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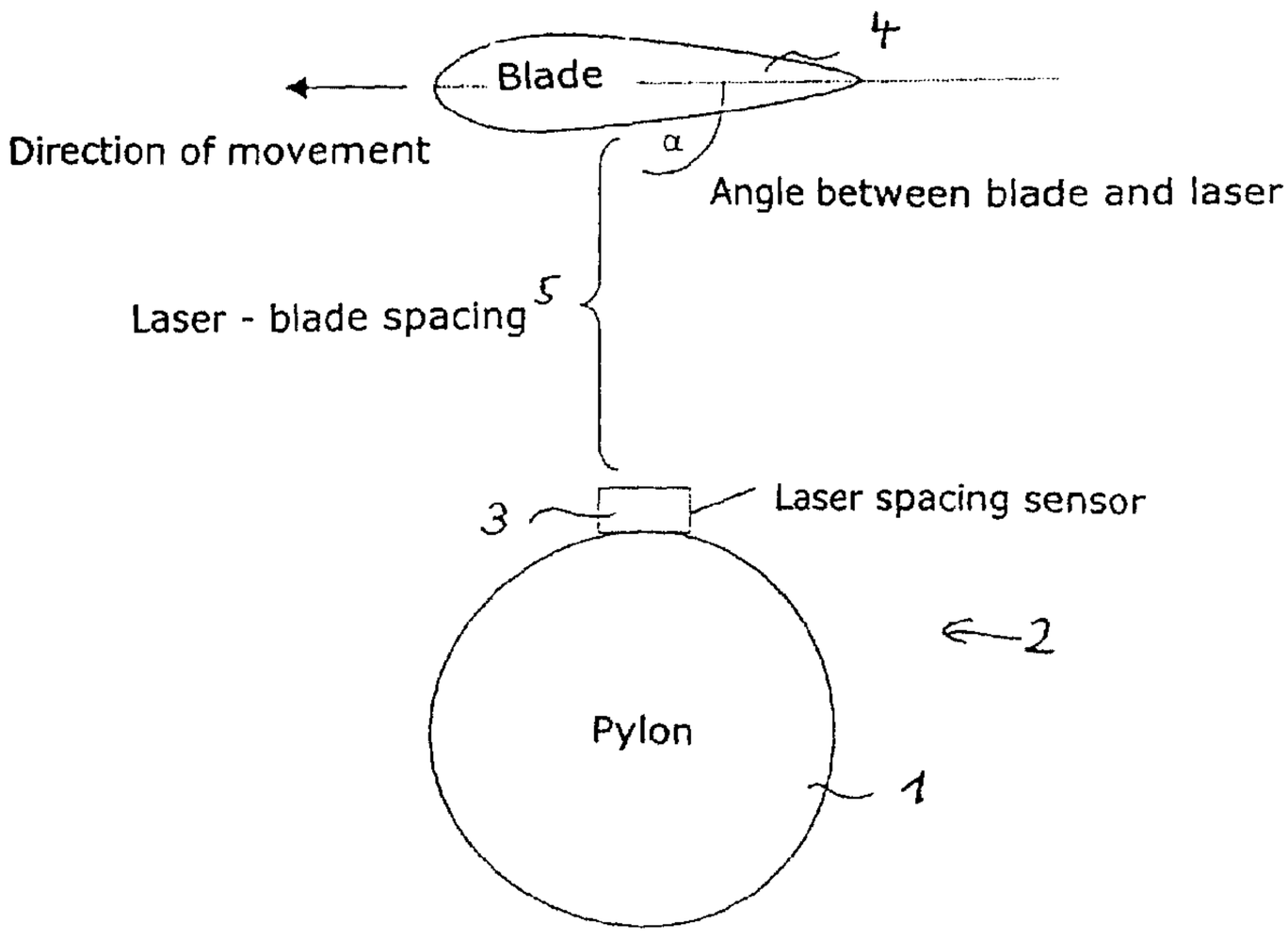
(54) Titre : PROCEDE POUR DETERMINER L'ANGLE D'UNE PALE DE ROTOR D'UNE INSTALLATION A ENERGIE EOLIENNE

(54) Title: METHOD FOR DETERMINING THE ANGLE OF A ROTOR BLADE PERTAINING TO A WIND ENERGY INSTALLATION



(57) Abrégé/Abstract:
In pitch-regulated wind power installations the angles of the rotor blades can be adjusted synchronously (standard construction) or independently of each other. The construction for adjustment independently of each other is described in patent application DE 197 31 918. That design can also be referred to as on-line individual blade adjustment. Both in the standard construction and also in the arrangement involving on-line individual blade adjustment, it is important that an initial blade angle, for example feathered position or maximum blade angle, can be set with a sufficient degree of accuracy. The object of the present invention is to avoid the above-discussed disadvantages so that it is possible to more quickly ascertain the correct blade angle and the results are more accurate than hitherto and also measurement from the ground is possible, while the entire measuring equipment should be easily disconnected so that simple transportation of the measuring equipment is also possible. A method of accurately determining the angle of a rotor blade of a wind power installation, wherein the spacing between the rotor blade and the pylon of the wind power installation is ascertained, the ascertained data are processed in a computer, and the angle (α) between a rotor blade and the spacing measuring device is determined from the stored values.

Abstract

In pitch-regulated wind power installations the angles of the rotor blades can be adjusted synchronously (standard construction) or independently of each other. The construction for adjustment independently of each other is described in patent application DE 197 31 918. That design can also be referred to as on-line individual blade adjustment. Both in the standard construction and also in the arrangement involving on-line individual blade adjustment, it is important that an initial blade angle, for example feathered position or maximum blade angle, can be set with a sufficient degree of accuracy.

The object of the present invention is to avoid the above-discussed disadvantages so that it is possible to more quickly ascertain the correct blade angle and the results are more accurate than hitherto and also measurement from the ground is possible, while the entire measuring equipment should be easily disconnected so that simple transportation of the measuring equipment is also possible.

A method of accurately determining the angle of a rotor blade of a wind power installation, wherein the spacing between the rotor blade and the pylon of the wind power installation is ascertained, the ascertained data are processed in a computer, and the angle (α) between a rotor blade and the spacing measuring device is determined from the stored values.

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Method of determining the angle of a rotor blade of a wind power installation

In pitch-regulated wind power installations the angles of the rotor blades can be adjusted synchronously (standard construction) or independently of each other. The construction for adjustment independently of each other is described in patent application DE 197 31 918. That design can also be referred to as on-line individual blade adjustment. Both in the standard construction and also in the arrangement involving on-line individual blade adjustment, it is important that an initial blade angle, for example feathered position or maximum blade angle, can be set with a sufficient degree of accuracy.

When the synchronous mode of operation is involved, it is necessary to ensure moreover that all blades are adjusted to the same angle, that is to say the relative angle of the rotor blades with respect to each other is equal to zero.

Maladjustments of the rotor blade angles can result in defective operation (wrong rotary speed-output power characteristic) or unbalance phenomena (and thus pylon oscillations and vibrations). That also results in increased loadings on the components of the installation.

Such maladjustments can arise for example from manufacturing tolerances (or manufacturing errors) such as for example displaced zero degree markings or displaced blade connecting bolts.

If after the wind power installation has been brought into operation defective blade angle settings are suspected, hitherto operation was implemented with blade jig templates. They were pushed over the blade tips as far as a defined position on the rotor blade. With the blade in a horizontal position a sensor on the jig template measures the angle of the plane of the blade to the surface of the earth (plumb angle). By further 180° rotation of the rotor and renewed measurement, possible inclined positionings of the pylon or any rotor axis angles that may be present are

averaged out and the procedure gives the absolute angle of the respective rotor blade.

Even if nowadays sensor systems permit wireless data transmission, that method is really complicated and expensive, this applying in particular in regard to large rotor blades and the large jig templates which are necessary for same.

The object of the present invention is to avoid the above-discussed disadvantages so that it is possible to more quickly ascertain the correct blade angle and the results are more accurate than hitherto and also measurement from the ground is possible, while the entire measuring equipment should be easily disconnected so that simple transportation of the measuring equipment is also possible.

The specified object is attained by a method having the following features:

A method of accurately determining the pitch angle of at least one rotor blade of a wind power installation, the method comprising the steps of:

a. along at least a portion of the surface of the rotor blade, measuring a spacing between each of a plurality of surface points of the rotor blade and a pylon of the wind power installation as the rotor blade moves past the pylon with a spacing measuring device mounted at the pylon, thereby producing measured data;

b. processing the measured data in a computer, thereby producing processed data; and

c. from the processed data determining the pitch angle between the rotor blade and the pylon.

The invention is described in greater detail hereinafter by means of an embodiment illustrated in the drawing.

Figure 1 shows a view of a wind power installation with a rotor which carries a plurality of rotor blades, and a pylon,

Figure 2 shows in this respect a view in cross-section through a wind power installation taken along line A-A in Figure 1, and

Figures 3 and 4 show measuring diagrams for scanning a rotor blade.

Mounted to the pylon 1 of the wind power installation 2 (for example a transmission-less installation) is a laser spacing sensor 3 as a spacing

measuring device. When the installation is working, that is to say therefore when a rotor blade is moved past the pylon, the spacing sensor (Figure 2) continuously measures the spacing 5 between the sensor and the blade. While a blade is moving past the pylon, the surface of the blade is therefore scanned by the laser a plurality of times (for example 40 times) and the individual different spacings are measured (as illustrated the blade is not of a uniform thickness in its transverse profile, but is markedly thicker at the leading edge than at the trailing edge of the rotor blade).

The data measured in that case (spacing values between the sensor and the respective scanned surface of the rotor blade) are stored in a computer and processed. The blade angles of the rotor blades can now be ascertained in the computer by way of mathematical functions, for example regression straight lines. In that case the angle between the blade and the spacing sensor is extremely accurately determined.

Figure 3 shows the measurement value representation when scanning a blade, wherein the illustrated example shows approximately 40 measurement points with a resolution of about 1 mm. The shape of the curve shows the lower blade profile. The spacing between the blade and the laser (spacing sensor) is indicated by the Y-axis.

Calculation of the angle between the laser and the blade can be seen from the representation in Figure 4. In this case, to calculate the blade angle, the rear portion of the blade (about 30% through 95%) is viewed in a first approximation as being straight. That region determines the regression straight line which is to be optimally adapted between the measurement points n = 30° and n = 95°. The gradient of the regression straight line (a) is a measurement in respect of the blade angle. The gradient is calculated in accordance with the following formula:

$$a = \frac{n \cdot \sum_{i=1}^{n} Xi \cdot Yi - \left(\sum_{i=1}^{n} Xi\right) \cdot \left(\sum_{i=1}^{n} Yi\right)}{n \cdot \left(\sum_{i=1}^{n} Xi^2\right) - \left(\sum_{i=1}^{n} Xi\right)}$$

The angle between the laser and the blade (in degrees) is now determined by way of $\alpha(^\circ) = \arctan(a)$.

In order to improve the measuring accuracy of the method according to the invention a plurality of blade passages are measured and the data averaged. The measurement results of the individual blades are now compared to each other. Compensation is effected on the basis of those relative angles; that is to say the blades are set to the same angle so that the relative angle becomes zero.

In order to be able to determine the 'true' blade angle, that is to say the angle between the blade and the blade hub, the angle between the laser beam and the hub must be known or they must be compared. The true blade angle can then be determined from the angle 'blade to laser beam' and the angle 'hub to laser beam'. The laser sensor can also be disposed in any other position. With suitable sensors, measurement could also be effected for example from the ground.

CLAIMS

1. A method of accurately determining the pitch angle of at least one rotor blade of a wind power installation, the method comprising the steps of:

   a. along at least a portion of the surface of the rotor blade, measuring a spacing between each of a plurality of surface points of the rotor blade and a space-measuring device mounted on a pylon of the wind power installation as the rotor blade moves past the pylon, the space-measuring device thereby producing measured data;

   b. processing the measured data in a computer, thereby producing processed data; and

   c. from the processed data determining the pitch angle between the rotor blade and the pylon.

2. A method as set forth in claim 1 wherein the pitch angles of all rotor blades of the wind power installation are determined, wherein measurement is effected in a plurality of blade passes.

3. A method as set forth in claims 1 or 2, wherein the spacing measuring device comprises a laser spacing sensor, by means of which, when the rotor blade passes the pylon, the spacings between the plurality of surface points of the blade and the sensor are measured.

4. A method as set forth in claims 1, 2 or 3, characterised in that to determine the rotor blade pitch angle, the angle between a laser beam from the laser spacing sensor and a hub is measured.

5. A method as set forth in claim 4 characterised in that to determine the rotor blade pitch angle, the angle between the rotor blade and the laser beam and the angle between the hub and laser beam is measured.

6. A method as set forth in claims 3, 4 or 5 characterised in that the spacing between the laser spacing sensor and the rotor blade is measured at a plurality of locations on the rotor blade along a surface line along in relation to the

rotor blade cross-section.

7. A method as set forth in any one of claims 1-6 characterised in that the spacing measuring device is mounted to the ground or another pre-defined position instead of the pylon of the wind power installation.

8. A method of adjusting the pitch angle of the rotor blades of a wind power installation, comprising the steps of:

a. determining the pitch angles of the individual blades of the wind power installation as set forth in any one of claims 1-7;
b. comparing the blade angles to one another, producing an average blade angle; and
c. adjusting the pitch angle of each one of said blades to equal the average blade angle so that the relative angle of all rotor blades with respect to each other is equal to zero.

9. The use of a spacing measuring device to determine the pitch angle of at least one rotor blade of a wind power installation in the method described in claim 1 , wherein the spacing measuring device measures the spacings between at least a portion of the surface of a rotor blade and a pre-defined position.

10. The use as set forth in claim 9 wherein the pre-defined position is the pylon of the wind power installation.

11. The use as set forth in claim 9 characterised in that the spacing measuring device comprises a laser spacing sensor which by means of a laser beam measures the spacings between the laser spacing sensor and the rotor blade as it moves past the laser spacing sensor.

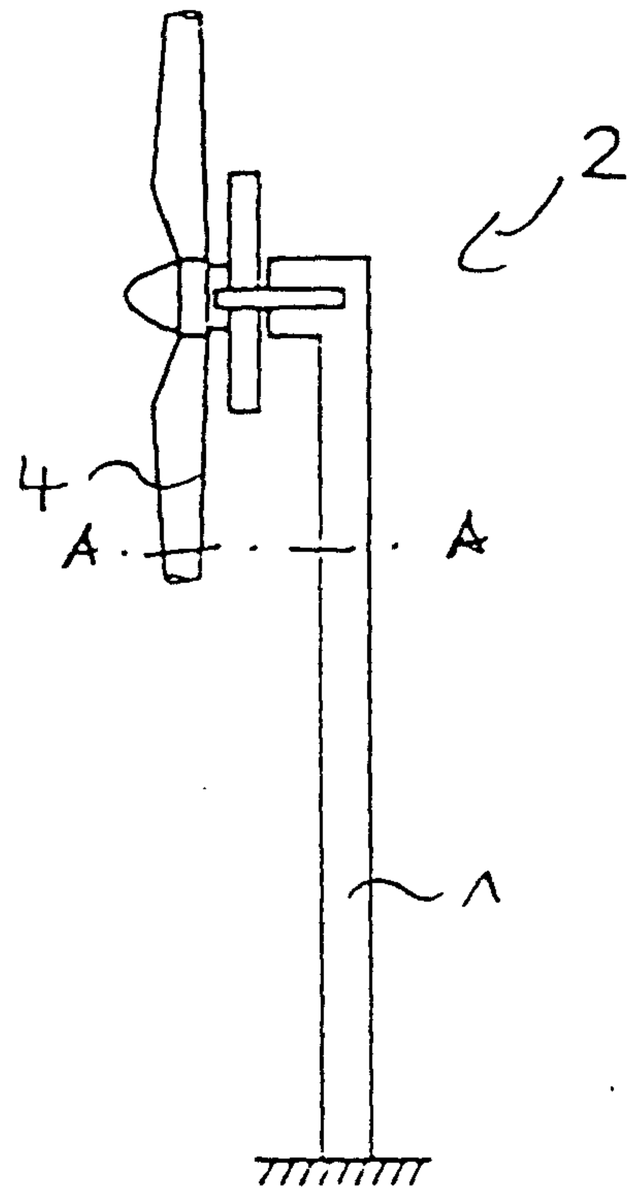

2
4
A
A

Fig. 1

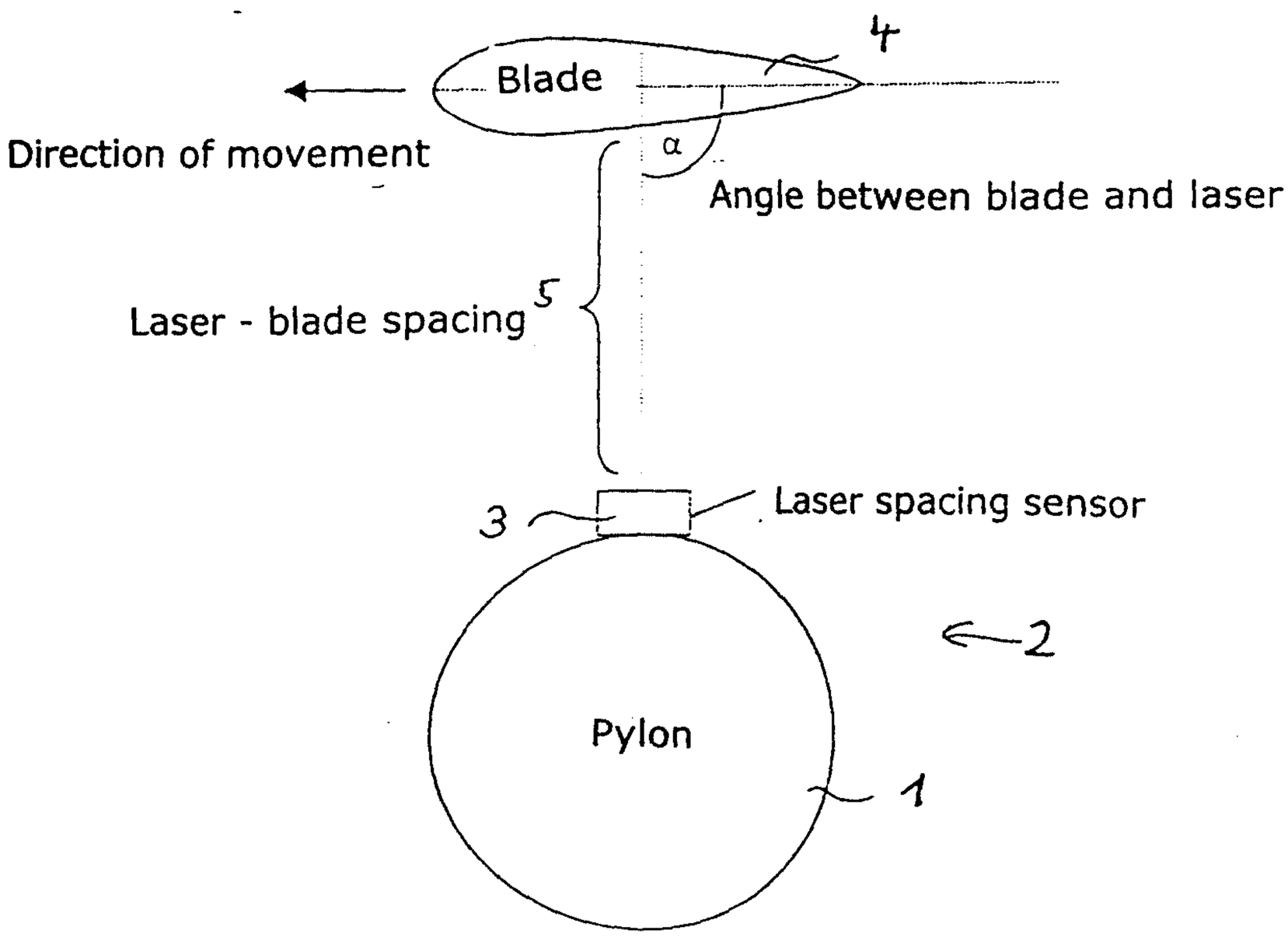

4
Blade
Direction of movement
α
Angle between blade and laser
Laser - blade spacing
5
3
Laser spacing sensor
2
Pylon
1

Fig. 2

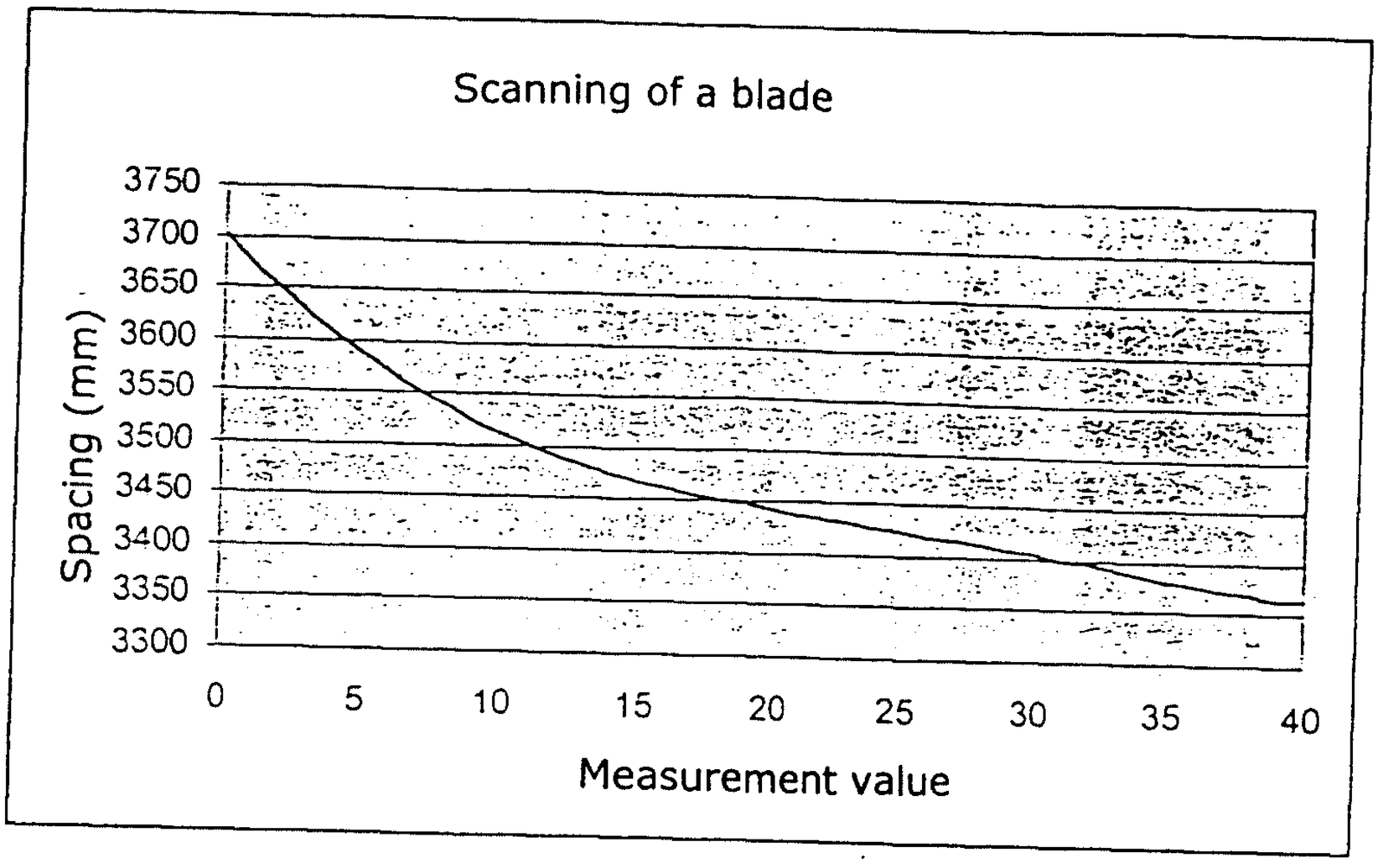
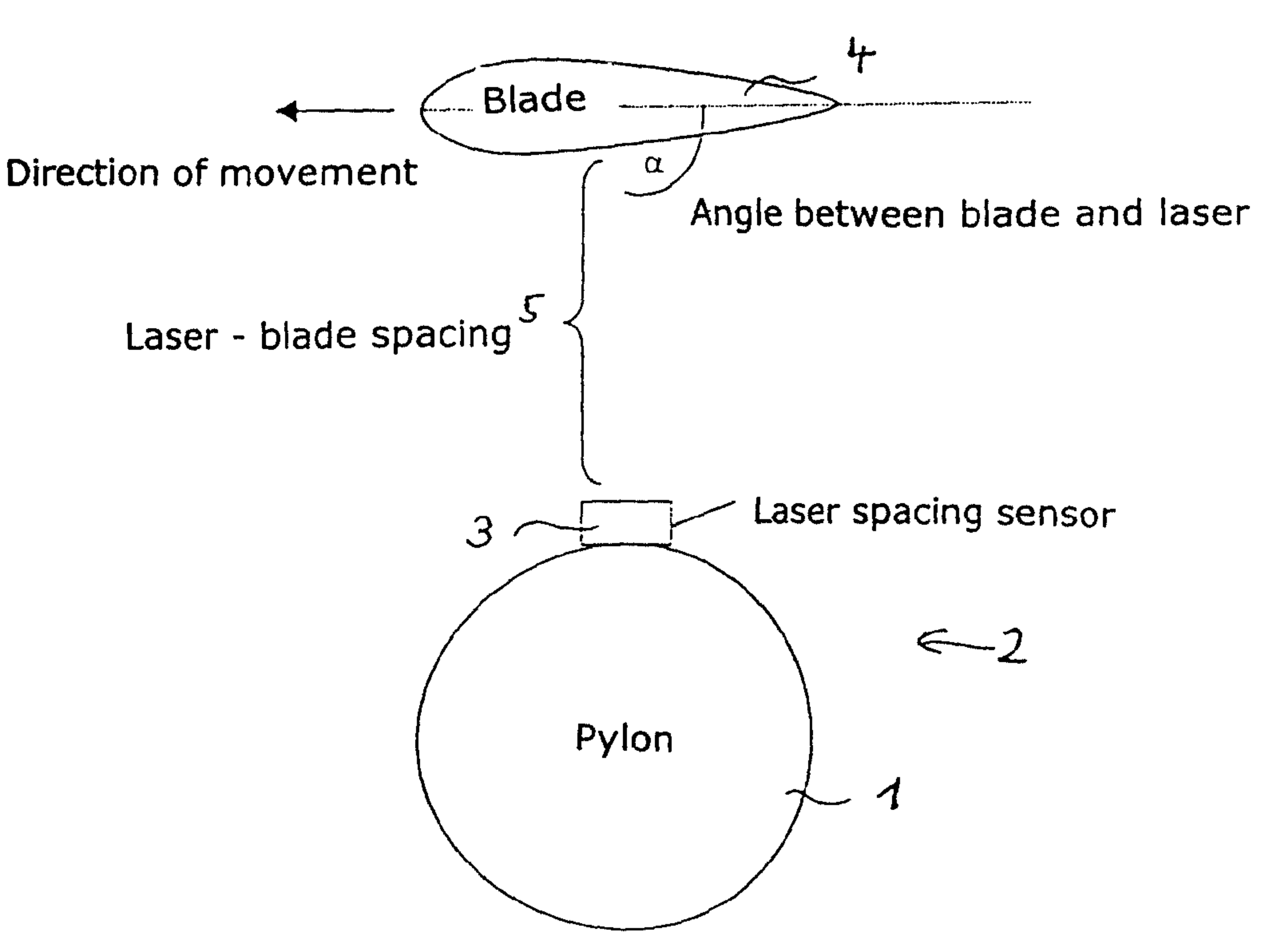

Scanning of a blade
3750
3700
3650
3600
3550
3500
3450
3400
3350
3300
Spacing (mm)
0
5
10
15
20
25
30
35
40
Measurement value

Fig. 3

Scanning of a blade
3750
3700
3650
3600
3550
3500
3450
3400
3350
3300
Spacing (mm)
0
5
10
15
20
25
30
35
40
Measurement value
Regression straight line
Blade angle α
Regression start 30%
Regression end 95%

Fig. 4


4
Blade
Direction of movement
α
Angle between blade and laser
5
Laser - blade spacing
3
Laser spacing sensor
2
Pylon
1