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(54) Benævnelse: **Apparat til overvågning af omdrejningstallet i et vindenergianlæg**

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Description

The present invention is related to a wind turbine comprising an apparatus for monitoring a rotational speed in said wind turbine. Such an apparatus is sometimes also referred to as rotational speed monitor.

The drive train of a wind turbine begins with a rotor which carries the rotor blades. The rotor is connected to a rotor shaft, which is coupled to a gearbox. The rotor shaft is sometimes also referred to as slow shaft. The output shaft of the gearbox runs out into the generator as the generator shaft and is also referred to as the rapid shaft. In known wind turbines, a toothed disc is arranged on the rotor shaft, which generates pulses via inductive pulse transmitters, the frequency of which is proportional to the rotational speed of the rotor shaft. The pulses are analysed by an electronic module. Also, the sampled pulses are converted into a current signal via a freqency/current converter (f-I converter) and provided to a central controller unit of the wind turbine. In the central controller unit of the wind turbine, a critical cut-off rotational speed is stored. If the rotational speed values of the rotor shaft are above the filed cut-off rotational speed, a controlled setback of the wind turbine takes place.

It has proven to be a drawback of the apparatus for monitoring the rotational speed that the rotational speed monitoring does not have sufficient functional security, in particular, it does not comply with a safety integrity level which is required for security directed implementations according to IEC 61508.

From EP 1832743 A1 a method and a device for controlling the rotor speed is known. The method provides to control the torque of the rotor shaft via the torque of the electric generator by means of the blade pitch angle of at least one rotor blade and to hold the blade pitch thereby substantially constant. Here, the rotational speed of the rotor shaft and the rotational speed of the generator shaft may alternatively be evaluated.

From US 2005/0276696 A1 a method and a device for ice detection on a rotor blade is known. Here, recorded speed values are evaluated to recognize a beginning of the formation of ice on the rotor blade.

The present invention is based on the objective to provide a wind turbine with an apparatus for monitoring the rotational speed which provides sufficient functional security for the implementation in a wind turbine comprising means which are as simple as possible.

According to the present invention, the objective is resolved by a wind turbine comprising the features of claim 1. Advantageous embodiments form subject matters of the subclaims.

The wind turbine of the present invention comprises an apparatus, which serves for monitoring a rotational speed in the wind turbine. The wind turbine has a rotor shaft driven by a rotor, which runs out in a gearbox. Further, the wind turbine has a generator shaft, which connects the output shaft of the gear unit with a generator/converter unit. The apparatus for monitoring the rotational speed is characterised by a first rotational speed detection unit on the rotor shaft and a second rotational speed detection unit on the generator shaft. Each one of the two rotational speed detection units has at least two rotational speed sensors working independently from each other. In addition, a processing unit for the rotational speed is provided, to which the measured signals of the rotational speed detection units are applied and which generates an error signal for a rotational overspeed when a certain maximum value for the rotational speed is exceeded. The wind turbine of the present invention with its apparatus for monitoring the rotational speed has a series of advantages. At first, the rotational speed is acquired on the rotor shaft as well as on the generator shaft, so that a more accurate and reliable analysis of the measurement results can take place in an analysis of the measured rotational speed values. In this, it is to be understood that the change of the rotational speed by the gear ratio in the gear unit is taken into account, so that certain maximum values of the rotational speed are related to either a rotational speed of the rotor shaft or to a rotational speed of the generator shaft.

The wind turbine of the present invention with its apparatus can not only recognise a rotational overspeed in the wind turbine, but in addition even shaft defects, like a shaft fracture or certain gearing defects for instance. In the preferred embodiment of the present invention, the processing unit for the rotational speed compares the measured values of the first rotational speed detection unit with the measured values of the second rotational speed detection unit, taking into account a gear ratio. When there is a deviation of the rotational speed values for at least a predetermined threshold value, an error signal for a shaft defect is generated. The error signal for the shaft defect indicates that the measured rotational speeds of rotor shaft and generator shaft are not in the ratio set by the gearbox.

In a preferred embodiment, the processing unit is connected to a safety chain for a central control of the wind turbine. The safety chain of a wind turbine designates a connection to the operation management of the wind turbine, which leads directly to the electric controller unit and to the operation management of the wind turbine without further signal processing, and which can forward security relevant control signals to the operation management. The safety chain is connected to an operating equipment switching unit, which causes a cut-off of the relevant operating equipments when it is triggered by the safety chain, and announces the cut-off to the operation management. The great reliability of the processing unit for the rotational speed provided according to the present invention permits to connect the same directly with the safety chain, without a further signal processing being connected there between.

In a preferred embodiment, it is provided that for predetermined operation conditions, the processing unit does not generate an error signal related to a rotational overspeed and/or a shaft defect. Even though it is provided for the predetermined operation conditions that no errors signals are generated, an analysis of the measured rotational speed values can take place anyway, in order to use the same for a control on the wind turbine, for instance.

In a preferred embodiment, each rotational speed detection unit is equipped with at least two rotational speed sensors. Preferably, each rotational speed sensor has a transducer disc mounted on the shaft, the rotation of which is acquired optically, mechanically, electrically or magnetically. In the preferred embodiment, the acquisition of the rotational speed takes place at least twofold on the rotor shaft and also on the generator shaft. In this way it is made sure that upon failure of one rotational speed sensor, the rotational speed at the rotor shaft and at the generator shaft can be reliably acquired further.

In a preferred embodiment, the transducer disc is realised as a toothed disc, which is coated with a high performance anticorrosion agent for protection against environmental influences at least in the region of its teeth. Conventional toothed discs have often the problem that the structure of the teeth is corroded by environmental influences, like weather-induced humidity, and thus deviations in the contour of the toothed disc occur. Then, such deviations lead to systematic measurement errors in the acquisition of the rotational speeds.

Due to the great accuracy of the acquired rotational speed, it may be provided in addition that the processing unit for the rotational speed forwards an actual value for the rotational speed of the generator shaft and/or of the rotor shaft to a controller of the generator/converter unit. Thus, the wind turbine of the present invention with its apparatus for monitoring the rotational speed permits in addition to use even the measured rotational speeds for the operation management of the wind turbine, and with this for the controller of the generator/converter unit.

The invention will be explained in more detail by one example in the following with regard to the apparatus for monitoring the rotational speed.

The single figure shows a rotor 10 with two rotor blades 12 in a schematic view. The rotor is coupled with a gearbox/clutch unit 16 via a rotor shaft 14. The gearbox/clutch unit 16 has a gearbox and it may feature a clutch as well as

other assembly parts. In the gearbox, there is a conversion of the rotational speed, the rotational speed being speeded up in this. The output shaft of the gearbox 20 is connected to the generator 24 via the generator shaft 22. Generator 24 and a converter for converting the generated current in common constitute the generator/converter unit.

On the rotor shaft 14, a rotational speed detection unit 26 is provided. The rotational speed detection unit 26 consists of two toothed discs arranged independently on the rotor shaft 14 (not shown), which have a toothing that points radially towards the outside. In the region of the toothing, the toothed discs are provided with a protective coating, which protects the teeth against environmental influences. The two signals of the toothed discs (not shown) are applied to a processing unit via separated channels 28, 30. In order to form a sufficient functional security for the sensor signals of the rotor shaft, the toothed discs are monitored separately from each other, the rotational speed sensors each having an own power supply and an own line. Even electronic processing and amplification of the signals take place independently from each other, so that there is still sufficient security in case of a malfunction of a component.

In a corresponding way, the rotational speed detection unit 34 on the generator shaft 22 is also shown in the single figure. The rotational speed detection unit 32 has also two toothed discs provided independently from each other (not shown), the rotation of which is read out by two sensors which are independent from each other. The corresponding sensors are supplied with current independently from each other and are each one individually connected to the central processing unit 32 via the channels 36 and 38.

The processing unit 32 has an error recognition module 40, to which the output signals of the rotational speed sensors are applied. The module checks out with the applied four signals which rotational speed is present. When the rotational overspeed is defined with respect to the generator shaft 22, the two applied signals 28 and 30 from the rotor shaft are converted, taking into account the gear ratio of the gearbox 20. Thereafter, it is checked whether one of the

measured values exceeds the preset maximum rotational speed. When the maximum rotational speed is exceeded, an error signal is applied to an error module 42 of the processing unit 32. The error signal causes that the operating equipment switching unit 60 deactivates all the operating equipments which are critical for the plant condition via a direct connection 44, and parallel to this, a controlled setback of the wind turbine into a safe operating condition takes place with active support by the central controller 46. The direct connection 44 with the operating equipment switching unit 60 is called a safety chain. The central controller 46 cannot exert any influence on the safety chain, because it analyses the condition of the direct connection 44 only in a reading manner. As can be recognised in the figure, the safety chain may also be directly connected with other safety relevant units. The further safety relevant units may also be directly applied to the central controller 46 and the operating equipment switching unit 60, by-passing the processing unit 32, as indicated by the line 48 for instance, or they may be applied to the processing unit 32 with the connector 50 and passed through the error module 42.

In addition to recognising a rotational overspeed, the error recognition module 40 may also compare the ratio of the rotational speed at the rotor shaft with the rotational speed at the generator shaft. When the ratio of the rotational speeds deviates for more than a predetermined threshold value from the preset gear ratio of the gearbox, the error recognition module 40 also generates an error signal, which is forwarded to the central controller 46 via the error module 42. The threshold value for the recognition of an error in the drive train may be 10% of the gear ratio, for instance. Besides to gearbox errors, which can be recognised by a wrong gear ratio between the rotational speeds, the error recognition module 40 can also recognise an error in the drive train, from which a fracture of the shaft or a breakaway of a shaft connection can be deduced. Upon such an error, there is no value for the rotational speed of the generator shaft.

Even in this case, an error signal is forwarded into the operating equipment switching unit 60 and into the central controller 46 (only reading and processing)

by the error module 42, which causes a setback of the wind turbine into a safe condition. In addition to the error recognition module 40 for processing the signals and to the error module 42 for delivering the error announcement for the operating equipment switching unit 60 and the central controller 46, the processing unit 32 has also two freqency/current converters (f-I converters).

The freqency/current converters 54, 56 convert the applied frequency signals of the rotational speed sensors into analog current signals. In the shown example, only the frequency signals of one sensor from the rotor shaft or one from the generator shaft are applied to the f-I converter at a time. In principle, it is also possible that both rotational speed sensor signals are applied to the f-I converter. It is also conceivable that it may be switched over between the rotational speed sensors purposefully (not shown).

The currents signals of the f-I converters 54, 56 are applied to a conversion calculation module 58, which converts the corresponding current values into a rotational speed of the generator shaft 22 and applies it to the central controller 46 of the wind turbine.

In the operation of the wind turbine, the control of the generator and/or of the converter takes place by the central controller 46 for the operation management at active operating equipment switching unit 60, which permits the operation of the wind turbine. In this, the values relating to the rotational speed of the generator shaft 22 necessary for the control are provided by the conversion module 58.

Patentkrav

1. Vindenergianlæg med et apparat til overvågning af et omdrejningstal i vindenergianlægget, og hvor vindenergianlægget har en rotoraksel (14), som drives af en rotor og indmunder i en drivenhed (16), en generatoraksel (22), som forbinder en udgangsaksel i drivenheden (16) med en generator/omformerenhed (24),

- en første omdrejningstal-affølingsenhed (26) gældende for rotorakselen (14), og en anden omdrejningstal-affølingsenhed (34) gældende for generatorakselen (22),

- og en udnyttelsesenhed (32) for omdrejningstallet, i hvilken nogle målte signaler (28, 30, 36, 36, 38) fra omdrejningstal-affølingsenhederne (26, 34) anvendes, og hvor der, hvis en bestemt maksimalværdi for omdrejningstallet er overskredet, kan frembringes et fejlsignal vedrørende et for højt omdrejningstal, **kendetegnet ved, at** hver omdrejningstal-affølingsenhed (26, 34) omfatter mindst to uafhængigt af hinanden arbejdende omdrejningstal – følere – og at udnyttelsesenheden (32) for omdrejningstallet i den første omdrejningstal-affølingsenhed (26), idet der tages hensyn til et drevomsætningsforhold, er indrettet til at kunne sammenligne de målte værdier (28, 30, 36, 38) fra den første omdrejningstal-affølingsenhed (26) med de målte værdier fra den anden omdrejningstal-affølingsenhed (34) og - såfremt der foreligger en afvigelse i omdrejningstal-værdien med mere end en forudbestemt tærskelværdi - kan frembringe et fejlsignal for en akselfejl.

2. Vindenergianlæg ifølge krav 1, **kendetegnet ved, at** udnyttelsesenheden er forbundet med en sikkerhedskæde (44) hørende til en central styreenhed (46) og/eller med en drivmiddel-indkoblingsmulighed (60) i vindenergianlægget.

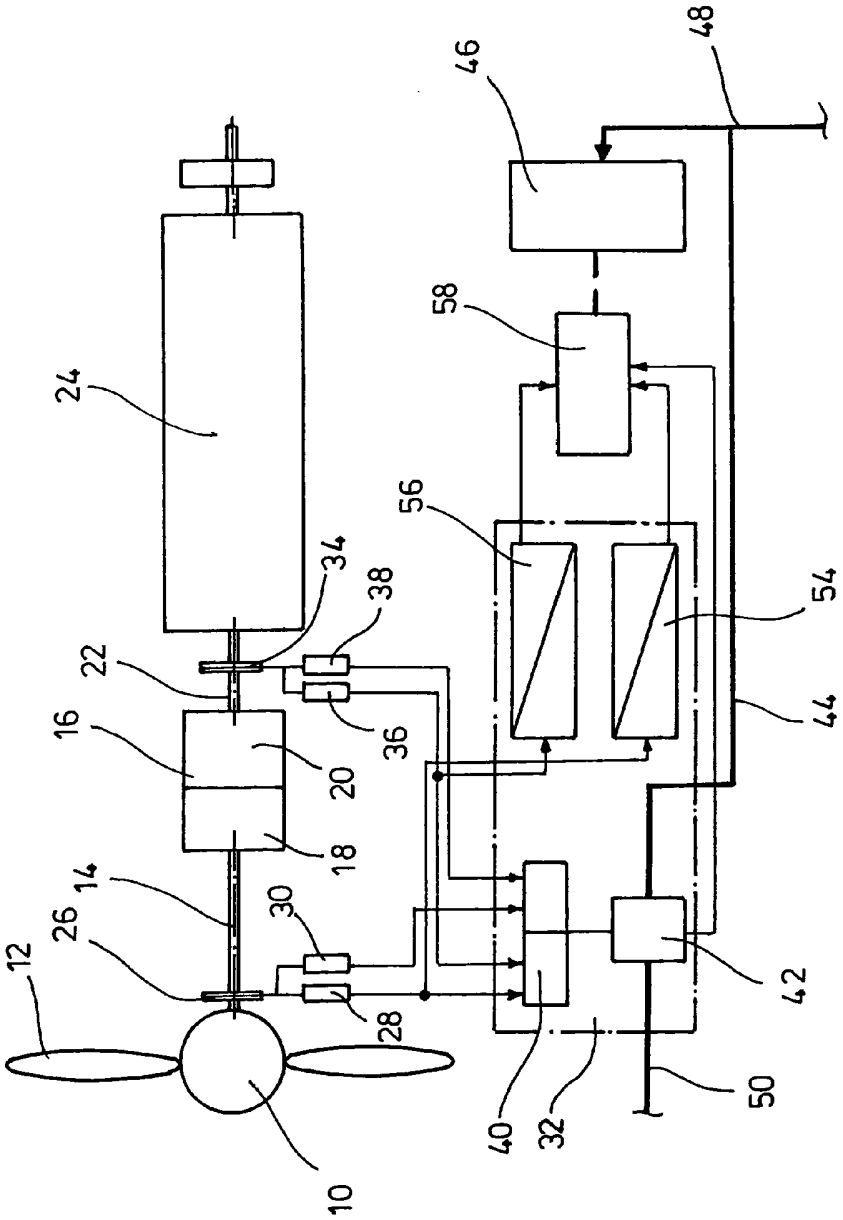
3. Vindenergianlæg ifølge krav 1 eller 2, **kendetegnet ved, at** udnyttelsesenheden (32) er således udformet, at den i forbindelse med visse forud bestemte driftstilstande ikke frembringer et fejlsignal i forbindelse med et for højt omdrejningstal og/eller en akselfejl.

4. Vindenergianlæg ifølge et af karvene 1 til 3, **kendetegnet ved, at** hver omdrejningstal-affølingsenhed (26, 34) har mindst to sendeskiver.

5. Vindenergianlæg ifølge krav 4, **kendetegnet ved, at** hver omdrejningsføler omfatter en på akselen monteret sendeskive, hvis omdrejning kan konstateres optisk, mekanisk, elektrisk eller magnetisk.

6. Vindenergianlæg ifølge et af kravene 1 til 5, **kendetegnet ved, at** der som sendeskive er tilvejebragt en fortandet skive, der i det mindste i sine tænders område er overtrukket med en korrosionsbeskyttelse.

7. Vindenergianlæg ifølge et af kravene 1 til 6, **kendetegnet ved, at** udnyttelsesenheden (32) for omdrejningstallet er således udformet, at den kan videresende en faktisk-værdi for generatorakselens omdrejningstal til en styring for generatoren (14) og/eller til dennes sidstnævntes ensretter.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