Internal distribution code:

(A) [-] Publication in OJ
(B) [-] To Chairmen and Members
(C) [-] To Chairmen
(D) [X] No distribution

Datasheet for the decision of 6 November 2020

Case Number: T 0578/18 - 3.2.04

Application Number: 12166371.0

Publication Number: 2520793

IPC: F03D7/02, F03D11/00

Language of the proceedings: EN

Title of invention:
Methods and apparatus for controlling wind turbine thrust

Patent Proprietor:
General Electric Company

Opponent:
Siemens Aktiengesellschaft

Headword:

Relevant legal provisions:
EPC Art. 54, 56

Keyword:
Novelty - (yes)
Inventive step - (yes)

Decisions cited:

Catchword:

Europäisches Patentamt
European Patent Office
Office européen des brevets

Beschwerdekammern

Boards of Appeal

Chambres de recours

Boards of Appeal of the
European Patent Office
Richard-Reitzner-Allee 8
85540 Haar
GERMANY
Tel. +49 (0)89 2399-0
Fax +49 (0)89 2399-4465

Case Number: T 0578/18 - 3.2.04

D E C I S I O N
of Technical Board of Appeal 3.2.04
of 6 November 2020

Appellant: (Opponent)	Siemens Aktiengesellschaft Werner-von-Siemens-Straße 1 80333 München (DE)
Respondent: (Patent Proprietor)	General Electric Company 1 River Road Schenectady, NY 12345 (US)
Representative:	Zimmermann & Partner Patentanwälte mbB Postfach 330 920 80069 München (DE)
Decision under appeal:	**Decision of the Opposition Division of the European Patent Office posted on 3 January 2018 rejecting the opposition filed against European patent No. 2520793 pursuant to Article 101(2) EPC.**

Composition of the Board:

Chairman	A. de Vries
Members:	S. Oechsner de Coninck
	W. Van der Eijk

Summary of Facts and Submissions

I. The appellant (opponent) lodged an appeal, received on 28 February 2018, against the decision of the Opposition Division dated 3 January 2018 to reject the opposition against the European patent EP 2 520 793, and paid the appeal fee the same day. The statement setting out the grounds of appeal was filed on 2 May 2018.

II. Opposition had been filed against the patent as a whole and based on Article 100(a) in conjunction with Articles 52(1), 54(2) and 56 EPC. The Opposition Division had held that the grounds for opposition mentioned in Article 100(a) EPC did not prejudice the maintenance of the granted patent, having regard to the following documents in particular:

D1: EP 2 063 110 A1
D2: EP 2 400 153 A2
D3: US 2010/133827
D4: EP 2 133 563 A1

III. In a communication in preparation for oral proceedings the Board gave its preliminary opinion on the relevant issues.

IV. Oral proceedings were held on 06 November 2020.

V. The appellant requests that the decision under appeal be set aside and that the European patent No. 2520793 be revoked.

VI. The respondent requests that the appeal be dismissed and the patent thus be maintained as granted, or auxiliarily, the appealed decision be set aside and the patent be maintained in amended form according to one of auxiliary requests 1-3, filed with letter of 7 September 2018.

VII. The independent claims as granted read as follows:

1. "A method for controlling wind turbine thrust, the method comprising:
measuring a tilt angle (42) of a wind turbine (10) in a loaded position using a measuring device (100), the wind turbine (10) comprising a tower (12), a nacelle (16) mounted on the tower, a rotor (20) coupled to the nacelle, and a plurality of rotor blades (22) coupled to the rotor whereby the measuring device (100) comprises an accelerometer (120); characterized by:
comparing the tilt angle (42) to a predetermined tilt angle for the wind turbine (10); and
if the tilt angle (42) exceeds the predetermined tilt angle, adjusting a pitch of at least one of the plurality of rotor blades (22) such that the tilt angle (42) is less than or equal to the predetermined tilt angle."

8. "A wind turbine (10), comprising:
a tower (12);
a nacelle (16) mounted on the tower;
a rotor (20) coupled to the nacelle;
a plurality of rotor blades (22) coupled to the rotor;
a measuring device (100) configured to measure a tilt angle of the wind turbine in a loaded position whereby the measuring device (100) comprises an accelerometer (120); and characterized by:

a control system in communication with the measuring device (100), the control system configured to compare the tilt angle to a predetermined tilt angle for the wind turbine and, if the tilt angle (42) exceeds the predetermined tilt angle, adjust a pitch of at least one of the plurality of rotor blades (22) such that the tilt angle is less than or equal to the predetermined tilt angle."

VIII. The appellant argues as follows:
D1 is novelty destroying and in particular discloses a reference value of the inclination that may be clamped and therefore anticipates the predetermined tilt angle.
D2 also anticipates all the steps and features of claims 1 and 8 when considering an inclination angle perpendicular to the surface as the predetermined reference.
Starting from D3 the skilled person would obviously translate the comparison of thrust values derived from the inclination of the wind turbine as equivalent or at least directly adaptable as the step of comparing tilt angles according to claim 1.

IX. The respondent argues as follows:
D1 discloses a dynamic system with a varying reference value and fails to disclose a fixed reference value of the tilt angle.
D2 fails to disclose a comparison of the sensed inclination angle with a reference value.
As for inventive step, starting from D3 the skilled person would not obviously depart from the control system based on a comparison of the current thrust of the rotor with a limit thrust value.

Reasons for the Decision

1. The appeal is admissible.

2. Background of the invention - interpretation of claims 1 and 8

2.1 The patent is concerned with a method and apparatus for controlling the thrust on the wind turbine.
As explained in paragraph 003 damage or failure should be avoided that may occur in operation when excessive thrust causes the tower to bend past a limit point. Estimating the thrust on the basis of the actual power produced depends on several extraneous factors described in paragraph 004, such as icing, fouling or pitching errors, all being detrimental to precision. The patent therefore seeks to increase accuracy of the rotor thrust control. According to claims 1 and 8 this is done by comparing a measured tilt angle of the wind turbine with a predetermined (threshold) value and pitching the angle of the blades such that the tilting angle remains below the predetermined value. The tilt angle 42 is expressed in paragraph 016 as the angle between the wind direction 28 that is substantially horizontal, parallel to the ground, and the axis 30 of the rotor 18.

2.2 The final pitch adjustment feature of both claims 1 and 8 pitch angle refers to "*the* predetermined tilt angle" (emphasis added) in the singular, which finds its antecedent in the preceding comparison feature referring to "a predetermined tilt angle", also in the singular. The two features define a control loop, in which the tilt angle (that measured in the preamble) is compared with the predetermined angle, and if it exceeds that value, pitch adjusted to bring the tilt angle back down to a value below or equal to the predetermined value. These features are easily understood by the skilled person using normal reading skills and with their mind willing to understand. Thus, from simple syntax and grammar, in particular the consistent use of articles in the singular, the skilled person understands "predetermined tilt angle" to refer to a single, specific value of tilt angle. Reading the claim wording contextually and using their normal understanding of terms, they further understand "predetermined" to mean determined in advance of the comparison that drives the control loop.

Nor is there anything in the detailed description or drawings that might suggest otherwise, cf. paragraphs 0019, 0021 and 0028. Thus, paragraph 0019 states that the predetermined tilt angle may be a maximum tilt angle, or the sum of "the first angle 44 and the maximum second angle 46". The latter may be a maximum angle before damage or failure and may include a factor of safety, or it may be calibrated with respect to a single, specific reference position, paragraph 0021. Subsequent comparison is then either with the sum or with the calibrated value, paragraph 0028. To the skilled reader these passages unequivocally suggest that the predetermined tilt angle is a well defined value, which allows straightforward subsequent comparison.

2.3 Tilt angle is not defined in the claim itself. However, the description, paragraph 0016, 2nd sentence, defines it as the angle between horizontal wind direction and the rotor axis. As follows from this paragraph and the paragraph 0017, due to thrust from wind acting on the rotor this angle increases in value from an unloaded position (figures 2 and 4, no wind) to its loaded position in which the tower is bent(figures 3 and 5). Paragraph 0018 then goes on to explain that accurate thrust control can limit tilt angle so as not to exceed a predetermined tilt angle, which, paragraph 0019, corresponds to a maximum value the turbine can endure. This is to be read in context with paragraph 0003 relating to excessive thrust and bending. Reading the final requirement of claims 1 and 8 in this context the skilled person understands that the unique value of the predetermined tilt angle, that should not be exceeded, is a positive non-zero value.

3. Main request - Novelty

3.1 Novelty with respect to D1

3.1.1 D1 discloses a method of damping tower vibrations of a wind turbine (paragraph 001) using a dynamic inclination control system. The method relies on a pitch controller connected to a pitch actuator system, with damping achieved by setting the pitch of the rotor blades (paragraph 009). Actively controlling a pitch angle of the rotor blades implicitly modifies the rotor's thrust, and this known method can therefore also be regarded as controlling the wind turbine thrust in the sense of claim 1.

3.1.2 The inclination control system shown in figure 1 comprises three inputs: an actual rotor speed 1, a speed reference input 3 and the inclination signal input 5 representing the inclination of the tower (paragraph 034). The inclination signal 5 representing the inclination value of the wind turbine is either sensed by an inclination sensor or derived from sensing the fore-aft acceleration (paragraph 042), with the latter corresponding to the case where an accelerometer is used as required by claim 1.

3.1.3 The gist of the D1 disclosure is the use of a modification unit 9 that generates a modified speed reference value representing a modification that takes into account tower vibrations (paragraph 009), thus avoiding coupling between resonant modes. The speed error signal calculated in the subtractor 11 compares the actual rotor speed and the modified speed reference calculated in the modification unit 9 and serves as an input to control the pitch. Thus the control parameter that is fed to the pitch controller of D1 is actively modified in advance to avoid that the pitch command signal results in driving the wind turbine at rotor speeds that correspond to detrimental resonant vibration frequency modes of the tower.
The pitch controller 13 that is the final control unit of D1 is detailed in paragraph 38 to 40 in reference to figure 2, and comprises a speed controller 15, an inclination controller 17 and a second subtractor 19 that output the final command signal for adjusting the blade pitch. This is done in the pitch controller as follows: the speed controller 15 establishes an inclination reference signal on the basis of the received speed error signal. This inclination reference signal is the output signal of the speed controller and is compared to the measured inclination signal 5 in the subtractor 19.

3.1.4 It follows from the above that the inclination reference signal is generated dynamically and thus adopts a variable, gliding value as it is calculated by the speed controller 15 in real time. In the Board's understanding of claims 1 and 8, see above, this dynamically varying inclination reference value does not correspond to the single, specific value that is the predetermined tilt angle of claims 1 and 8. Nor can such a reference value fairly be construed as "predetermined", that is set in advance, in the sense of the invention defined in claims 1 and 8. Even if *schematically* in figure 2 speed controller 15 precedes inclination controller 17, such an electronic circuit practically speaking operates instantaneously with no temporal differentiation between input and output that warrants the qualification of the former as "predetermined" in its normal technical sense.

3.1.5 The appellant also considers the possibility expressed in paragraph 017 that the inclination reference value may be clamped to a given value, to correspond to a single tilt angle that has been determined in advance. In the Board´s understanding, clamping however refers to the process of limiting the amplitude of a varying signal. This is entirely in keeping with the aim of avoiding large tower movements caused by wave loads as stated in paragraph 0017: when unchecked such wave loads would cause the reference value to vary excessively resulting in excessive or over corrective action and the system would "overshoot". Thus, rather than implying that the inclination reference value is set to a predetermined value, this sentence merely suggests setting bounds to the amount by which the reference signal may vary. It does not however change the dynamically varying nature of the reference signal, which is therefore still not "predetermined" in the normal sense of that term.

3.1.6 As D1 does not disclose comparison of (measured) tilt angle with a "predetermined tilt angle" as that term is understood by the Board, it also does not disclose the final feature of claim 1 of adjusting pitch when that value is exceeded.

3.2 Novelty with respect to D2

3.2.1 D2 is a European patent application published after the priority date of the present patent but claiming an earlier priority date. It thus belongs to the state of the art according to Article 54(3) EPC, i.e. is relevant to the question of novelty only.

3.2.2 D2 relates to the control of the operation of a floating wind turbine (paragraph 001). To improve stability in this type of floating wind turbine (paragraph 003, last sentence), based on a measurement of the tower inclination, operating parameter control values are determined that serve to adjust wind turbine operation. The operating parameters help to maintain a maximum wind swept area of the rotor (paragraph 010). An acceleration sensor may be used to measure an inclination angle 140 and an inclination direction 138 (paragraph 021, figures 4,5). The inclination angle 140 is measured relative to a normal to the water surface 112 and represents an inclination with respect to an ideal inclination of, for example, 0° (paragraph 027). As further detailed in that paragraph, it is sought to maintain the rotor perpendicular to the wind direction 122 by changing the yaw of the nacelle 12, and thus to maximise the wind swept area 206 of the rotor (paragraph 028).

3.2.3 The appellant specifically refers to the adjustment of the pitch disclosed in paragraph 034. This adjustment concerns the case where the inclination direction of the wind turbine tower is perpendicular to the wind direction (sentence bridging column 10 and 11). In this case the pitch angle of the rotor blades is adjusted towards feathering to reduce the inclination angle in the same direction as the wind or away from feathering to reduce the inclination angle in the opposite direction. Adjusting wind turbine operation based on wind turbine inclination is effected to maximize the output power, by a compromise between optimum blade angle (i.e. its pitch angle) and optimum tower inclination (paragraph 034, last sentence).

3.2.4 In the control logic of D2 the pitch control is actively effected towards or away from feathering of the blade as soon as the sensed inclination is measured in the same direction as the wind or in a direction against it. Establishing that the measured wind tower inclination is different from zero (and it is thus leaning into or away from the wind) and controlling a pitch angle to reduce the measured inclination towards the vertical is, the Board holds, not the same as adjusting pitch when tilt angle exceeds a predetermined value to bring it down below or equal to that value, see above. In particular, as indicated in section 2.3, the predetermined tilt angle of claims 1 and 8 is a positive, non-zero value and thus does not correspond to the vertical (0°) tilt angle of D2, that the appellant has identified as the relevant reference value for comparison.

3.2.5 The appellant further submits that the accelerometers must be calibrated implying a calibration reference value against which measurement signals are compared and which would thus constitute a "predetermined value" in the sense of claim 1.
This may correspond or be analogous to the calibration described in paragraph 0021 of the patent with respect to an unloaded or rest position. However, such a

calibration value is not used as a threshold value to decide whether or not to adjust pitch and is thus different from the predetermined value of the characterizing features of claims 1 and 8 used to control pitch.

3.3 It follows from the above that the subject-matter of claim 1 is novel with respect to the disclosures of both D1 or D2. This conclusion also holds for the wind turbine of claim 8 that defines the steps of claim 1 in terms of corresponding functional limitations. The Board thus confirms the findings of the Opposition Division in respect of novelty.

4. Main request - inventive step

4.1.1 D3 discloses a method and system for controlling a wind turbine. The control system includes a sensor to measure an angle of inclination of the tower with respect to a surface, a pitch assembly to adjust a pitch angle of the rotor blade, and a control system to control the pitch assembly or the generator based on the measured angle of inclination (paragraph 005). More particularly, according to paragraph 026 the control system can adjust the pitch angle of the rotor blades when, for example, a calculated thrust force is greater than a desired value of thrust.

4.1.2 According to paragraph 023 the control system 150 uses the measured angle of inclination 162 of the tower to calculate (step 204) the thrust force induced in the wind turbine 100 by the wind. To this end the control system 150 may also use a lookup table to determine an amount of force required to bend tower 102 by an amount approximately equal to the angle of inclination, and thereby derive a thrust value from the measured inclination (paragraph 023, sentence bridging pages 2 and 3). This calculated thrust is used by the control system to avoid exceeding the desired value of thrust as explained in paragraph 026. More particularly, the control system 150 increases the pitch angle when the calculated thrust force is greater than a desired thrust force of wind turbine, and therefore avoids exceeding the desired value of thrust.

4.1.3 The appellant considers that the comparison of a thrust derived from the measurement of an inclination and compared to a certain limit thrust that must also correspond to a certain inclination value to be equivalent to a direct comparison of the corresponding actual and limit tilt angle values as in claim 1.

4.1.4 The Board disagrees. Even if the inclination and thrust are directly related by the use of the lookup table that relates a measured value of inclination to a single value of thrust, there is no indication in D3 that the inclination signal can itself be used or compared. Even if directly related the two values represent different operating parameters. Thus, where D3 explicitly considers comparing either thrusts values or even generator torque values, that differs from directly comparing inclination values.

4.1.5 Therefore, the method of claim 1 differs from D3 by comparing the tilt angle to a predetermined tilt angle; and adjusting a pitch of at least one of the plurality of rotor blades such that the tilt angle is less than or equal to the predetermined tilt angle. Otherwise it is undisputed that D3 also does not disclose an accelerometer as measuring device for measuring tilt angle.

4.1.6 Compared to calculating and comparing thrust as in D3, using the measured tilt angle to directly compare it with a predetermined angle, allows to adjust the pitch in an accurate manner (paragraph 004 of the patent). The objective technical problem can thus be formulated as in paragraph 006 of the patent, namely how to more accurately control wind turbine thrust

4.1.7 D4, see paragraph 020, is cited as teaching the known use of an accelerometer for measuring the inclination of the wind turbine. Even if it might be obvious in the light of D4 to use an accelerometer for measuring the inclination measured in D3, the Board is unconvinced that the skilled person would then also, in a further step and as a matter of obviousness, modify D3's teaching to compare tilt angles (however they are measured) rather than thrust values.

4.1.8 The Board agrees that measuring inclination and using this measured value to derive a corresponding thrust value to be compared with a limit thrust value, seems to be a particularly complicated way of realizing the core idea of D3 expressed in claim 1, see also paragraph 0031, namely of controlling pitch based on a measured angle of inclination. However, the focus in D3 is squarely on torque or thrust force. Thus, D3´s main aim is to reduce damage to wind turbine components due to torque or thrust force generated, paragraph 003, first four sentences. In the following lines it considers then known methods of thrust force measurement and open loop control as inadequate for not providing an effective or accurate measure of thrust force. In paragraph 0012 it then proposes measuring angle of inclination, but that inclination is then used to derive other turbine properties for comparison to desired operating parameters. In the exemplary, detailed embodiments, see figures 3 and 4, paragraph 0022 onwards, thrust force is cited as the main example of an operating property to be derived from inclination angle and used for control, though other derived properties such as wind speed are also considered. This operation is based on the conversion of inclination measurement signals (first sentence of paragraph 023) into values of thrust using a lookup table or a "tower model" (last sentence of paragraph 023). The gist of D3's disclosure read in its totality will be clear to the skilled person: measure inclination angle in order to *derive* a control parameter.

For the skilled person to realise that the inclination of the tower may itself be a suitable control parameter, given D3´s exclusive focus on derived parameters, in particular thrust or torque, in the Board's opinion requires a special insight beyond routine considerations. Taking the scheme of figure 3 as example, there appears to be no obvious reason to depart from the control logic shown there measuring angle of inclination of the tower, calculating or reading a corresponding thrust value, comparing the value obtained with a threshold thrust value and adjusting pitch angle of the blade based on that comparison. This is especially so, as the inclination measurement signals also serve to derive other properties used in the control system such as wind properties (rated or desired wind speed, acceleration; paragraphs 024 and 025) or wind turbine operating properties (paragraph 025), which could, as suggested in paragraph 025, also be used for control purposes.

D3 does describe then known methods of measuring the displacement of the tower or nacelle in order to derive a value of the wind speed, or on monitoring the power output of the generator (paragraph 004). None of these suggest to the skilled person that inclination of the tower can itself be used as a control parameter.

4.1.9 The appellant also argues that when drawing up the lookup table or wind turbine model at the design phase of the wind turbine, the skilled person will as a matter of course take into account limit values for all operating parameters, including for inclination angle. In the example of the lookup table they would realize that just as all other thrust values the limit thrust value will also have a corresponding limit value for inclination angle.

The Board is not convinced, even if a given wind turbine might be designed for a rated limit value of inclination among other design characteristics. Realising that, among the many rated design parameters, the one for inclination might be used directly as control parameter in the control system of D3 again requires a special insight, which similar to that discussed above, goes well beyond routine skill.

4.2 It follows from the above that the subject-matter of claim 1 involves an inventive step starting from D3 in view of D4. This conclusion also holds for the wind turbine of claim 8, which recites the steps of claim 1 in terms of corresponding functional limitations. The Board thus confirms the opposition division's positive assessment of inventive step.

5. In the light of the above, the Board confirms the opposition division's decision to reject the opposition, Article 101(2) EPC. Thus there is no need for the Board to consider the respondent's auxiliary requests.

Order

For these reasons it is decided that:

The appeal is dismissed

The Registrar: The Chairman:

G. Magouliotis A. de Vries

Decision electronically authenticated