the main cylinder **14**. The positioning cylinder **16** serves to increase or decrease the inclination of the longitudinal axis of the main cylinder **14** with respect to the flooring plane of the winch **10** by extending the head of the piston rod or retracting the head of the piston rod, respectively. The piston rod may remain in the fully or partially extended (or retracted) position for a period of time so as to hold the main cylinder **14** in the desired inclined position.

The pawl **20** engages the ratchet winch wheel **12** at one of the teeth. The gentle slope on one edge of the tooth acts as a ramp for the pawl to ride on. The pawl **20**, which is usually spring-loaded to keep it engaged with the teeth, will ride up or "climb" the gentle slope when the ratchet winch wheel **12** is rotated in one direction, e.g. the anti-clockwise direction. The pawl **20** will then slip or "jump" down the steep slope on the other edge of the tooth into the bottom of the tooth space after riding over the gentle slope, and the spring will have pushed the pawl **20** there, thereby engaging the ratchet wheel **12** at one of the teeth.

As the ratchet winch wheel **12** continues to move in the same direction, the pawl **20** will then ride up the next slope on the next tooth. But if the ratchet winch wheel **12** is rotated in the opposite direction the pawl **20** will jam, because the pawl **20** will only allow movement along the gentle slope **24a** of the tooth towards the bottom of the tooth space, and does not allow movement along the steep slope **24b** of the tooth. The pawl **20** bears against the surface of the bottom of the tooth space at an angle so that any backward (or opposite) motion will cause the pawl **20** to jam against the surface and thus prevent any further backward motion. This

will limit the backward movement of the ratchet winch wheel **12** to a tooth length at maximum, as long as the pawl **20** is acting normally to check the backward rotation. In other words, the ratchet winch wheel **12** and the pawl **20**, working in concert, will serve to jam the mechanism when an attempt is made to turn the
5 ratchet winch wheel **12** in the backward direction, while allowing free movement when turned in the forward direction.

At any one time, the ratchet winch wheel **12** is capable of rotating in the forward direction during, for example, the pull mode and in the backward direction during
10 the pay-out mode.

Prior to the operation of the winch **10**, lock pins on the main cylinder **14** and pawl cylinder **18** are released.

The operation of the ratchet winch wheel **12** will now be described in following
15 paragraphs.

In **FIGURE 1**, which illustrates the 'Home position' step, the piston rod of the main cylinder **14** is shown to be in a fully retracted position and is about to extend upon activation. At this fully retracted position, the head of the piston rod of the main cylinder **14** is not engaging any one of the teeth **24** at a tooth space **26**. The piston
20 rod of the positioning cylinder **16** is shown to be in a retracted position and remains in the retracted position throughout the step. The piston rod of the pawl cylinder **18** is shown to be in an extended position and remains in the extended position throughout the step. The piston rod of the positioning cylinder **16** may or may not be in a fully retracted position. The piston rod of the pawl cylinder **18** may
25 or may not be in a fully retracted position so long as the pawl **20** engages the

ratchet winch wheel **12** at one of the tooth space **26** to thereby hold the ratchet winch wheel **12** stationary. When the piston rod of the main cylinder **14** is fully retracted, the piston rod of the positioning cylinder **16** retracted, and the piston rod of the pawl cylinder **18** extended, such positioning is termed as 'Home Position'.

5 The ratchet winch wheel **12** is presently at rest and not rotating in any direction.

In **FIGURE 2**, which illustrates the pull step or pull mode, the ratchet winch wheel **12** is shown to rotate in the forward (shown as counter-clockwise) direction. The piston rod of the positioning cylinder **16** begins to extend gradually and slowly
10 increase the inclination of the main cylinder **14**. The piston rod of the position cylinder **16** stops extending and remains in the extended position when the desired inclination of the main cylinder **14** has been achieved. At the same time, the piston rod of the main cylinder **14** is gradually extending from the main cylinder **14**. The piston rod of the pawl cylinder **18** remains in the same extended position
15 throughout this process. The piston rod of the main cylinder **14** continues to extend, push and rotate the ratchet winch wheel **12** in the forward direction. As the ratchet winch wheel **12** is rotating in the forward direction, the pawl **20** is climbing along the gentle slope of one of the teeth of the ratchet winch wheel **12**.

20 The ratchet winch wheel **12** continues to rotate in the forward direction as the piston rod of the main cylinder **14** continues to extend, as shown in **FIGURE 3**. At one stage the pawl **20** jumps down the steep slope on the other edge of the tooth into the bottom of the tooth space **26** after riding over the gentle slope, and the pawl cylinder **18** pushes the pawl **20** towards the tooth space **26**, thereby
25 engaging the ratchet winch wheel **12** at one of the teeth. The rotation of the ratchet

winch wheel **12** continues until the piston rod of the main cylinder **14** is fully extended. The piston rod of the position cylinder **16** remains in the extended position.

Upon reaching a desired 'pull mode' position, the piston rod of the main cylinder

5 **14** starts to retract from an extended position as illustrated in Figure 4. The retraction may or may not necessarily be made from a fully extended position.

Prior to the retraction of the piston rod of the main cylinder **14**, the piston rod of the pawl cylinder **18** is first made fully extended so that the pawl **20** firmly engages the tooth space at one of the teeth of the ratchet winch wheel **12**. As the piston rod of

10 the main cylinder **14** starts to retract slowly and gradually loses contact with the ratchet winch wheel **12**, the pawl **20** continues to engage the tooth space so that backward rotation of the ratchet winch wheel **12** is prohibited. The piston rod of the positioning cylinder **16** is set at neutral position without exerting force on the main cylinder **14** during the retraction of the piston rod of the main cylinder **14**. After the
15 piston rod of the main cylinder **14** is fully retracted, the piston rod of the positioning cylinder **16** slowly retracts and the piston rod of the pawl cylinder **18** slowly retracts to achieve the 'Home Position'. And the cycle continues again to move the ratchet winch wheel **12** forward as described above. It is to be appreciated in Figure 4 that the ratchet winch wheel **12** is not rotating.

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Preferably the main cylinder **14** and the pawl cylinder **18** is each fitted with a lock pin. The lock pin serves to lock the respective cylinder to prevent accidental operation of the respective cylinder before and after use. Before operating the respective cylinder, for example prior to setting the main cylinder **14**, the

25 positioning cylinder **16**, and the pawl cylinder **18** at the 'Home Position', the lock

pins of the main cylinder **14** and the pawl cylinder **18** are released. The piston rod of the pawl cylinder **18** is extended until the pawl **20** engages one of the tooth space **26**. The piston rod of the positioning cylinder **16** is retracted until the piston rod of the main cylinder **14** touches the ratchet winch wheel **12**.

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The 'pay-out mode', which is the backward reverse rotation of the ratchet winch wheel **12** will now be described in following paragraphs. Initially the piston rod of the main cylinder **14** is engaging one of the tooth spaces of the ratchet winch wheel **12** when the piston rod is fully extended. At the same time, the piston rod of the pawl cylinder **18** is fully retracted so that the pawl **20** is not in contact with the ratchet winch wheel **12** at all. The ratchet winch wheel **12** is supported solely by the piston rod of the main cylinder **14** at this position. To rotate the ratchet winch wheel **12** in the backward (clockwise) direction, the piston rod of the main cylinder **14** is slowly retracted and the ratchet winch wheel **12** follows the motion of the retracting piston rod. At a suitable retracted position of the piston rod of the main cylinder **14**, the retracting motion stops and the piston rod of the pawl cylinder **18** slowly extends until the pawl **20** engages the ratchet winch wheel **12** at one of the tooth spaces firmly. To continue the backward rotation, the piston rod of the positioning cylinder **16** is extended to increase the inclination of the main cylinder **14** until the piston rod of the main cylinder **14** is no longer in contact with the ratchet winch wheel **12**. When the piston rod of the main cylinder **14** is no longer contacting, the piston rod of the main cylinder **14** is extended fully. At this fully extended position, the piston rod of the positioning cylinder **16** is retracted to slowly allow the piston rod of the main cylinder **14** to engage the ratchet winch wheel **12** at one of the tooth spaces again. After this, the piston rod of the pawl

cylinder **18** is slowly retracted until the pawl **20** is no longer contacting the ratchet winch wheel **12**. The piston rod of the main cylinder **14** is then slowly retracted to allow the ratchet winch wheel **12** to rotate backward again, and the cycle continues.

5 An operator operating the winch may be made with reference to Figures 5 to 7.

At the home position (step 500), an operator awaits instructions on whether he is to activate the pull mode or pay out mode.

Upon receiving an instruction to pull, the operator activates a control, preferably but not restricted to a joystick to pay in (step 502). Once the joystick is pay in, the

10 pawl cylinder 18 extends such that the pawl 20 contacts a tooth space of the ratchet winch wheel 12 (step 502). Next, the positioning cylinder 16 retracts (step 506) such that the main cylinder 14 contacts a tooth space 26 on the winch wheel 12. The main cylinder 14 extends and the winch wheel 12 begins to rotate in an anti-clockwise direction (step 508) as the main cylinder 14 urges against the steep
15 slope 24b. An algorithm in the control system checks if the extension limit has been reached (for one tooth) and if so retracts the main cylinder so that it slides out of the tooth along gentle slope 24a. As the main cylinder 14 slides out of the tooth 24, the pawl 20 prevents the winch wheel 12 from moving in the opposite clockwise direction. Step 508 repeats itself as the main cylinder 14 extends and
20 contacts an adjacent tooth space 26, until the load is paid in. It is appreciated that the main cylinder 14 and pawl cylinder operates in conjunction to move the winch wheel at 'one tooth' at a time. This ensures safety, avoids slippage and prevents 'jumping of tooth'.

If the operator receives an instruction to pay out (step 520), the main cylinder 14 retracts to slide out along gentle slope 24a (step 522) and the positioning cylinder extends so as to disengage the main cylinder 14 from the winch wheel (step 524).

An algorithm checks if the main cylinder 14 and positioning cylinder 16 are both

5 fully retracted and extended respectively (step 526). Once done, the main cylinder

14 extends (step 528) progressive until near its limit (step 530). The positioning

cylinder 16 then starts to retract such that the main cylinder 14 contacts a tooth

space 26 of the winch wheel 12 (step 532). An algorithm checks if the positioning

cylinder 16 and the main cylinder 14 reaches their retraction and extension limit

10 (step 534). If so, the pawl cylinder 18 retracts to disengage the pawl 20 from the

winch wheel 12 (step 536). An algorithm checks if the pawl cylinder 18 reaches its

retract limit (step 538). If so, the main cylinder 14 starts to retract and the winch

wheel 14 is rotated in the clockwise direction without pawl 20 preventing the

rotation (step 540). An algorithm checks if the main cylinder 14 is near its

15 retraction limit (step 542) and if so it means that the main cylinder 14 is going to

slip out of the tooth space 26 along gentle slope 24a. At this juncture the pawl

cylinder 18 is extended (step 544) and is checked to continue to extend (step 546)

until the pawl 20 contacts the winch wheel, and prevents the winch wheel 12 from

slipping. The main cylinder is then retracted until home position (step 548).

20 **EXAMPLE**

As an illustration of the capability of the winch of the present invention, the

following specifications (see **Table 1** below) of the winch components have been tested and achieved successfully.

LINE PULL & LINE SPEED:

DRIVE	Ø ROPE	LAYER	V(m/min)	L(m)	PULL(t)
HYDRAULIC MOTOR	Ø48	1ST	14	70.6	100
		2ND	14.6	144.2	96
		3RD	15.2	220.9	92.2
	Ø136	1ST	14	51.3	100.7
		2ND	15.6	108.7	90.2
		3RD	17.2	172	81.7
MAIN CYLINDER	Ø136	1ST	2.50	51.3	740
		2ND	2.79	108.7	662
		3RD	3.08	172	600

1. LINE MAX PULL: 600 ton @ FULL DRUM.
2. DRUM CAPACITY: 150M x Ø136mm PP ROPE (3 LAYERS);
AND 200M x Ø48mm PP ROPE (3 LAYERS).
3. LAY TYPE: RIGHT HAND ORDINARY LAY.
4. DRUM DIMENSION: Ø2200mm(BARE) x 590 2060mm(W) x 3560mm FLANGE
5. TYPE: SINGLE DRUM WITH GEAR REDUCTION DRIVE BY 3 UNITS HYDRAULIC MOTOR AND GEAR BOX (2 UNITS PINION).
6. BRAKES
 - 6.1) ON INDIVIDUAL MOTOR
CAPACITY: 150% OF RATEDS LINE PULL;
TYPE : DISC BRAKE, HYDRAULIC APPLY, HYDRAULIC RELEASE.
 - 6.2) ON MAIN DRUM DRAG BRAKE
CAPACITY: 20T;
TYPE : BAND BRAKE, HYDRAULIC APPLY, HYDRAULIC RELEASE.
7. SYSTEM PRESSURE: FOR MTR 3700 psi / 255 bar MAX.
FOR CYL 3000 psi / 214 bar MAX.
8. FLOWRATE REQD: FOR MTR 180 gpm / 682 lpm MAX.
FOR CYL 260 gpm / 985 lpm MAX.
9. MAIN CYLINDER Ø550(B) x 254(R) x 720(STR)
10. RESERVE WIRE ROPE LAST 4 WRAPS ON 1ST LAYER.
11. SS316L PIPING, FITTING FOR SIZE UP TO 1"
CARBON STEEL PIPING, FITTING FOR SIZE ABOVE 1".
ALL FITTING TO BE GYROLOC.
12. TAGGING AND NAME PLATE MATERIAL: SS 316.
13. WEIGHT: ESTIMATED ~77 TONS WITHOUT WIRE ROPE.

NOTES:

1. WHEN USE MAIN CYLINDER DRIVE DRUM,
DRUM AVERAGE SPEED IS 0.19 RPM.
2. WHEN USE HYDRAULIC MOTOR DRIVE DRUM,
DRUM MAX SPEED IS 1.98 RPM.

Table 1 Specification of the Winch

The afore-described winch allows pull loads of at least 450 tonnes to be achieved with minimum components.

It is to be appreciated that the gentle slope 24a and steep slope 24b of each of the plurality of teeth 24 ensures that for both pay-out and pull modes during operation;
5 the respective cylinders 14, 18 engages each successive teeth at a time. This prevents 'slips' in the engagement of the ratchet wheel gear 12 and thus ensuring proper safety and control of the winch 10.

10 Although the foregoing invention has been described in some detail by way of illustration and example, and with regard to one or more embodiments, for the purposes of clarity of understanding, it is readily apparent to those of ordinary skill in the art in light of the teachings of this invention that certain changes, variations and modifications may be made thereto without departing from the spirit or scope
15 of the invention as described in the appended claims.

CLAIMS:

1. A winch comprising:

- a winch wheel;
- 5 – a main cylinder adapted to rotate the winch wheel in a first direction;
- a positioning cylinder connected to the main cylinder, the positioning cylinder operable to move the main cylinder between a first position whereby the main cylinder rotates the winch wheel in the first direction and a second position whereby the main cylinder does not rotate the
10 winch wheel;
- a pawl adapted to engage the winch wheel to thereby restrict the rotation of the winch wheel in a second direction; and
- a pawl cylinder connected to the pawl, the pawl cylinder operable to move the pawl between a third position whereby the pawl engages the
15 winch wheel and a fourth position whereby the pawl does not engage the winch wheel.

2. The winch according to claim 1, wherein the second direction of rotation of the winch wheel is in the reverse direction relative to the first direction of rotation of the
20 winch wheel.

3. The winch according to claim 1 or 2, wherein the winch wheel is a ratchet winch wheel comprising a gear with a plurality of teeth.

4. The winch according to claim 3, wherein each of the plurality of teeth is uniform but asymmetrical, with each tooth having a gentle slope on one edge and a steep slope on the other edge.

5 5. The winch according to any one of the preceding claims, wherein the main cylinder, positioning cylinder and pawl cylinder each comprises a hydraulic piston.