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METHOD FOR DETERMINING THE DISTRIBUTION CHARACTERISTICS OF A DISTRIBUTION MACHINE

Description

The invention relates to a method for determining the distribution characteristic of a distribution machine according to the preamble of Patent Claim 1.

Distribution machines, designed as centrifugal spreaders, which typically distribute agricultural material from at least preferentially two throwing discs by means of throwing blades typically two in each case arranged on the throwing discs have been the state of the art for some time. The spreadable material is accelerated in the radial direction by means of the throwing blades arranged on the rotating throwing disc through the centrifugal forces that occur and distributed in this manner. The throwing distance and geometry of the spreading fan, i.e. the range in which the spreadable material is distributed, depends on a great many factors:

- The geometry of the throwing disc influences, inter alia, the vertical ejection angle.
- The arrangement of the throwing blade on the throwing disc as well as length and geometry of the throwing blade influence the throwing speed and flying direction of the spreadable material.
- The condition of the spreadable material (grain size, grain geometry and density) influences the throwing speed and the flying speed and thus the throwing distance.
- The output point of the spreadable material on the throwing disc influences the throwing speed and the horizontal ejection angle.
- The throwing disc rotational speed likewise has repercussions on the throwing speed.

The increasing precision in agricultural technology, which aims at avoiding environmental impacts and unnecessary costs and protecting resources calls for ever more detailed adjusting possibilities of the agricultural machines. Accordingly this means that for the centrifugal spreaders that not only the quantity of the output spreadable material as well as the throwing disc rotational speed are adjustable, but that in the meantime the output point of the spreadable material on the throwing disc and the throwing blade geometry can also be adapted. Special devices for distributing the spreadable material in edge regions of an agricultural area are also known.

The adjusting of the different parameters is performed with the help of tables, formulas and/or graphs in which as a function of the spreading parameter, for example the throwing disc rotational speed, for a certain throwing disc, throwing blade and output point, the mean horizontal ejection angle, i.e. the ejection angle relative to a line which is drawn from the centre of the throwing disc against the travelling direction in the radial direction, and the mean throwing distance is indicated. Tables, formulas and/or graphs can equally be present, for the creation of which other quantities were varied, kept constant and measured (DE 36 17 377 C2, DE 33 10 424 C2).

The prior art also includes determining the ejection angle by means of sensors and making adaptations to the mentioned parameters according to the above tables, formulas and/or graphs upon deviation regarding a predetermined set point value (DE 38 87 218T2, DE 197 23 359 A1). Here it is provided, in particular, to detect the mass distribution of the spreadable material during the distribution process. In order to achieve a satisfactory result in the process, it is required for example to either move a sensor in small steps over the width of the spreading range in order to determine the transverse distribution of the spreadable material, which means a great time expenditure. Alternatively, many sensors can be arranged so that a detection of the entire spreading range is ensured.

It should be noted that in the case of two-disc spreaders an overlapping region occurs in each case, in which spreadable material particles are output by both throwing discs. Since the adjustment of the spreadable material parameters of both throwing discs has an effect on the distribution characteristic in this overlapping region, this has to be taken into account during the closed-loop control. Furthermore, an overlapping region also exists directly on the spreader, where a sensor device detects the fertiliser particles of both throwing discs. This can lead to deviations in the measurement result. This is true more so for spreaders in the case of which the distribution characteristic, assuming a symmetrical distribution, is only measured by means of sensors for one throwing disc.

Thus, the problem of the prior art to be solved consists in that during the determination of the distribution characteristic in particular of the mean ejection angle of a centrifugal spreader inaccuracies occur in the region between the throwing discs.

The object of the present invention therefore is to solve the aforementioned problem of the prior art and determine an improved and more accurate determination of the distribution characteristic, in particular of the mean ejection angle, of the spreadable material of a throwing disc of a fertiliser spreader.

This is achieved through a method for determining the distribution characteristic of a distribution machine according to the preamble of Patent Claim 1, wherein the determining and/or adjusting of the mean ejection angle of the spreadable material of at least one of the throwing discs taking into account the overlapping region of the spreading fan is conducted with the spreading fan of the respective other throwing disc. In this way, by taking into account the spreadable material particles of the respective other throwing disc, which enter the measuring range of the sensors an improved determination of the distribution characteristic, in particular of the mean ejection angle of the spreadable material particles can be achieved.

In a further development of the invention, the entirety of the at least one sensor devices detects the range of the spreading fan, which is at least predominantly determined by the spreading behaviour of a first of the two throwing discs.

In a further development of the invention, the mean ejection angle and/or the spatial mass distribution of the second throwing disc assuming a symmetrical spreading behaviour of the second throwing disc to the first throwing disc is determined taking into account the adjustment parameters of both throwing discs, such as output point and/or throwing disc rotational speed and/or utilisation of a boundary spreading device and/or throwing blade geometry and/or output quantity, and/or external influences such as terrain slope and/or wind conditions and/or based on the determined mean ejection angle of at least one of the adjustment parameters for achieving the desired mean ejection angle of the spreadable material particles ejected using the second throwing disc adjusted and/or the determined mean ejection angle of the second throwing disc indicated to the driver of the distribution machine on a suitable display device. In this way and taking into account the overlapping region of the throwing discs and assuming that the distribution characteristic of the throwing discs is symmetrical, the distribution characteristic of the second throwing disc can be advantageously adjusted in a particularly simple and precise manner. Here, a mirror-symmetry of the spreading behaviour relative to an axis through the centre of the distribution machine in travelling direction should be generally assumed. External influences, such as wind or terrain slope, deviating adjustments of the respective throwing disc parameters or deviating spreading behaviour of the throwing discs however can also result in that the symmetry to be expected cannot be observed.

In an advantageous further development of the invention, a correction variable for consideration of the influence of the terrain slope on the flying behaviour and/or of the terrain slope on the output point of the spreadable material on the throwing disc is integrated in determining and/or controlling the mean ejection angle. By way of this, effects which generally asymmetrically influence the spreading pattern and thus also the distribution in the overlapping region of the at least two throwing discs can be advantageously taken into account for determining the distribution characteristic and the choice of the adjustment parameters.

In an alternative configuration of the invention, at least one first sensor for detection of a first range, which is at least predominantly defined by the spreading behaviour of the first throwing disc, and at least one second sensor for detecting a second range, which is at least predominantly defined by the spreading behaviour of the second throwing disc, are arranged on the distribution machine. By way of this, a more precise determination of the distribution characteristic, in particular of the mean ejection angle of the throwing discs can take place. In particular, by way of this, effects which asymmetrically influence the spreading pattern can be left out of consideration in determining the distribution characteristic since the effects are directly determined by the sensors on the at least two throwing discs. Device-induced changes of the spreading characteristic, caused for example by unilateral utilisation of boundary spreading screens or in the case of a possible selection of different throwing blades are also directly determined and incorporated and need not be algorithmically calculated.

In an advantageous configuration of the invention, a correction variable is taken into account for the simultaneous adjustment of the ejection angle of the two throwing discs, which is created by means of subtracting the mean ejection angles of the two throwing discs and at least one pre-factor and counteracts a potential incrementation of the adjustment of the mean ejection angle of at least one of the two throwing discs. By way of this, an adjustment of the adjustment parameters of the throwing discs that is as unsusceptible to errors as possible is made possible. Otherwise, an incrementation of the closed-loop control of the distribution characteristic could occur since the measurement results of the sensors of the particles in the overlapping region is obtained both through changes of the adjustment parameters of the first and also of the second throwing disc.

In an advantageous further development of the invention, the mass distribution within the overlapping region of the two spreading plates is assigned, pro-rata, to the respective throwing discs. Accordingly, the distribution characteristic, in particular the mean ejection angle of the throwing discs can be advantageously determined individually. In the case of an asymmetrical adjustment of the adjustment parameters of the throwing discs and/or asymmetrical spreading pattern through the occurrence of asymmetrical effects such as wind, this can be advantageously achieved for example by using suitable formulas, tables and/or graphs.

The derivation of these formulas, tables and/or graphs can be advantageously determined by a unilateral test of the spreading behaviour of the distribution machine, i.e. upon exclusion of the spreading quantity and/or of the respective other spreading plate. Here, the influence of the respective other throwing disc on the overlapping region is eliminated by switching off the distribution of this throwing disc.

In an alternative configuration of the invention, the pro-rata assignment of the mass distribution of one and/or both throwing discs within the overlapping region is determined by measuring the mass distribution outside the overlapping region with different spreading parameters and extrapolation of the mass distribution into the overlapping region taking into account the entire mass distribution caused in the overlapping region by both throwing discs.

In an advantageous configuration, the proportions of the spreadable material particles ejected by the first and/or the second throwing disc in the measuring range of at least one sensor are determined in that out of the Doppler signal of the measurement signal determined by at least one sensor at least one speed signal based on the flying direction of the sensor signals is extracted from the measurement signal. By way of this, the place of origin of particles located closely together can be advantageously determined since the Doppler signal of these particles provides information regarding the place of origin. Here it is immaterial that the particles ejected by one throwing disc also do not fly exactly in the same direction. Since the trajectory of the spreadable material particles differs greatly at least in the measuring range, provided they were ejected by different throwing discs, the quantity proportion of the measured particles ejected by a specific throwing disc can be at least determined therefrom.

In an advantageous further development of the invention, the speed of the spreadable material particles is determined by means of a comparison of at least two data sets of two spatially separate sensors by means of the Doppler effect based on the sensor position and by combining these data sets the speed of the spreadable material particles relative to the travelling direction and perpendicularly to the travelling direction determined and/or from this data the ejection location of the spreadable material particles determined in each case. By way of this, the speed and movement direction of the spreadable material particles can be determined and both the ejection location and also the probable output point on the agricultural area determined.

Further details of the invention can be taken from the description of the example and the drawings. Here

Fig. 1
: shows a schematic representation of a centrifugal spreader with two throwing discs and the corrected mean ejection angle,

Fig. 2
: shows a schematic representation of the measurement of the speed, which was ejected from the first throwing disc,

Fig. 3
: shows a schematic representation of the measurement of the speed, which was ejected from the second throwing disc.

The method according to the invention and possible preferred configurations of a distribution machine according to the invention are shown in a schematic representation in Fig. 1 to 3. For the sake of clarity, design details, which are immaterial for the representation of the invention, but which are indispensible for the functioning of the distribution machine, have been omitted.

In a schematic representation, a centrifugal spreader 1 with a first throwing disc 2 and a second throwing disc 3 is shown in Fig. 1. The particles to be distributed by means of the throwing discs are output onto the throwing discs from a storage tank which is not shown by means of a known introduction system in each case which is therefore likewise not shown. The introduction system can be configured moveable in its position in the radial and also in the circumferential direction relative to the respective centre point of the throwing disc and electronically controllable.

The radially orientated boundaries of the throwing range A of the first throwing disc of the respective throwing disc are shown by means of the lines 4 and 5, those of the throwing range B of the second throwing disc by means of the lines 6 and 7. The spreading fan of the respective throwing disc is thus delimited at least approximately in the radial direction by the corresponding lines 4 and 5 respectively 6 and 7.

The particles output by the first disc 2 are detected by means of a measurement device 8. In this exemplary embodiment, the measurement device consists of multiple sensors 9, which detect a certain section of the range A in the circumferential direction. These can be one or more sensors. The sensors can be designed for example as ultrasound, radar sensors or optical sensors and be attached so as to be stationary or moveable. The measurement signals are detected and processed by a control unit 10. As a reaction to the measurement signals, the control unit can determine and emit signals for activating the throwing discs and/or for changing the output point of the spreadable material on the throwing discs. The data of the measurement device 8 can also be processed and indicated to an operating person, for example in the cab of a tractor pulling the centrifugal spreader.

The predominant part of the particles output by the second disc 3 remains on the, seen against the travelling direction FR, left side of the centre line 12 and thus does not reach the measuring range of the measurement device 8. A considerable part however is ejected beyond the centre line and in particular those, which are ejected along or in the vicinity of the boundary line 6 from the second throwing disc 3, fly very far into the throwing range of the first throwing disc A. Of these particles ejected into the range A by the disc 3, at least the predominant part also passes the measurement device 8. This creates the problem that the particles ejected into the range A by the throwing disc 3 and detected by the measurement device 8 negatively influence the precision of the detection of the fertiliser distribution and/or of the mean ejection angle by the measurement device 8. Provided that no measures for distinguishing the particles output by the respective throwing disc are taken, an incorrect, virtual ejection angle AWWv is thus obtained. However, the real ejection angle AWWr of the particles ejected by the first throwing disc 2 can be determined by suitable measures.

To this end, the throwing characteristic of the first throwing disc can be calibrated for certain spreading parameters with the second throwing disc switched off. These spreading parameters can be for example the output position of the spreadable material on the throwing disc, the type of the spreadable material as well as type and rotational speed of the throwing disc. By means of this information, the spreading behaviour of the throwing disc can be predicted for entirely different conditions and accordingly also the spreading behaviour in the overlapping region of the two regions A and B by the two throwing discs determined. With known spreading parameters and taking into account the measurement data of the measurement device 8, it is thus possible to at least approximately determine for the respective region A and B the proportion of the particles spread out there which were output by the first and which were output by the second throwing disc.

Alternatively or additionally, a determination of the particles flung into the range A by the second throwing disc can be determined by means of extrapolation of the signal of those sensors 9 of the measurement device 8, for which a detection of particles of the second throwing disc 3 can be excluded. The proportion of the sensors 9 of the measurement device 8, for which it can be assumed that spreadable material particles from the second throwing disc 3 are likewise detected, are marked with reference number 11 in Fig. 1, while the proportion of the sensors 9 of the measurement device 8, for which a detection of spreadable material particles of the throwing disc 3 can be excluded, are marked with the reference number 10. Since by way of test measurements it is known what the distribution characteristic of a throwing disc looks like with different spreading parameters, a correction signal for the sensors 11, which was adjusted by the signal generated by the second throwing disc 3, can be generated by extrapolation of the signals of the sensors 10.

Naturally it is entirely conceivable for increasing the precision of the determination of the distribution characteristic to provide a second measurement device, which is arranged on the second throwing disc 3 and which detects the spreadable material output by the same. In the event that the control device 12 performs the adjustment parameters of the throwing discs 2 and 3 on the basis of the measurement data of the first and second measurement device it is necessary in this case to perform a correction variable in the closed-loop control, which takes into account the overlapping of the spreading regions. The reason is that a change of the adjustment parameters of the first throwing disc 2 also influences the measurements of the second measurement device since the first throwing disc likewise flings spreadable material into the measuring range of the second measurement device and vice versa, so that an incrementation in the closed-loop control of the two throwing discs can occur.

Furthermore there is also the possibility to detect the intensity with which the inner sensors 11 react to fertiliser from the throwing disc 3, and put the same into relation with the signals which sensors assigned to the disc 3 generate. To this end, it is necessary in turn to unilaterally spread only using the disc 3 and that the data of all measurement systems (assigned to the discs 2 and 3) is evaluated. Once these influences are known, these can be calculated during the two-sided spreading by mutual offset calculation.

Here it is additionally advantageous to take into account slope and/or wind sensors 13 or suitable weather data for determining the distribution characteristic of the throwing discs 2 and 3 and incorporate these in the closed-loop control of the spreading parameters by the control device 12. Since a slope gradient that is present or a corresponding wind influence results in an asymmetrical influencing of the spreading behaviour of the throwing discs, taking into account such a signal is particularly advantageous.

A possibility of directly determining the place of origin of the spreadable material particle is shown in Fig. 2 and 3. Here, it is not only the distance between measurement device and particle that is determined by means of a sensor signal, for example radar waves, for a spreadable material particle 20 by means of the measurement device 21 but also the component of the relative speed between sensor and particle is deduced approximately parallel to the spreading direction of the radar waves v_{p1} along the line 22. In order to detect the ejection location of the particle, a further measurement would now have to be performed for the same particle, for example by way of an adjacent sensor or by the same sensor at a different time, in order to be able to deduce the speed component v_{s1} perpendicularly to v_{p1}.

Even if this were not performed it would already be possible from the signal v_{p1} alone to determine the throwing discs by which the particle 20 was ejected. This can be achieved in that the speed v_{p1} is compared with a mean speed v_g averaged across all particles. For the speed distribution of all ejected particles, a Gaussian distribution, for example, is to be assumed, the characteristic form of which can be determined by means of test measurements as a function of different spreading parameters such as throwing disc type and type of fertiliser. If it is approximately assumed that all fertiliser particles are ejected with the same speed v_g, which can be determined from the signals of the measurement device 8, the speed v1 of the particle 20 is equal to the mean speed v_g. From this, in turn, the proportion of the speed v1 that is brought about by the speed component v_{p1} can be determined and thus if the particle 20 was ejected by the first throwing disc 2 or the second throwing disc 3.

Fig. 3 shows the case for a particle 30 ejected by the second throwing disc 3, the movement direction and speed of which is given by the vector v2. The particle 30 is detected by the measurement device 21 and merely has a very small speed component v_{p2} parallel to the line 22. Characterising the measured particles could now be performed in such a manner that those particles, which have a speed component, which relative to the average speed v_g of all detected particles undershoot a certain threshold value S are assigned to the second throwing disc: $v_{p1}/v_g < S$. Here, the value S will typically range between 0 and 0.6.

PATENTKRAV

1. Fremgangsmåde til bestemmelse og/eller indstilling af gennemsnitudsmidningsvinkel og/eller rumlig mængdefordeling af partikler af et spredbart materiale, fortrinsvis en gødning, udsmidt ved hjælp af udsmidningsbladene af en udsmidningsskive rotationsdrevet af en landbrugsfordelingsmaskine (1), der har to udsmidningsskiver (2, 3) og i hvert tilfælde mindst en indretning til positionering outputpunktet af partiklerne af det udspredbare materiale på de respektive udsmidningsskiver, og mindst en føleindretning (8), fortrinsvis mindst en radarføler, som udsender og modtager elektromagnetiske bølger for at karakterisere partikelfordelingen indenfor spredningsviften af de udsmidte spredbare materialepartikler, fortrinsvis for at bestemme middeludsmidningsvinklen (AWWr) af de spredbare materialepartikler og/eller for at bestemme vægtfordelingen af de spredbare materialepartikler indenfor spredningsviften, hvor udsmidningsvinklen måles i den vandrette retning i forhold til bevægelsesretningen (FR) af fordelingsmaskinen, hvor bestemmelsen og/eller indstillingen af den gennemsnitsudsmidningsvinklen og/eller den rumlige mængdefordeling partiklerne af et spredbart materiale og/eller i hvert tilfælde er udført individuelt for en af udsmidningsskiverne (2, 3), **kendetegnet ved**, at bestemmelsen og/eller indstillingen af gennemsnitudsmidningsvinklen (AWWr) af bredbart materiale og/eller vægtfordelingen af spredbare materialepartikler indenfor spredningsviften af mindst en af udsmidningsskiverne bliver udført under hensyn til overlappende område af spredningsviften med spredningsviften af de respektive andre udsmidningsskiver, som gennemtrænger målerækkevidden af følerne af den ene udsmidningsskive.

2. Fremgangsmåde ifølge krav 1, **kendetegnet ved**, at helheden af den mindst ene føleindretning (8) detekterer rækkevidden af spredningsviften, som er bestemt i det mindste hovedsageligt ved hjælp af spredningsegenskaber af en første af to udsmidningsskiver (2).

3. Fremgangsmåde ifølge krav 2, **kendetegnet ved**, at gennemsnitsudsmidningsvinklen og/eller den rumlige mængdefordeling af den anden udsmidningsskive er bestemt efter en formodet symmetrisk spredning af den anden udsmidningsskive (3) i forhold til den første udsmidningsskive (2) under hensyn til indstillingsparameterne af de to

udsmidningsskiver, således at udledningspunktet og/eller rotationshastigheden af udsmidningsskiverne og/eller anvendelse af en begrænset spredningsindretning og/eller spredningsbladgeometri og/eller udledningsmængde og/eller ydre indflydelse såsom skrånende jordoverflade og/eller vindforhold, og/eller i det mindste en af indstillingsparameterne for at opnå den ønskede gennemsnitsudsmidningsvinkel af de spredbare materialepartikler udsmidt med den anden udsmidningsskive indstillet på basis af den bestemte gennemsnitsudsmidningsvinkel, og/eller den bestemte gennemsnitsudsmidningsvinkel (AWWr) af den anden udsmidningsskive er udvises på et egnet displayindretning til føreren af fordelingsmaskinen.

4. Fremgangsmåde ifølge ethvert af de foregående krav, **kendetegnet ved**, at en korrektionsvariabel er integreret i bestemmelsen og/eller styringen af den gennemsnitsudsmidningsvinkel (AWWr) for at tage hensyn til indflydelsen af skrånende jordoverflade på flyveegenskaberne og/eller skånende jordoverflade på udledningspunktet af de spredbare materiale på udsmidningsskiven.

5. Fremgangsmåde ifølge ethvert af de foregående krav, **kendetegnet ved**, at der på fordelingsmaskinen er arrangeret mindst en første føler til detektering af et første område, der defineret i det mindste hovedsageligt af spredningsegenskaberne af den første udsmidningsskive (2), og mindst en anden føler til detektering et andet område, der er defineret i det mindste hovedsageligt af spredningsegenskaberne af den anden udsmidningsskive (3).

6. Fremgangsmåde ifølge krav 5, **kendetegnet ved**, at den samtidige indstilling af udsmidningsvinklen af de to udsmidningsskiver (2, 3) tager hensyn til en korrektionsvariabel, der er genereret ved at forme forskellene mellem den gennemsnitudsmidningsvinkel af de to udsmidningsskiver og mindst en forfaktor modvirker en potentiel pludselig stigning i styringen af indstillingen af gennemsnitsudsmidningsvinklen af mindst en af de to udsmidningsskiver.

7. Fremgangsmåde ifølge ethvert af de foregående krav, **kendetegnet ved**, at mængdefordelingen indenfor det overlappende område af fordelingszonerne (A, B) af de to udsmidningsskiver er tildelt proportionalt til de respektive udsmidningsskiver (2, 3).

8. Fremgangsmåde ifølge ethvert af de foregående krav, **kendetegnet ved**, at den proportionelle tildeling af mængdefordelingen af en og/eller af begge udsmidningsskiverne (2, 3) indenfor overlapningsområdet af fordelingszonerne (A, B) er bestemt ved at udlede en funktionel afhængighed, en tilsvarende kurve eller en tabel af mængdefordelingen ud fra spredningsparameterne ved hjælp en ensidet test af spredningsegenskaberne af fordelingsmaskinen, dvs. når fordelingen via de respektive andre udsmidningsskiver er afbrudt.

9. Fremgangsmåde ifølge ethvert af de foregående krav, **kendetegnet ved**, at den proportionale tildeling af mængdefordelingen af en og/eller begge udsmidningsskiver indenfor det overlappende område af fordelingszonerne (A, B) bestemmes ved at måle mængdefordelingen udenfor det overlappende område for varierende spredningsparametre og ekstrapolere mængdefordelingen in i det overlappende område under hensyn til den samlede mængdefordeling i det overlappende område forårsaget af begge udsmidningsskiver.

10. Fremgangsmåde ifølge ethvert af de foregående krav, **kendetegnet ved**, at andelene af de spredbare materialepartikler, som er udsmidt af den første og/eller den anden udsmidningsskive ind i måleområdet af mindst en føler (21) bestemmes ved uddrage målesignalerne fra Dopplereffekten bestemt af mindst en føler (21) og mindst et hastighedssignal (v_p1) relateret til flyveretningen af følesignalerne fra målesignalet.

11. Fremgangsmåde ifølge krav 10, **kendetegnet ved**, at hastigheden af de spredbare materialepartikler er bestemt ved hjælp af Dopplereffekt relateret til følerpositionen ved hjælp af en sammenligning af mindst to dateoptagelser fra to rumligt adskilte følere, og hastigheden af de spredbare materialepartikler relativt til flyveretningen og vinkelret på flyveretningen er bestemt ved at kombinere disse dateoptagelser og/eller udsmidningsstedet af de spredbare materialepartikler er respektivt bestemt ud fra disse dataenheder.

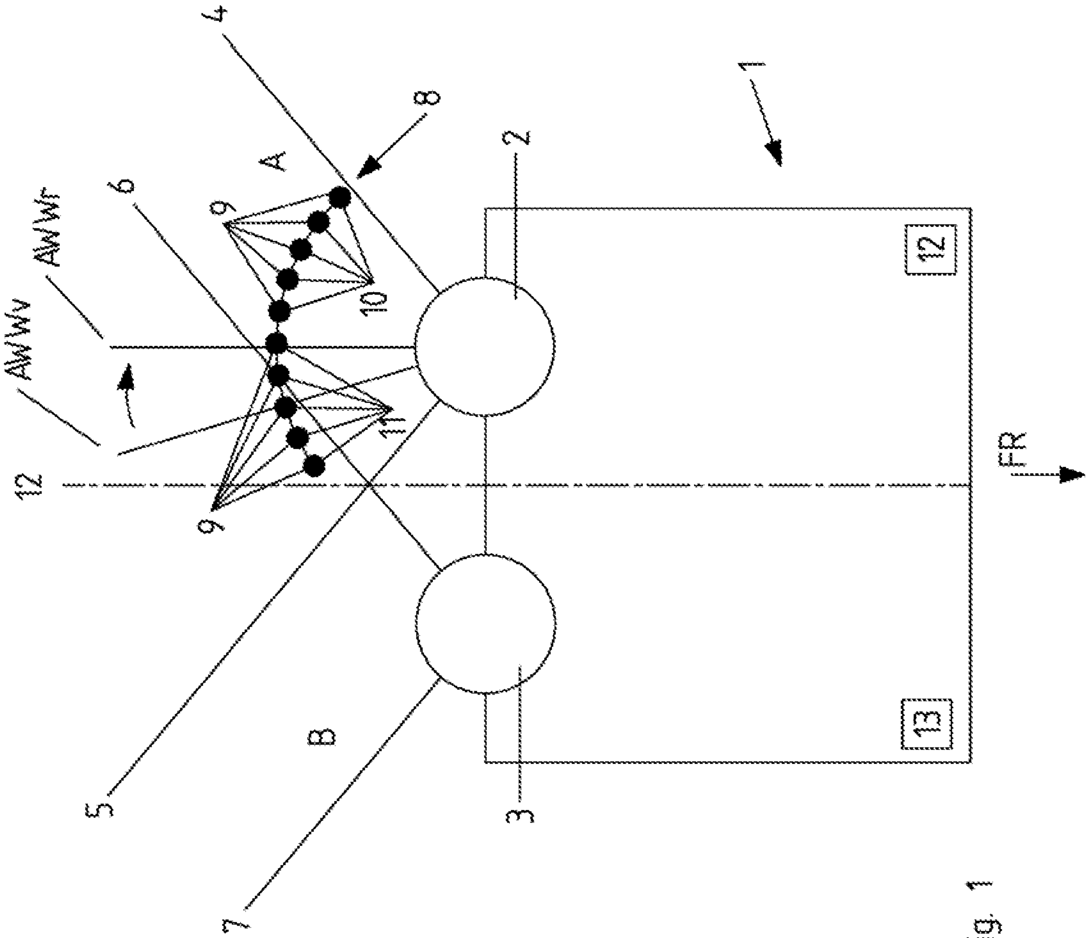

Fig. 1

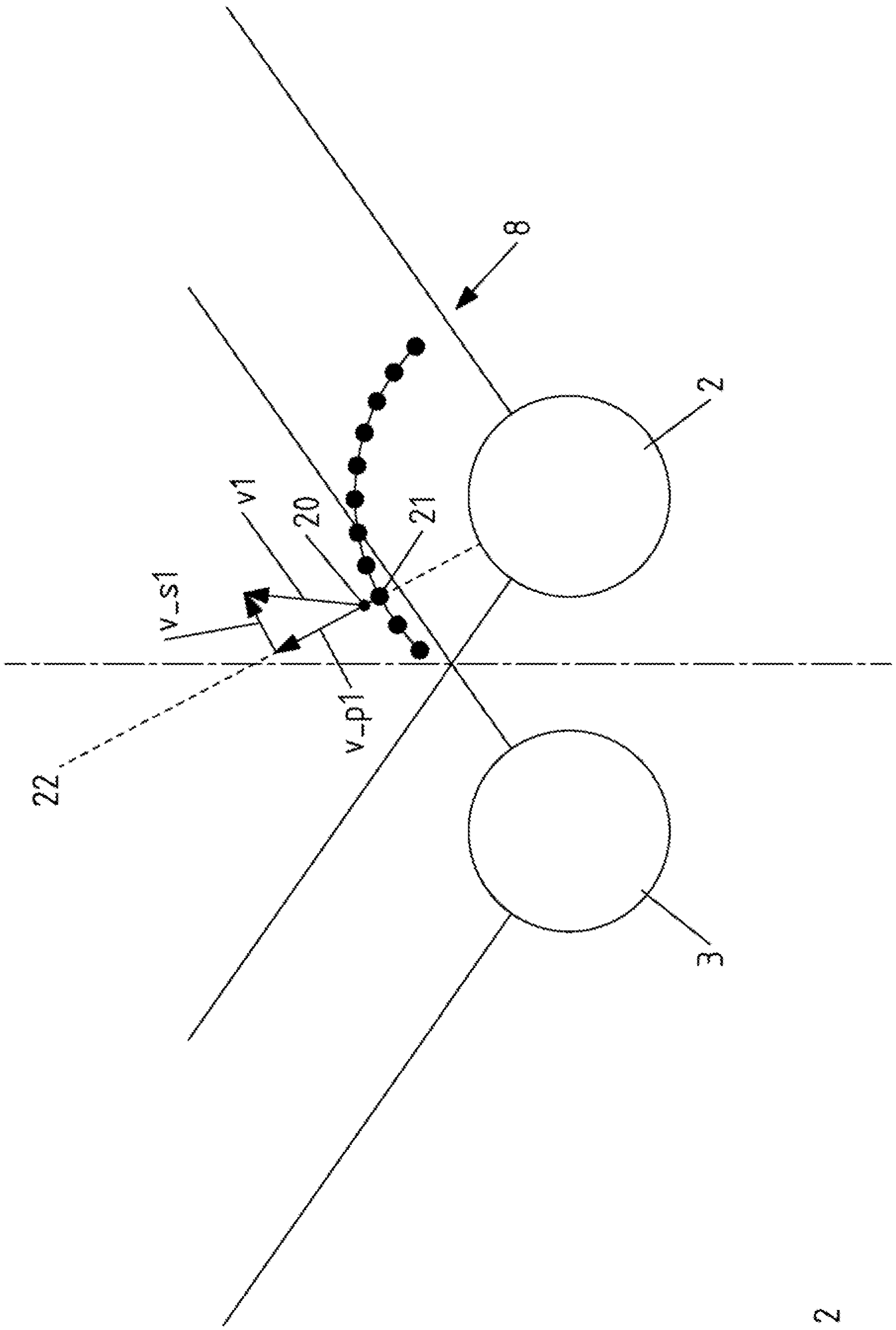

Fig. 2

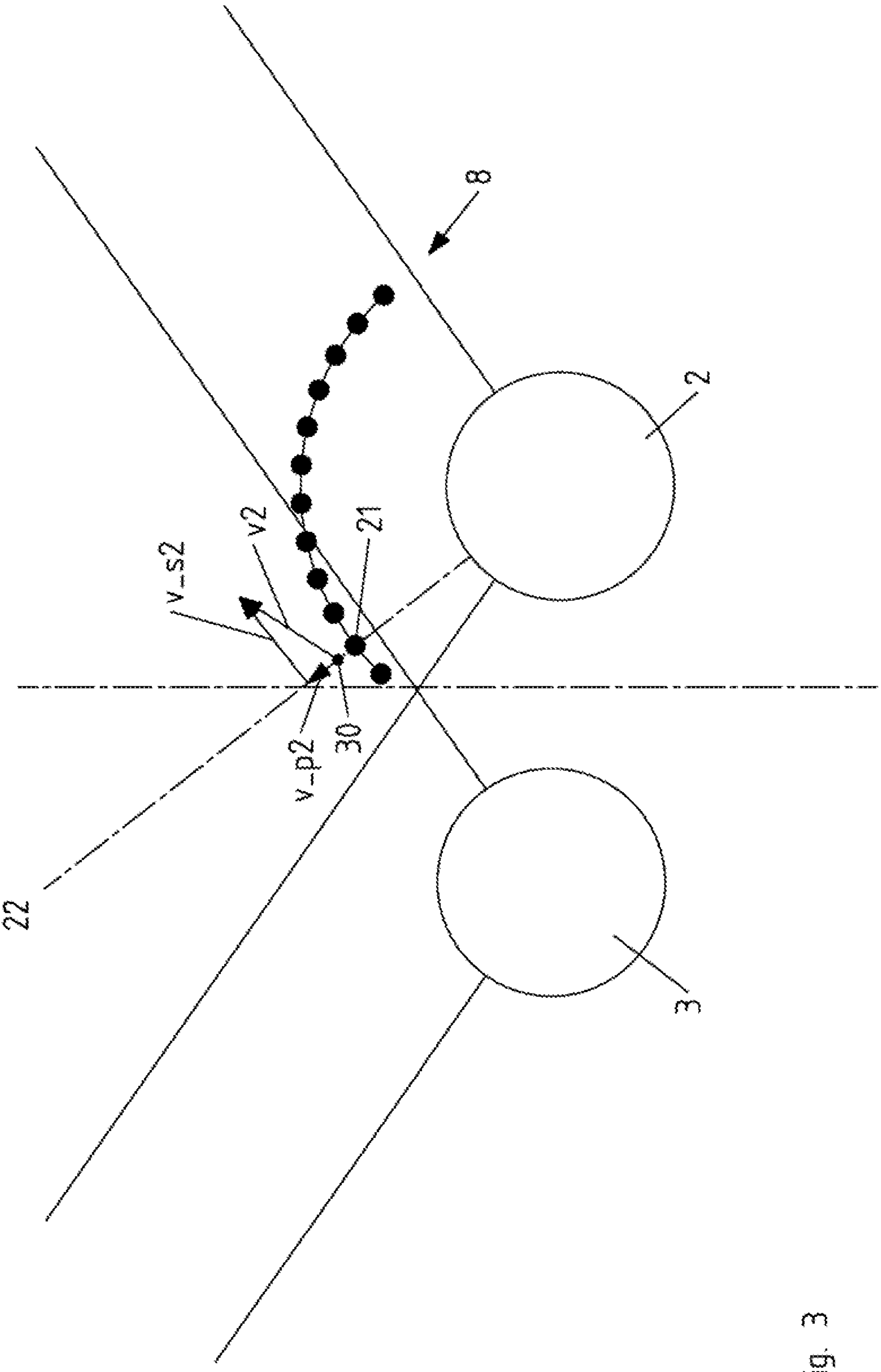

Fig. 3