

(19) **DANMARK**

(10) **DK/EP 3696407 T3**



(12)

Oversættelse af europæisk patentskrift

Patent- og
Varemærkestyrelsen

-
- (51) Int.Cl.: **F 03 D 80/50 (2016.01)**
- (45) Oversættelsen bekendtgjort den: **2023-02-27**
- (80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2023-01-25**
- (86) Europæisk ansøgning nr.: **19157228.8**
- (86) Europæisk indleveringsdag: **2019-02-14**
- (87) Den europæiske ansøgnings publiceringsdag: **2020-08-19**
- (84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
- (73) Patenthaver: **Siemens Gamesa Renewable Energy A/S, Borupvej 16, 7330 Brande, Danmark**
- (72) Opfinder: **Schmidt, Soeren Adrian, Prinsessegade 20G, 1tv, 7000 Fredericia, Danmark**
- (74) Fuldmægtig i Danmark: **Zacco Denmark A/S, Arne Jacobsens Allé 15, 2300 København S, Danmark**
- (54) Benævnelse: **Sikkerhedssystem til en vindmølle**
- (56) Fremdragne publikationer:
EP-A1- 2 740 928
WO-A1-2005/090780
DE-A1-102009 015 305
DE-A1-102010 043 436
DE-A1-102014 218 804

DESCRIPTION

[0001] The present invention relates to a safety system for a wind turbine as well as a wind turbine comprising a nacelle, a hub and a rotor blocking system with several rotor locks, each engageable into a locked position for blocking a rotor of the wind turbine from rotating. Further, the invention relates to a method for providing safety to a person in a wind turbine and in a hub of the wind turbine, respectively.

[0002] As wind turbines are steadily increasing in size, there is need for more rotor clamping and/or blocking force when technicians are working in a hub of the wind turbine. This clamping and blocking force is given by a rotor blocking system comprising rotor locks distributed around the main shaft. Rotor locks used in the wind turbine industry are typically mounted to the main rotor shaft of the wind turbine, between gearbox and generator. The rotor blocking system is activated by running lock bolts into a lock disc using hydraulic power. Today, each rotor lock must be inserted manually by activating switches in different positions in the nacelle of the wind turbine. With an increasing number of rotor locks, the work and time spent for applying these tasks also increase. With a conventional rotor blocking system, a technician has to engage or disengage each rotor lock manually by activating a switch. When a rotor lock is engaged, a key is released which can be used to open a gate to the hub. Since the key is only related to one rotor lock, it is known that misuse of the system happens, by means of which only one of the rotor locks is engaged, while the key is then used to enter the hub. Due to compromised blocking capacity in this case, this could result in mechanical failure in the rotor lock, after which the turbine could start to idle with the technician in the hub.

[0003] A prior art example is disclosed in DE102014218804A1.

[0004] It is an object of the present invention to address at least part of the above-mentioned problems. In particular, it is an object of the present invention to provide a safety system and related method for persons working in the wind turbine for safely, reliably and/or quickly locking the rotor during maintenance works.

[0005] Aforesaid object is achieved by the subject-matters of the claims. In particular, the object is achieved by a safety system according to claim 1, a wind turbine according to claim 5 as well as a method for providing safety according to claim 6 of the present application. Further features and details of the invention result from the dependent claims, the description and the figures. Features and details discussed with respect to the inventive safety system are also correlated with the inventive wind turbine, the inventive method and the other way around.

[0006] According to a first aspect of the present invention, a safety system for a wind turbine is provided, wherein the wind turbine comprises a nacelle, a hub and a rotor blocking system with several rotor locks, each engageable into a locked position for blocking a rotor of the wind turbine from rotating. The inventive safety system comprises a central switching unit comprising one switch for each of the rotor locks for manually engaging a corresponding rotor

lock into the locked position when activating the related switch and a feedback unit generating from one central position and providing a safe-signal in a safe state of the hub, in which every rotor lock is engaged into the locked position.

[0007] By introducing the present safety system, a technician can insert all rotor locks from a central location in the nacelle while receiving the safe-signal when all rotor locks are in position. Thus, the technician may recognize at a glance whether the hub is safe to work in or not. This provides the desired safety for the technician in an easy and reliable manner. Moreover, the inventive safety system can be easily adapted to present wind turbines without the need of expensive modifications.

[0008] The switches for the rotor locks are configured to manually engage an accompanying rotor lock into the locked position when activating the related switch. For example, a first switch may belong to a first rotor lock, a second switch may belong to a second rotor lock, a third switch may belong to a third rotor lock, etc. When the first switch is activated and/or operated, the first rotor lock will be engaged or released, depending on in which state the switch currently is or which kind of switch is provided. When the second switch is operated, the second rotor lock will be engaged or released. And when the third switch is operated, the third rotor lock will be engaged or released. The switches can be operated manually by a technician. For example, each switch may be provided as a button or a lever and can be pressed or shifted by the technician for operating the same. Alternatively, each switch may be provided as a switch that can only be operated by inserting and/or turning a key in it. Such a key may be a mechanical and/or an electronic key.

[0009] As soon as the switches are operated and/or activated and the rotor locks are engaged, the feedback unit generates and provides the safe-signal, which can be directly or indirectly recognized by the technician at the central switching unit. That is, the technician does not have to move around in the nacelle in order to check whether all the rotor locks are engaged. This saves time and thus money. As described above, the switches are centrally located at the central switching unit. That is, the switches are arranged in a position in which the technician can operate and/or monitor them without moving.

[0010] The rotor blocking system comprises several rotor locks like, two, three, four, five, six, seven or eight rotor locks, wherein there are embodiments possible with even more rotor locks. For safety reasons, it is preferred that each rotor lock can be operated by one related switch only. However, it is also possible that the switches are configured to operate several rotor locks each, like at least one switch is configured to operate two or three rotor locks at once. This saves time and thus money while locking the rotor for maintenance work in the hub of the wind turbine.

[0011] The central switching unit preferably comprises a housing to be mounted to an inner wall of the nacelle, wherein the switches are mounted to be operated on one outer wall member of the housing.

[0012] Activating a switch preferably means operating the same in order to move the related at least one rotor lock into the engaged position. Consequently, deactivating a switch preferably means operating the same in order to move the related at least one rotor lock into a released position, in which the at least one rotor lock does not block the rotor and the rotor may be able to spin.

[0013] The safe-signal is particularly generated and provided to be perceived by a person like a technician in the nacelle and in front of the central switching unit, respectively. In addition, the safe-signal may be generated and provided to be received by a computer and/or a machine in order to use the safe-signal for further safety measures. The safe-signal can be understood as a signal which provides information about a safety state in the hub, i.e., whether it is safe for a person to enter the hub or not.

[0014] According to the invention, the safety system may comprise a user communication unit connected to the feedback unit for providing the safe-signal in terms of visually and/or acoustically informing a person at the central switching unit in the nacelle about the safe state when receiving the provided safe-signal by the user communication unit. That is, the user communication unit is configured to provide the safe-signal in terms of a visual and/or acoustic signal, which can be perceived by a person like a technician in the nacelle and at the central switching unit. A visual and/or acoustic signal is an easy and cheap way to inform the technician about the state in the hub, i.e., whether it is safe to work in there or not. The user communication unit comprises a display for displaying the safe-signal on a display and/or a loudspeaker for a suitable sound signal to inform the technician about the safe state. The display and/or the loudspeaker can be arranged at the central switching unit, specifically, at a housing of the central switching unit. This solution can be provided in a cheap and simple way in particular on the ground that there has to be only one display and only one loudspeaker at the central switching unit, i.e., not at different location as it was necessary in prior art systems. The safe-signal can be displayed by means of a color code, like red for not safe and green for safe, or by means of a suitable message, written and/or shown at the display.

[0015] Further, it is possible that the safety system according to the present invention comprises a controller connected to the feedback unit for unlocking an access door from the nacelle to the hub when receiving the provided safe-signal by the controller. This is an additional safety measure and increases the safety for the technician, respectively. According to the described embodiment, the access door will only be unlocked when the controller receives the safe-signal. The access door can then be unlocked by means of the controller. That is, the controller is configured to unlock the access door when receiving the provided safe-signal. In other words, as long as there is no safe-signal received by the controller, the access door will be locked and cannot be entered by a person.

[0016] Moreover, an inventive safety system may comprise a door signal unit for providing a locked-signal in a locked state of a door lock of a door from the nacelle to the hub, and a controller connected to the door signal unit for allowing to release any one of the rotor locks only when receiving the locked-signal from the door signal unit. That is, a rotor lock can only be

released by means of the switches when the access door is locked. This makes sure, that a rotor lock can only be released when the technician left the hub, closed the access door and then operates one of the switches, which are arranged at the central switching unit in the nacelle, i.e., outside of the hub. Hence, by means of the inventive door signal unit, safety for a person in the hub can be further enhanced.

[0017] In accordance with a further embodiment of an inventive safety system, the feedback unit can be integrated into the central switching unit. Thus, the safety system can be provided with a space saving design, which is important in a wind turbine, where saving space is always an issue. The feedback unit can be integrated into a computer and a controller, respectively.

[0018] According to another aspect of the invention there is provided a wind turbine with a nacelle, a hub, a rotor blocking system comprising several rotor locks, each engageable into a locked position for blocking a rotor of the wind turbine from rotating, and a safety system according to any one of the above described embodiments. Therefore, the inventive wind turbine brings up the same advantages that have been discussed in detail with respect to the inventive safety system. The wind turbine may be configured as an onshore and an offshore wind turbine.

[0019] A further aspect of the present invention relates to a method for providing safety to a person in a wind turbine with a safety system according to any one of the above described embodiments. The method comprises the steps of recognizing a safe state of the hub, in which every rotor lock is engaged into the locked position, and generating as well as providing a safe-signal in said safe state of the hub, in which every rotor lock is engaged into the locked position. Hence, the inventive method also brings up the advantages that have been discussed in detail with respect to the inventive safety system.

[0020] The method can be carried out by a computer program product and/or a computer program product can be configured to carry out the method when installed on a memory and/or a computer. In another embodiment of the present invention the computer program product comprises computer readable program means initiating a computer to carry out the prescribed method.

[0021] According to the present invention, the safe-signal is provided in terms of visually and/or acoustically informing a person at the central switching unit in the nacelle about the safe state by means of a user communication unit connected to the feedback unit when receiving the provided safe-signal by the user communication unit. Further, the inventive method may comprise the step of unlocking an access door from the nacelle to the hub by means of a controller connected to the feedback unit when receiving the provided safe-signal by the controller. Moreover, the method according to the present invention may comprise the steps of providing a locked-signal in a locked state of a door lock of a door from the nacelle to the hub by means of a door signal unit, and allowing to release any one of the rotor locks only when receiving the locked-signal from the door signal unit by means of a controller connected to the door signal unit.

[0022] The present invention is discussed in more detail with respect to the accompanying drawings, in which

Fig. 1

shows a block diagram for explaining a safety system according to a preferred embodiment of the present invention,

Fig. 2

shows a flow chart for explaining a method according to a first embodiment of the present invention,

Fig. 3

shows a flow chart for explaining a method according to a second embodiment of the present invention, and

Fig. 4

shows a wind turbine with an inventive safety system.

[0023] Fig. 1 shows a safety system 1 for a wind turbine 2 with a nacelle 3, a hub 4 and a rotor blocking system 5 with three rotor locks R1, R2, R3, each engageable into a locked position for blocking a rotor 6 of the wind turbine 2 from rotating. The wind turbine 2 with its components is shown in Fig. 4.

[0024] The safety system 1 of Fig. 1 is shown in the form of a block diagram to simplify the explanation of the same. As shown in Fig. 1, the safety system 1 includes a central switching unit 7 comprising one switch S1, S2, S3 for each of the three rotor locks R1, R2, R3 for manually engaging a corresponding rotor lock R1, R2, R3 into the locked position when activating the related switch S1, S2, S3. According to Fig. 1, a first switch S1 belongs to a first rotor lock R1, a second switch S2 belongs to a second rotor lock R2, and a third switch S3 belongs to a third rotor lock R3. When the first switch S1 is operated, the first rotor lock R1 will be engaged or released. When the second switch S2 is operated, the second rotor lock R2 will be engaged or released. And when the third switch S3 is operated, the third rotor lock R3 will be engaged or released. The switches S1, S2, S3 are configured to be operated manually by a technician. Specifically, each switch S1, S2, S3 can only be operated by means of a specific activation key.

[0025] The safety system 1 further comprises a feedback unit 8 generating and providing a safe-signal in a safe state of the hub 4, in which every rotor lock R1, R2, R3 is engaged into the locked position. As can be drawn from Fig. 1, the feedback unit 8 is integrated into the central switching unit 7.

[0026] Moreover, the safety system 1 comprises a user communication unit 9 connected to the feedback unit 8 for providing the safe-signal in terms of visually informing a person at the central switching unit 7 in the nacelle 3 about the safe state when receiving the provided safe-signal by the user communication unit 9. According to Fig. 1, the user communication unit 9

comprises a display to show the technician or any other user the safety state of the hub, i.e., whether it is safe to work in there or not. In addition to the display, there may also be arranged a loudspeaker at the central switching unit 7 to inform a user about the safety state in the hub acoustically, for example.

[0027] Furthermore, the safety system 1 comprises a controller 10 connected to the feedback unit 8 for unlocking an access door from the nacelle 3 to the hub 4 when receiving the provided safe-signal by the controller 10.

[0028] In addition, the safety system 1 of Fig. 1 comprises a door signal unit 11 for providing a locked-signal in a locked state of a door lock L1 of a door from the nacelle 3 to the hub 4, and a controller 10 connected to the door signal unit 11 for allowing to release any one of the rotor locks R1, R2, R3 only when receiving the locked-signal from the door signal unit 11.

[0029] Fig. 2 shows a flow chart to explain a method for providing safety to a person in a wind turbine 2 with the above described safety system 1. In step S10, the routine starts. In step S20, a safe state of the hub 4 is recognized by determining whether the rotor locks R1, R2, R3 are engaged into the locked position or whether at least one of them is released from said safe position. When it is determined that the rotor locks R1, R2, R3 are not yet engaged into the locked position, the routine returns to step S10 for a new start. When it is determined that every rotor lock R1, R2, R3 is engaged into the locked position, the routine proceeds to step S22, in which the safe-signal is generated and provided. In a subsequent step S30 the safe-signal is output as a visual and/or acoustical signal by means of the user communication unit 9. While outputting the safe-signal, the access door from the nacelle 3 to the hub 4 will be unlocked by means of the controller 10, which is connected to the feedback unit 8.

[0030] Fig. 3 shows a flow chart to explain a method for providing additional safety to a person in a wind turbine 2 with the above described safety system 1. In step S40, the routine starts. In step S50, a signal is provided by means of the door signal unit 11 whether the door lock L1 of the door from the nacelle 3 to the hub 4 is locked or not. When it is detected that the door is locked, an allowing-signal will be released by the controller 10 at step S51 to allow releasing any one of the rotor locks R1, R2, R3 by means of the related switches S1, S2, S3. When it is detected that the door is unlocked, a prohibiting-signal will be released by the controller 10 at step S52 to prohibit releasing of any one of the rotor locks R1, R2, R3.

[0031] The controller 10 of the safety system 1 may be configured as a computer comprising a computer program for carrying out any one of the above described methods.

[0032] Fig. 4 shows the wind turbine 2 with the nacelle 3, the hub 4, the rotor blocking system 5 comprising three rotor locks R1, R2, R3, each engageable into the locked position for blocking the rotor 6 of the wind turbine 2 from rotating, and the above described safety system 1.

[0033] The aforesaid description of the accompanying drawings is only by the way of detail

and example. Specific features of each aspect of the present invention and the figures can be combined with each other if of technical sense.

REFERENCES CITED IN THE DESCRIPTION

Cited references

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- DE102014218804A1 [0003]

P a t e n t k r a v

5 1. Sikkerhedssystem (1) til en vindmølle (2), hvor vindmøllen (2) omfatter en nacelle (3), et nav (4) og et rotorblokeringsystem (5) med flere rotorlase (R1, R2, R3), der hver især kan gå i indgreb i en låst position for at blokere en rotor (6) på vindmøllen (2) i at rotere,

hvor

10 en central omskiftningsenhed (7), der omfatter en kontakt (S1, S2, S3) for enhver af rotorlåsene (R1, R2, R3) til manuelt at aktivere en tilsvarende rotorlås (R1, R2, R3) i den låste position ved aktivering den pågældende kontakt (S1, S2, S3) og en tilbagemeldingsenhed (8), der genererer og giver et sikkerhedssignal i en sikker tilstand af navet (4), hvor hver rotorlås (R1, R2, R3) er aktiveret i låst position,

kendetegnet ved

15 en brugerkommunikationsenhed (9), der er forbundet med tilbagemeldingsenheden (8) for at tilvejebringe sikkerhedssignalet ved visuelt og/eller akustisk at informere en person ved den centrale omskiftningsenhed (7) i nacellen (3) om den sikre tilstand ved modtagelse af det tilvejebragte sikkerhedssignal af brugerkommunikationsenheden (9), hvor brugerkommunikationsenheden (9) om-

20 fatter et display til visning af sikkerhedssignalet.

2. Sikkerhedssystem (1) ifølge krav 1,

kendetegnet ved

25 en styreenhed (10), der er forbundet med tilbagemeldingsenheden (8), til at låse en adgangsdør op fra nacellen (3) til navet (4) ved modtagelse af det tilvejebragte sikkerhedssignal af styreenheden (10).

3. Sikkerhedssystem (1) ifølge et hvilket som helst af de foregående krav,

kendetegnet ved

30 en dørsignalenhed (11) til at tilvejebringe et låsesignal i en låst tilstand af en dørlås (L1) af en dør fra nacellen (3) til navet (4), og en styreenhed (10), der

er forbundet til dørsignalenheden (11) for kun at tillade at udløse en hvilken som helst af rotorlåsene (R1, R2, R3), når låsesignalet modtages fra dørsignalenheden (11).

5 **4. Sikkerhedssystem (1) ifølge et hvilket som helst af de foregående krav, kendetegnet ved, at**
tilbagemeldingsenheden (8) er integreret i den centrale omskiftningsenhed (7).

10 **5. Vindmølle (2) med en nacelle (3), et nav (4) og et rotorblokeringsystem (5) omfattende flere rotorlåse (R1, R2, R3), der hver især kan gå i indgreb i en låst position for at blokere en rotor (6) af vindmøllen (2) fra at rotere, kendetegnet ved**
et sikkerhedssystem (1) ifølge et hvilket som helst af de foregående krav.

15 **6. Fremgangsmåde til at tilvejebringe sikkerhed til en person i en vindmølle (2) med et sikkerhedssystem (1) ifølge et hvilket som helst af kravene 1 til 4, kendetegnet ved**
genkende en sikker tilstand af navet (4), hvor hver rotorlås (R1, R2, R3) er i indgreb i den låste position, og genererer såvel som tilvejebringer et sikkerhedssignal i den sikre tilstand af navet (4), hvor hver rotorlås (R1, R2, R3) er i indgreb i den låste position,

20 **kendetegnet ved, at**
sikkerhedssignalet tilvejebringes ved visuelt og/eller akustisk at informere en person ved den centrale omskiftningsenhed (7) i nacellen (3) om den sikre tilstand ved hjælp af et display på brugerkommunikationsenheden (9), der er forbundet med tilbagemeldingsenheden (8), når den modtager det tilvejebragte sikkerhedssignal af brugerkommunikationsenheden (9).

25 **7. Fremgangsmåde ifølge krav 6, kendetegnet ved**
30

at oplåse en adgangsdør fra nacellen (3) til navet (4) ved hjælp af en styreenhed (10), der er forbundet med tilbagemeldingsenheden (8), når den modtager det tilvejebragte sikkerhedssignal fra styreenheden (10).

5 **8. Fremgangsmåde ifølge krav 6 eller 7,**

kendetegnet ved

10 at tilvejebringe et låsesignal i en låst tilstand af en dørlås (L1) i en dør fra nacellen (3) til navet (4) ved hjælp af en dørsignalenhed (11) og kun tillade at frigøre en hvilken som helst af rotorlåsene (R1, R2, R3), når låsesignalet modtages fra dørsignalenheden (11) ved hjælp af en styreenhed (10), der er forbundet med dørsignalenheden (11).

DRAWINGS

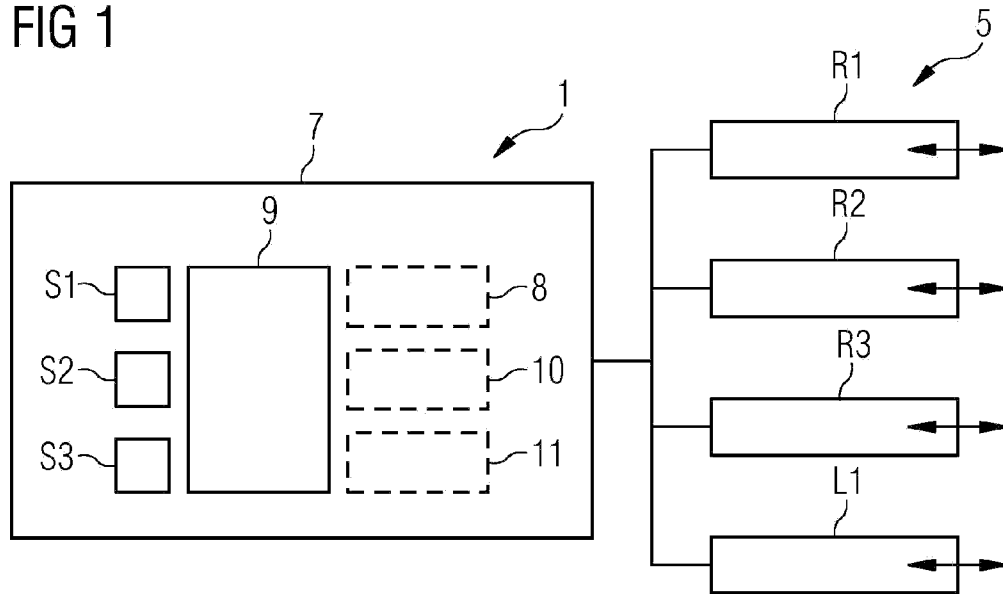
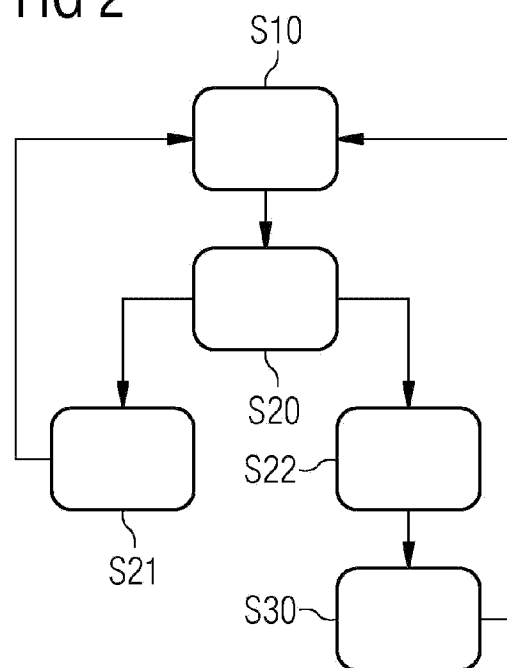
FIG 1**FIG 2**

FIG 3

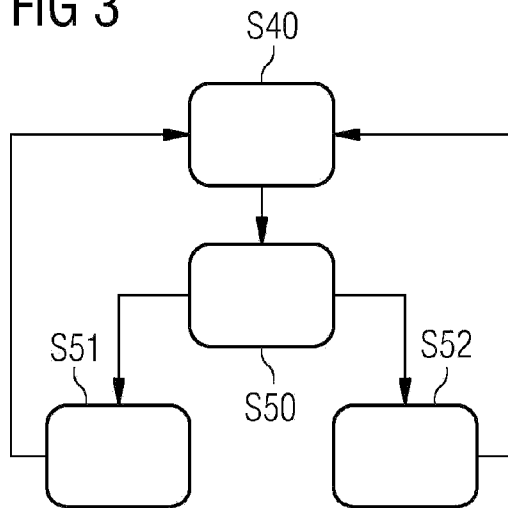


FIG 4

