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CENTRIFUGAL SPREADER

Description

The invention relates to a method for determining the distribution of spreading material according to the preamble of Patent Claim 1, as well as a distribution machine for carrying out such a method according to the independent Patent Claim 7.

Distribution machines, designed as centrifugal spreaders which typically distribute agricultural material from at least one, preferably two spreader discs by means of throwing blades arranged on the spreader discs, typically two in each case, have been known in the prior art for a long time. The spreading material is accelerated in the radial direction by means of the throwing blades arranged on the rotating spreader disc due to the centrifugal forces occurring and it is distributed in this way. The throwing distance and geometry of the spreading fan, i.e., the region in which the spreading material is distributed, depends on various factors:

- The geometry of the spreader disc influences the vertical ejection angle, among other things.
- The arrangement of the throwing blades on the spreader disc as well as the length and geometry of the throwing blades influences the ejection velocity and flight direction of the spreading material.
- The texture of the spreading material (grain size, grain geometry and density) influences the ejection velocity and thus the throwing distance.
- The impact point of the spreading material on the spreader disc influences the ejection velocity as well as the horizontal ejection angle.
- The spreader disc rotational speed likewise has effects on the ejection velocity.

The increasing precision in farming technology, which is aimed at avoiding environmental burdens and unnecessary costs, as well as sparing of resources, demands even more detailed capabilities of adjusting the farming machinery. Accordingly, for centrifugal spreaders, not only can the quantity of the spreading material laid down and the spreader disc rotational speed be set, but also the impact point of the spreading material on the spreader disc and the spreader blade geometry are adapted. Special devices for distributing the spreading material in marginal zones of an agricultural area are also known.

The setting of the various parameters is done with the aid of tables, formulas and/or graphs in which, as a function of the spreading parameter, such as the spreader disc rotational speed for a particular spreader disc, throwing blade and feed point, one finds the average horizontal ejection angle, i.e., the ejection angle relative to a line which is drawn from the centre of the spreader disc outward in the radial direction against the driving direction, and the average throwing distance. In the same way, tables, formulas and/or graphs may be available which were created by varying, holding constant, and measuring other variables (DE 36 17 377 C2, DE 33 10 424 C2).

It is likewise known in the prior art how to determine the ejection angle by means of sensors and to adapt accordingly the above tables, formulas and/or graphs to the mentioned parameters upon deviation from a predetermined target value (DE 38 87 218T2, DE 197 23 359 A1). In EP 2 756 745 A1, radar sensors utilizing the Doppler effect are used for this purpose.

Thus far no attention has been paid in this regard to the demixing of spreading materials consisting of several components during the distribution process. The simultaneous application of different spreading materials, preferably manure or seeds, during a single distribution process is in keeping with the previously mentioned increasing demands in farming practice, since it raises the efficiency and thus saves on costs, resources, and also time. The drawback to this procedure is that demixing occurring during the application of mixed granular spreading materials results in a partial oversupply or undersupply of the areas being worked with the various components (on this, see e.g. Heege, H.J. "Hofnahes Mischen von Düngemitteln und der teilflächenspezifische Landbau ["On-site mixing of fertilizers and specific farming for partial fields"]. BERICHTE ÜBER LANDWIRTSCHAFT-HAMBURG- 79.1 (2001): 94-106.).

The simultaneous applying of different spreading material components had already been proposed decades ago and distribution machines were developed accordingly to make possible the simultaneous applying of different kinds of spreading material in a single work step (DE 26 22 782 A1, DE 41 02 783 A1).

However, the technical configuration of these solutions is either impractical or relatively complicated. Thus, DE 26 22 782 A1 proposes regulating the mixing ratio of the spreading material applied by means of a slide valve. The different kinds of spreading material in this configuration are kept on hand in separate segments of the supply tank of the distribution machine. The drawback with this solution is that the distribution of the spreading material cannot be regulated as a function of the demixing which occurs during the distributing itself, so as to minimize the demixing, since for example the feed point for the kinds of spreading material is situated immediately next to each other and cannot be regulated independently. On the other hand, the mixing ratio of the spreading material is not a problem which presents itself in today's prior art, since normally the optimal mixing ratio is determined prior to the distribution process for the area to be worked and it is then no longer changed during the distribution process. Therefore, the distribution machine is typically loaded with already premixed spreading material with the optimal spreading material ratio.

Although it has been possible to set individually the distribution for different kinds of spreading material by utilizing the other proposed solution of DE 41 02 783 A1, there is no provision made for checking this during the distribution process. Furthermore, the design expense of this solution is enormous, since two spreader discs are provided each time for the preferably two different kinds of spreading material. The costs of this solution as compared to a typical centrifugal spreader would accordingly be very high. However, since the proportion of the mixed spreading materials which are applied with a corresponding distribution machine and which exhibit a significant demixing during the distribution process is relatively low in comparison, such a configuration proves to be too complicated and thus too cost intensive.

The problem which the present invention proposes to solve is therefore to determine in the most simple and economical fashion the demixing of spreading material consisting of several components that occurs during the distribution process so that the distribution process can preferably be monitored and adapted in keeping with the measured demixing.

This is accomplished by a method for determining the distribution of spreading material which has been mixed from at least two components, according to the preamble of Patent Claim 1, wherein demixing of spreading material components is detected on the basis of the measurement data of the at least one sensor, preferably radar sensor, which operates in a contactless fashion, at a sufficient distance from the distribution machine of preferably at least 1 m, and in each case an average ejection angle is calculated for each component by means of the program installed on the job computer or terminal. In this way, the demixing of the applied spreading material components can be permanently observed and monitored during the distribution process in that the applied spreading material is monitored by means of at least one movable sensor or at least three sensors which are positionally fixed in different positions. If the demixing is too large, for example, the distribution process can be adapted accordingly by reducing the working width of the distribution machine and changing the overlap zone of adjacent driving lanes and/or the arrangement of the driving lanes.

In one advantageous development of the invention, in addition to the average ejection angle, the average throwing distance is additionally determined from two values of the speed of flight for each component by means of at least two sensors, preferably radar sensors which measure the speed of the spreading material in different phases of flight, that is to say different distances from the distribution machine. Thus, in order to obtain a more complete picture of the demixing and the distribution of the distribution machine of the respective spreading material components, the throwing distance and in addition the impact point of the different spreading material components in an alternative modified embodiment are determined even more precisely individually for each spreading material component.

In one advantageous embodiment of the invention, the distributed spreading material quantity is determined individually for each spreading material component and/or the quantity ratio and/or volume and/or mass ratio of the distributed spreading material components on the basis of the measurement signals of the at least one sensor. Hence, for example, a demixing of the spreading material components in the spreading material tank itself can be monitored and detected. It is conceivable, for example, that because of a demixing of the spreading material components in the spreading material tank of the distribution machine at the start of the spreading process which is caused during a transport there will be laid down a significantly larger proportion of a first spreading material component with larger spreading material particles as compared to a second spreading material component with smaller spreading material particles and this relationship is reversed during the distribution process with decreasing fill height in the spreading material tank. Without the method according to the invention, such a process would normally go unnoticed. On this basis, for example, an estimate can be made as to whether the particular mixed spreading material is suitable for future applications or not.

In one advantageous development of the invention, the setting parameters of the distribution machine are set in such a way that the demixing of the at least two spreading material components is adjusted by means of a program stored on the job computer and/or terminal, in accordance with values which are stored in the job computer and/or terminal and/or which are predefined by the operating personnel, preferably a maximum degree of demixing is specified, and when this is exceeded the setting parameters, preferably the spreader disc rotational speed and/or feed point of the spreading material onto the spreader disc are/is adjusted. In this way, the setting parameters can be influenced during the distribution process so as to reduce the demixing. Preferably, the working width can be reduced and the arrangement of the driving lanes on the area being worked can be adapted appropriately.

In one advantageous development of the invention, the average ejection angle of the spreading material components is set automatically on the basis of predefined parameters which are stored in the job computer and/or the terminal, in particular the mixing ratio of the spreading material components or other weighting factors, by setting setting parameters of the distribution machine such as preferably the feed point of the spreading material on to the spreader disc and/or spreader disc rotational speed by the job computer and/or the terminal. In this way, for example, the mixing ratio of the spreading material components and/or other factors can be called upon for the automatic setting of the setting parameters of the distribution machine. For example, it may be important to the distribution for one component to be especially evenly distributed in the overall context of the different driving lanes used, while this plays a lesser role in the case of a second component.

The invention furthermore contains an independent claim relating to a distribution machine for carrying out the method according to the invention in keeping with the preamble of Patent Claim 7, wherein demixing of spreading material components is detected on the basis of the measurement data of the at least one sensor, preferably radar sensor, at a sufficient distance from the distribution machine of preferably at least 1 m, and a program is installed on the job computer or terminal, by means of which in each case an average ejection angle is calculated for each component.

Further details of the invention will be found in the description of examples and the drawings. There are shown

Fig. 1 schematically, the arrangement of the spreader discs and the sensors coordinated with them for the detecting of the distributed spreading material,

Fig. 2 a diagram to determine the horizontal ejection angle of the different spreading material components and

Fig. 3 a diagram to determine the throwing distance of the different spreading material components.

The method according to the invention and possible preferred embodiments of a distribution machine according to the invention are presented in a schematic representation in Fig. 1. For clarity, structural details not important to the presentation of the invention, even though essential to the functioning of the distribution machine, have been omitted. In particular, to ensure the clarity of the representation, the ejected spreading material is not shown in Figure 1.

Fig. 1 shows schematically a spreader disc A and two throwing blades B arranged on it. Furthermore, the preferred direction of rotation of the disc is indicated. At distance r from the spreader disc there is arranged at least one movable sensor for measurement at different positions at the same distance from the centre of the spreader disc or three sensors which are positionally fixed, preferably sensors which operate in a contactless fashion. In the present exemplary embodiment, there are seven radar sensors, each one situated at the distance r from the centre of the spreader disc on a connection line to the centre of the spreader disc, each of them making different angles α_1 - α_7 with an axis R running contrary to the driving direction through the midpoint of the spreader disc. The sensors are preferably arranged such that they do not hinder the movement of the ejected spreading material, i.e., preferably above or below the spreading material flying past them, and they are arranged at a distance r of preferably around 0.5 m from the centre of the spreader disc. The measurement point and thus the distance of the sensors from the spreader disc is advantageously chosen such that the movement of the spreading material particles after leaving the spreader disc has become stabilized, but the distance and hence the splitting up of the ejected spreading material is not yet too large, on the other hand. Furthermore, the sensors are arranged such that the region of the circular circumferential segment approximately at the distance r from the spreader disc is preferably detected, from which the ejected spreading material preferably passes.

Each time the sensors represented in Fig. 1 are with a schematic diagram with a curve of a corresponding Doppler measurement. As is already evident from the diagrams, one component of the ejected spreading material, which in this example should consist of at least two spreading material components, has preferably passed through the measurement region of the sensor 3 in the direction v_{K1} at the angle α_{K1} to the axis R, since the largest signal amplitude A_3 was measured there. In addition, a similarly large signal amplitude was measured at sensor 5, so that it can be assumed that the second spreading material component was ejected preferably at this angle and has passed the sensor 5 in the direction v_{K2} at the angle α_{K2}. In particular, the signal measured by means of 1 shows a lower amplitude than the sensors 3 and 5. The signal amplitude is accordingly further reduced toward sensors 1 and 7, situated at the edge of the sensor arrangement.

Fig. 2 shows a diagram which enables the determination of the ejection angle of the two spreading material components. Here, the amplitudes of a measurement performed at least approximately at the same time with all seven sensors is plotted against the respective angle α and a corresponding distribution curve is interpolated with known mathematical methods, making the assumption that the curve consists of a superpositioning of two distribution functions. Now, at the maxima of this curve, it is possible to determine the average ejection angle for the two spreading material components α_{K1} and α_{K2}, which in this example correspond to the angles α_3 and α_5. Alternatively, in the present diagram it is possible to plot, instead of the amplitude of the individual measurement curves, their integral, i.e., the area beneath the curve. This would be a more precise measure of the number of spreading material particles which have moved past the sensor, but such a forming of the integral is appreciably more complicated, yet it does not result in significantly more precise results. Besides the average ejection angle, furthermore the variance of the average ejection angle can be determined from the diagram after the computation of the two dashed distribution curves. In departure from the representation shown, and depending on the mixing ratio of the spreading material components and their physical properties, the maximum which indicates the average ejection angle of a first spreading material component may be very much larger than the maximum which indicates the average ejection angle of a second component. In particular, the difference between the ejection angles may be so slight and/or the mixing ratio so large that only one maximum can be observed. For example, the second spreading material component may show as a shoulder in the measurement curve. In this case, a determination of the ejection angle by means of mathematical fit functions is required in order to determine the individual distribution functions.

In a further step, it is now possible to use Doppler measurement to determine from the sensor signals the speed of flight of the spreading material particles. In analogous manner, it is also possible here to consider the variance, if detailed statements need to be made as to the distribution. In the Doppler measurement, the electromagnetic waves or sonic waves emitted by the sensor are scattered and/or reflected at the spreading material particles to be detected. The wavelength of the measured signals depends on the velocity of the spreading material particles, their position and flight direction, the latter two variables being at least approximately known. An evaluation can be made here similar to the procedure of Fig. 2, insofar as the distribution of the spreading material involves a demixing in terms of the speed of flight and throwing distance. If two kinds of spreading material differing in the flight characteristics are subjected to a Doppler measurement and a significant demixing of the velocity has occurred at the time of the measurement, a measurement result as shown for example in Fig. 3 can be expected. The term demixing of the velocity pertains here to the fact that different kinds of spreading material typically also have at least approximately the same velocity upon ejection from the spreader disc. A detection of different velocities is thus only possible after a brief flight duration, such as 1 meter or more distant from the spreader disc, because then the different flight characteristics of the particles have already had their effects.

Fig. 3 shows the exemplary representation of a Doppler measurement of a spreading material consisting of two components. The two maxima of the curve are roughly the same size, so that it may be inferred that the spreading material at the particular angle is being applied in equal parts. However, very different amplitudes may also occur, for example depending on the angle at which the sensor is arranged relative to the axis R and depending on the demixing behaviour and mixing ratio of the spreading material components. For highly different heights of the maxima of the two functions to be determined, whose superpositioning is represented as measurement function in Fig. 3, or if the difference between the measured frequencies of the maxima is very small, it may occur that, similar to the determination of the ejection angle, no well distinguishable maxima can be identified in the measurement curve. In this case, a calculating of the throwing distance by means of a mathematical fit function is provided to determine the individual Doppler signals of the two spreading material components from the superimposed measurement signal.

However, since the velocity of the spreading material has developed differently after being ejected from the spreader disc, it is to be assumed that the throwing distance of the two spreading material components is different. The different velocities may be determined from the different frequencies f_{K1} and f_{K2} of the maxima of the curves coordinated with the two spreading material components. In addition, a calculation of the two individual curves can be done with known mathematical fit functions from the superimposed measurement curve, shown as the dashed curves in Fig. 3. This is especially advantageous if the amplitude of one of the individual curves is much greater than that of the other.

A calculation of the throwing distance is now possible if either the flight characteristics of the spreading material components are known or if another velocity measurement is done at another distance and thus the flight trajectory of the spreading material particles can be calculated. Furthermore, other distribution parameters are required for the calculation, such as for example the position of the distribution machine. To improve the calculation, it is also possible to factor in additional parameters, such as for example the spreader disc rotational speed, the spreader disc geometry and the throwing blade geometry. Moreover, in the case of several Doppler measurements at the same distance, but different ejection angles, as in Fig.1 for example, the data of the different sensors may advantageously be combined in order to improve the calculation of the throwing distance for the different components.

The calculated values may now be used advantageously to select the setting parameters of the distribution machine so that the distribution on the area being worked is as uniform as possible. For this, an ongoing/repeated monitoring of the average throwing distance and/or the average ejection angle of the distributed spreading material components is required. Thus, preferably in event of a very intense demixing of the components the spreader disc rotational speed may be reduced and the driving lane system of the distribution process may possibly be adapted. These processes may also be carried out by a corresponding program on a job computer and/or terminal of the distribution machine and/or an agricultural traction machine. In addition or alternatively, information may be displayed to the operators of the distribution machine as to the demixing and/or the distribution of the spreading material being applied. For example, the calculated average ejection angle and/or its coefficient of variation and/or the average throwing distances and/or their coefficient of variation may be displayed. This may advantageously be combined with a calculation and displaying of the distribution of the individual spreading material components. Also in addition the mixing ratio of the spreading material components may be calculated from the measurement data and compared with a target value, or the trend in the mixing ratio may be monitored during the application process.

It may also be provided to communicate the mixing ratio to the terminal and/or job computer and thus factor it into the computation. Weighting factors may also be stored, taking into account the fact that a uniform distribution for example in the case of a first spreading material is more important than that of a second one, so that the distribution machine can be set in particular so that the distribution of the first spreading material is as uniform as possible.

The coordinating of the measured and/or calculated throwing distances and/or ejection angles with the different spreading material components is done either with the aid of the known mixing ratio, which is compared to the measurement data of the sensors, or the operating personnel can make a selection with the aid of known differences in the distribution of different spreading material components or store these in the terminal and/or job computer. For example, it may be known and/or it may have been stored in the job computer and/or terminal that a first spreading material component for the same distribution parameters has a larger mean flight range, because the particles of this component are larger and heavier, than a second spreading material component. Furthermore, this selection can often be made straight away by a brief examination of the spreading material.

PATENTKRAV

1. Fremgangsmåde til bestemmelse af fordelingskarakteristikken for spredegods, som er blandet af mindst to komponenter i vilkårligt forhold, fortrinsvis mindre end 9:1, og udkastes ved hjælp af en landbrugs-fordelermaskine med i det mindste én, fortrinsvis to spredeskiver (A), som fortrinsvis råder over to kasteskovle (B), hvorved fordelermaskinen råder over mindst en bevægelig sensor og/eller mindst tre, i forhold til fordelermaskinen stationære, sensorer (1-7), fortrinsvist berøringsløst arbejdende sensorer, med henblik på individuel detektering af den horisontale udkastningsvinkel for spredegodset for hver spredeskive (A), og en job-computer eller terminal på fordelermaskinen og/eller en landbrugs-trækmaskine, som er tilknyttet den, **kendetegnet ved, at** der ud fra måledataene fra den mindst ene sensor (1-7), fortrinsvis en radarsensor, i tilstrækkelig afstand fra fordelermaskinen, fortrinsvis mindst 1 m, detekteres en adskillelse af spredegodset i dets bestanddele, og en respektiv gennemsnitlig udkastningsvinkel (α_{K1}, α_{K1}) for hver komponent beregnes ved hjælp af det på jobcomputeren eller terminalen installerede program.

2. Fremgangsmåde ifølge krav 1, **kendetegnet ved, at,** ud over den gennemsnitlige udkastningsvinkel (α_{K1}, α_{K1}), den gennemsnitlige kastevidde bestemmes ud fra to værdier af flyvehastigheden for hver komponent ved hjælp af mindst en sensor, fortrinsvis radarsensorer, som måler hastigheden af spredegodset i forskellige flyvefaser, altså i forskellig afstand fra fordelermaskinen.

3. Fremgangsmåde ifølge krav 1 eller 2, **kendetegnet ved, at** det gennemsnitlige rammepunkt for spredegodskomponenterne på landbrugsarealet for mindst to spredegodskomponenter beregnes enkeltvist ud fra udkastningsvinklen (α_{K1}, α_{K1}) og/eller som gennemsnitsværdi for kastevidden.

4. Fremgangsmåde ifølge mindst et af kravene 1-3, **kendetegnet ved, at** den fordelte spredegodsmængde bestemmes individuelt for hver spredegodskomponent og/eller mængdeforholdet og/eller volumen og/eller masseforhold for de fordelte spredegodskomponenter på basis af målesignalerne fra den mindste ene sensor.

5. Fremgangsmåde ifølge mindst et af kravene 1-4, **kendetegnet ved, at** indstillingsparametrene i fordelermaskinen indstilles således, at adskillelsen af de mindst to spredegodskomponenter indstilles ved hjælp af et program, som er lagret på jobcomputeren og/eller terminalen i overensstemmelse med værdier, der er lagret i jobcomputeren og/eller terminalen, og/eller som forud er indgivet af betjeningspersonalet, der fortrinsvis specificeres en maksimal grad af adskillelse, og der ved overskridning foretages en tilpasning af indstillingsparametrene, fortrinsvis spredeskive-rotationshastighed og/eller tilførselspunkt for spredegodset til spredeskiven (A).

6. Fremgangsmåde ifølge mindst et af kravene 1-5, **kendetegnet ved, at** den gennemsnitlige udkastningsvinkel (α_{K1}, α_{K1}) for spredegodskomponenterne automatisk indstilles ved hjælp af jobcomputeren og/eller terminalen på basis af forud indgivne parametre, som er lagret på jobcomputeren og/eller terminalen, navnlig blandingsforholdet for spredegodskomponenterne eller andre vægtningsfaktorer, ved indstilling af indstillingsparametre for fordelermaskinen, såsom fortrinsvis tilførselspunktet for spredegodset på spredeskiven (A) og/eller spredeskivens rotationshastighed.

7. Fordelermaskine til realisering af en fremgangsmåde ifølge mindst et af kravene 1-4 med i det mindste én, fortrinsvis to spredeskiver (A), som fortrinsvis råder over to kasteskovle (A), hvorved fordelermaskinen råder over mindst én bevægelig sensor og/eller mindst tre (stationære i forhold til fordelermaskinen) sensorer (1-7), fortrinsvis berøringsløst arbejdende sensorer, med henblik på individuel detektering af den horisontale udkastningsvinkel for spredegodset for hver spredeskive (A), og en jobcomputer eller terminal er anbragt på fordelermaskinen og/eller en dertil knyttet landbrugs-trækmaskine, **kendetegnet ved, at** der ud fra den mindst ene sensor (1-7), fortrinsvis en radarsensor, i tilstrækkelig afstand fra fordelermaskinen, fortrinsvis mindst 1 meter, detekteres en adskillelse af spredekomponenterne, og der er installeret et program på jobcomputeren eller terminalen, ved hjælp af hvilket der for hver komponent i hvert tilfælde beregnes en gennemsnitlig udkastningsvinkel (α_{K1}, α_{K1}).

8. Fordelermaskine ifølge krav 7, **kendetegnet ved, at** der ud over ud over den gennemsnitlige udkastningsvinkel (α_{K1}, α_{K1}) sker bestemmelse af den gennemsnitlige kastevidde ud fra to værdier af flyvehastigheden for hver komponent ved hjælp af mindst to sensorer, fortrinsvis radarsensorer, som måler hastigheden af spredegodset i forskellige flyvefaser, altså i forskellig afstand fra fordelermaskinen.

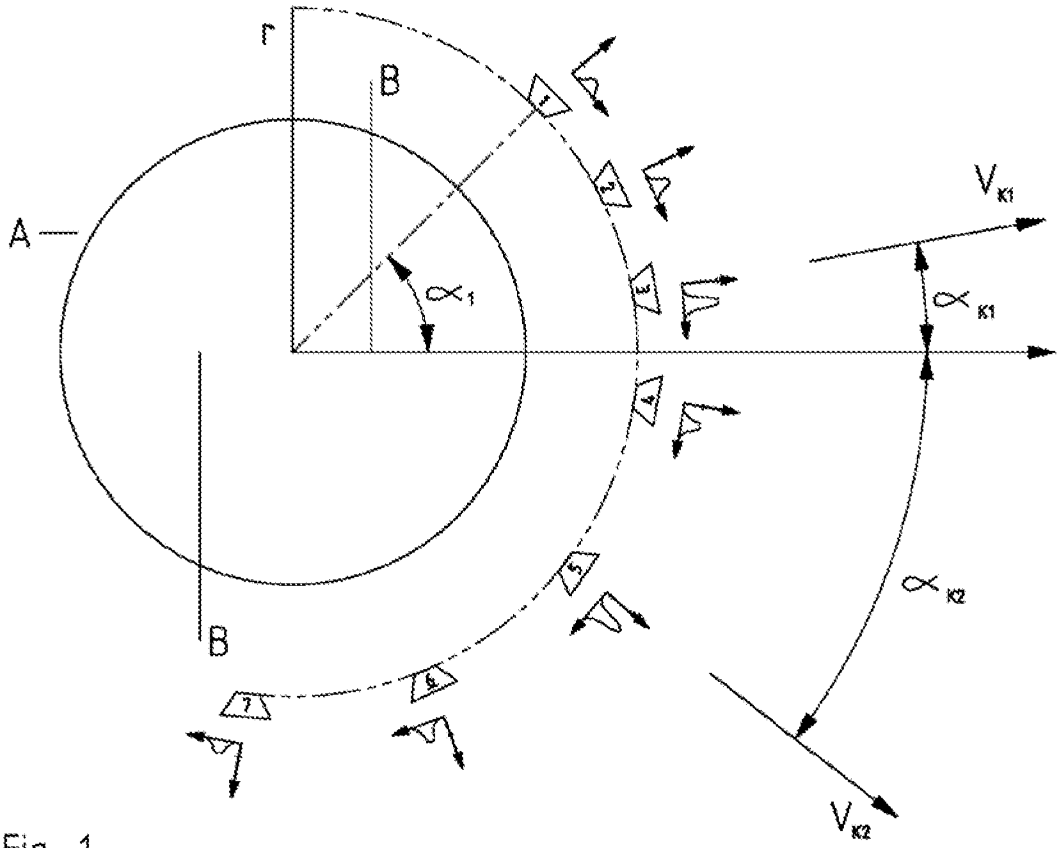

Fig. 1

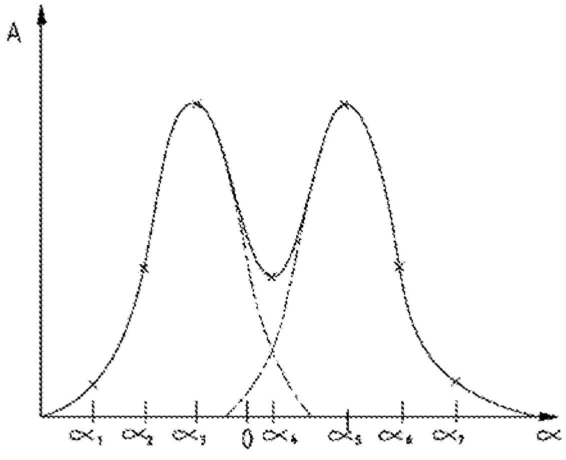

Fig. 2

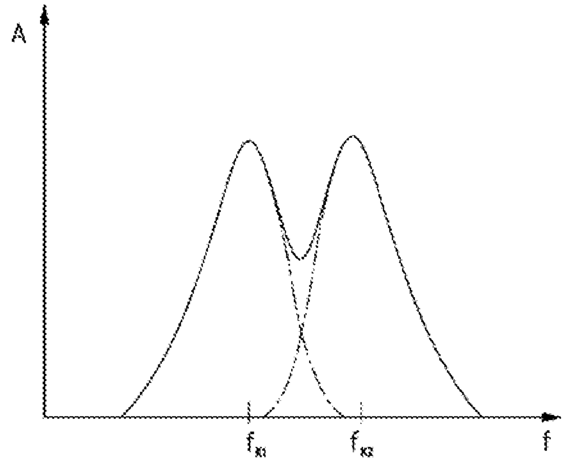

Fig. 3