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(54) Benævnelse: **Rheometer**

(56) Fremdragne publikationer:
EP-A- 0 469 302
WO-A-97/36162
US-A- 2 896 926
"MEASURING THE RHEOLOGY OF DIFFICULT MATERIALS THE FT3 POWDER RHEOMETER" APPLIED RHEOLOGY, APPLIED RHEOLOGY, EDITORIAL OFFICE, ZURICH, CH, vol. 10, no. 6, November 2000 (2000-11), pages 310-312, XP001048856

DESCRIPTION

[0001] This invention relates to a rheometer incorporating a blade mounted for rotation about an axis.

[0002] Rheometers are well known and used in a wide variety of chemical and material processing industries for assessing characteristics, such as flow characteristics, of materials such as powders, liquids and semi-solids such as pastes, gels, ointments and the like.

[0003] One particular rheometer is described in WO-A-9736162 and "Measuring the rheology of difficult materials - The FT3 powder rheometer", Applied Rheology November/December 2000, pages 310-312, in which blades extend substantially radially from a rotor shaft and are disposed at an angle relative to the axis of the shaft. The blades may be of twisted form; however the blade is at an angle over its entire length, relative to the axis of the shaft.

[0004] We have found that, although this arrangement of the prior art is generally satisfactory, some disadvantages can arise with regard to achieving repeatability when testing materials of different bulk density and rheology and particularly when comparing data derived from blades of different sizes.

[0005] US-A-2 896 926 describes a device for mixing or treating fluids or free-flowing powders and comprising a rod or other support carrying a plurality of radial or diverging arms hinged or jointed to the rod or support.

[0006] EP-A-0 469 302 describes mixing impellers which have a plurality of fluidfoil blades which have camber and twist.

[0007] It is therefore an object of the present invention to provide a rheometer incorporating a blade which eliminates or at least ameliorates the above disadvantages.

[0008] According to the present invention there is provided a rheometer incorporating a blade mounted for rotation about an axis, a variable speed device and gearbox unit for rotating the blade, and means whereby, for each revolution of the blade, the blade is displaced by a predetermined lead distance along the axis of rotation, wherein the blade is of twisted form such that:

a first region of the blade substantially at the axis of rotation has a first angle formed by its surface with respect to a plane perpendicular to the axis of rotation such that the surface of the blade in the first region extends substantially parallel to the axis of rotation;

a second region of the blade spaced from the axis of rotation has a second angle, different to the first angle, formed by its surface with respect to the plane perpendicular to the axis of rotation; and

the second angle has a natural tangent defined as the predetermined lead distance divided by the distance from the axis of rotation.

[0009] The blade may extend substantially at right angles to the axis of rotation, preferably substantially horizontally.

[0010] The height elevation of the twisted blade may be in mathematical proportion to blade lead distance, the blade lead distance being defined as the displacement of the blade along the axis of rotation for each revolution of the blade.

[0011] Alternatively, the height elevation of the twisted blade may be in mathematical proportion to blade diameter.

[0012] As a further alternative, the height elevation of the twisted blade may be in mathematical proportion to a ratio of blade lead distance, to blade diameter, the blade lead distance being defined as the displacement of the blade along the axis of rotation for each revolution of the blade.

[0013] The blade may be provided such that it has an initial planar form having a progressively increasing width with increasing distance from the axis of rotation, whereby after twisting a substantially constant height elevation of the twisted blade is obtained.

[0014] The blade of the present invention demonstrates enhanced geometry compared with the prior art, enabling optimisation of performance and improved repeatability to be achieved in rheometers when used for testing materials of different bulk density and rheology. Data derived from blades of different sizes can be more reliably compared than hitherto.

[0015] For a better understanding of the present invention and to show more clearly how it may be carried into effect reference will now be made, by way of example, to the accompanying drawings in which:

Figure 1 is an isometric view of a blade for a rheometer according to the present invention;

Figures 2 and 3 are side and end-on views of the blade of Figure 1, illustrating the arrangement of the twisted blade;

Figure 4 is a diagram illustrating the angular twisting arrangement of the blade of Figure 1 as a function of blade lead distance and distance from the axis of rotation;

Figures 5A and 5B are diagrammatic representations of the effect of blade width geometry in the blade of Figure 1; and

Figure 6 is a diagrammatic illustration of an embodiment of a rheometer according to the present invention incorporating the blade of Figure 1.

[0016] Referring to Figure 1, a blade 1 for a rheometer is arranged to be mountable in a rheometer for rotation about an axis 2 on a shaft 3. The blade 1 has a region 4 arranged substantially at the axis of rotation 2 and such that the surface of the blade at this region 4 is substantially parallel to the axis of rotation 2. This means that the blade 1 where connected to the shaft 3 has its major surface in that region aligned with the axis of rotation 2 and the shaft 3.

[0017] The blade 1 extending outwards from that region is of twisted form and is arranged to extend radially, that is substantially at right angles to the axis of rotation 2 and preferably horizontally when in operation in a rheometer. As illustrated in Figure 2, this means that at any one of locations A, B, C along the blade, straight line paths 5 drawn across the blade surface perpendicular to the blade edge will be parallel to the axis of rotation 2.

[0018] As illustrated in Figure 3, reference numeral 6 refers to a plane through and along the blade 1, aligned with the axis of rotation 2. By way of explanation, such plane 6 through the axis of rotation extends effectively out of the plane of the paper. The twisted form of the blade results in the angle of surface 7 of the blade varying along the blade with respect to plane 6. Such angle X1, X2, X3, increases progressively with increasing distance along the blade from the axis of rotation 2. Correspondingly, the twisted form of the blade results in the angle of surface 7 of the blade decreasing progressively with regard to a plane perpendicular to the axis of rotation 2.

[0019] When the blade 1 is in use in a rheometer, it is arranged that for each revolution of the blade, the blade is displaceable by a predetermined distance along the axis of rotation 2. Such predetermined distance will hereinafter be referred to as the lead distance. As shown in Figure 4, the twisted blade 1 at any point A, B, C along its length has an angle Y1, Y2, Y3 formed by its surface with respect to a plane perpendicular to the axis of rotation 2. Such angle Y1, Y2, Y3 has a natural tangent which is inversely proportional to the distance D1, D2, D3 of the respective point A, B, C from the axis of rotation, in particular a natural tangent which is defined as the lead distance divided by the distance D1, D2, D3. The defined angle Y1, Y2, Y3 decreases progressively with increasing distance D1, D2, D3 from the axis of rotation 2.

[0020] Although the blade 1 may be provided in its twisted form from an initially planar rectangular form, it is preferred that the initially planar form demonstrates progressively increasing width with increasing distance from what will be the axis of rotation in the finished twisted blade. The reason for this is illustrated in Figures 5A and 5B which show top and side views respectively of a blade 1 mounted on a shaft 3. If the blade 1 is formed from an initially planar rectangular form, the height elevation H of the resulting twisted blade is not constant along the length of the blade, but decreases along the length of the blade from the shaft 3, as denoted by reference numeral 8. If, however, the blade in its initially planar form is designed to have progressively increasing width with increasing distance from the shaft 3, the height elevation H of the resulting twisted blade can be made substantially constant along its length as denoted by reference numeral 9.

[0021] The height elevation H of the twisted blade can be arranged to be in mathematical proportion to the lead distance of the blade, or to the diameter of the blade, or to the ratio of these parameters, the lead distance, as previously defined, being the distance of displacement of the blade along its axis of rotation for each revolution of the blade.

[0022] The blade of the present invention demonstrates enhanced design geometry, enabling optimisation of performance and improved repeatability to be achieved in rheometers when used for testing materials of different bulk density and rheology. The specific design criteria according to the present invention can be applied to blades of different diameters so that data derived from different sized blades can be reliably compared.

[0023] A standard blade form can be adopted, with the overall blade diameter adjusted to suit the diameter of vessels containing a test material, such as a powder, into which the blade is to be inserted for operation.

[0024] When using test vessels and blade assemblies of different diameters, a constant ratio of lead distance to the distance from the axis of rotation to the end of the blade may be adopted whereby test results can be meaningfully related.

[0025] The blade 1 of the present invention, or a plurality of such blades, can be used in rheometers of well-known form. Such rheometers are described, for example, in WO-A-9736162. Figure 6 shows an embodiment of a rheometer in which the blade of the present invention is provided. The rheometer comprises a generally cylindrical vessel 10 for containing a material 11, such as a powder, to be assessed. A blade 1, as detailed in Figure 1, is supported for rotation on a shaft 3 and is arranged as a close fit within the vessel 10. The blade is arranged to be rotated at a variable speed, either clockwise or anti-clockwise, by a variable speed device, such as a servo-motor, and gearbox unit 13.

[0026] The vessel 10 is supported on a torque and force measurement table 14. The blade can be raised or lowered in the axial direction of the vessel by means of a linear guidance system 15, operable at a variable velocity by means of a combined variable speed reversible drive and gearbox unit 17. The blade 1 is therefore able to undergo relative displacement along the axis of rotation of the shaft 3 with respect to the vessel 10 containing the material 11.

[0027] The combined movements of the blade and the vessel cause the blade to move along a helical path through the material 11 contained within the vessel 10.

[0028] A force and torque transducer unit 18 measures axial forces imposed on the material 11 as it is displaced and also measures torque imposed on the material.

[0029] The rheometer is controlled in known manner by a computer (not shown).

[0030] In an alternative arrangement, the blade 1 is fixed and the vessel 10 arranged to be raised or lowered around the blade.

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- WO9736162A [0003] [0025]
- US2896926A [0005]
- EP0469302A [0006]

Non-patent literature cited in the description

- Measuring the rheology of difficult materials - The FT3 powder rheometerApplied Rheology, 2000, 310-312 [0003]

PATENTKRAV

1. Rheometer, som omfatter et blad (1), der er monteret til at rotere omkring en akse (2), en variabel hastighedsindretning og gearkasseenhed (13) til at rotere bladet og midler, hvormed bladet for hver omdrejning af bladet forskydes med en forudbestemt frontafstand langs med rotationsaksen, kendetegnet ved, at bladet har snoet form, således at:

en første region (4) af bladet (1) i det væsentlige ved rotationsaksen (2) har en første vinkel, som dannes af dens overflade i forhold til et plan, som er vinkelret på rotationsaksen, således at overfladen af bladet i den første region strækker sig i det væsentlige parallelt med rotationsaksen;

en anden region af bladet (1) i en afstand fra rotationsaksen (2) har på et hvilket som helst punkt langs med sin længde en anden vinkel (Y1, Y2, Y3), som er forskellig fra den første vinkel, og som er dannet af sin overflade i forhold til det plan, der er vinkelret på rotationsaksen; og

den anden vinkel (Y1, Y2, Y3) har en naturlig tangent, som defineres som den forudbestemte frontafstand divideret med afstanden af punktet fra rotationsaksen.

2. Rheometer ifølge krav 1, kendetegnet ved, at bladet (1) strækker sig i det væsentlige i rette vinkler i forhold til rotationsaksen (2).

3. Rheometer ifølge krav 2, kendetegnet ved, at bladet (1) strækker sig i det væsentlige horisontalt.

4. Rheometer ifølge krav 1, 2 eller 3, kendetegnet ved, at højden (H) af det snoede blad er matematisk proportionalt med bladets frontafstand, idet bladets frontafstand defineres som forskydningen af bladet langs med rotationsaksen (2) for hver omdrejning af bladet (1).

5. Rheometer ifølge krav 1, 2 eller 3, kendetegnet ved, at højden (H) af det snoede blad er matematisk proportionalt med bladets diameter.

6. Rheometer ifølge krav 1, 2 eller 3, kendetegnet ved, at højden (H) af det snoede blad er matematisk proportionalt med et forhold mellem bladets frontafstand, bladets diameter, idet bladets frontafstand defineres som forskydningen af bladet (1) langs med rotationsaksen (2) for hver omdrejning af bladet.

7. Rheometer ifølge et hvilket som helst af de foregående krav, kendetegnet ved, at bladet (1) har en indledningsvis plan form, som har en progressivt stigende bredde med stigende afstand fra rotationsaksen (2), hvorved der efter snoning opnås en i det væsentlige konstant højde (H) af det snoede blad.

DRAWINGS

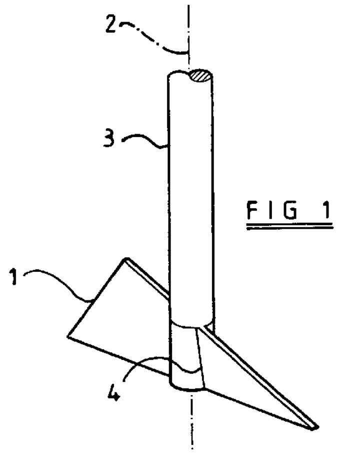


FIG 1

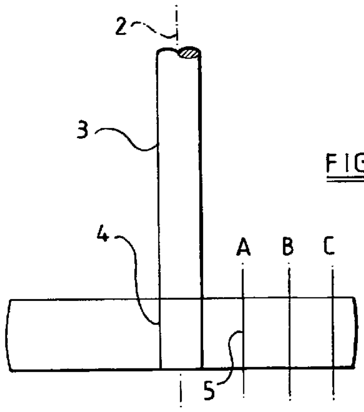


FIG 2

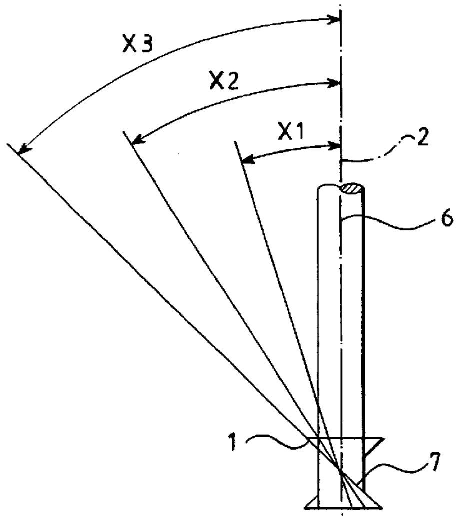


FIG 3

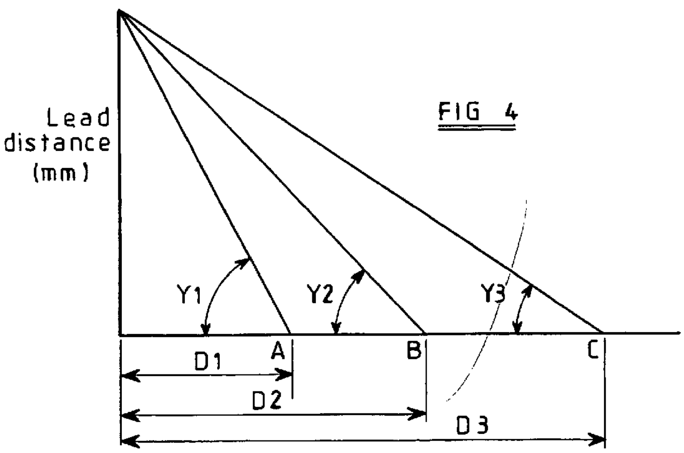
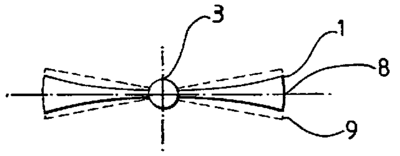


FIG 4

FIG 5a



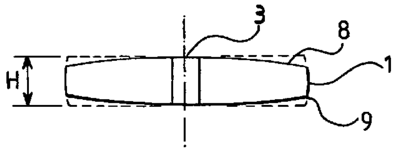


FIG 5b

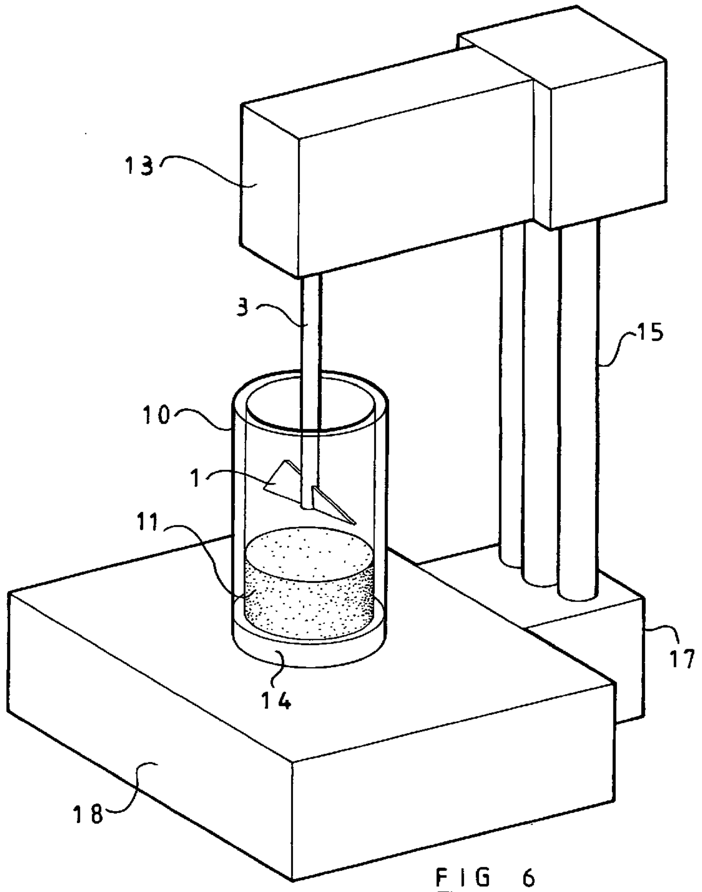


FIG 6