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(54) Pellet mill

(57) A pellet mill is provided comprising a cylindrical die member (1) with die passages (2) therethrough and having an axis of symmetry, a plurality of die-rollers (18,19) located within said die member (1), each mounted on a shaft (14,15) for rotation about a respective axis of rotation, said shafts extending in parallel with and spaced from said axis of symmetry, and further comprising drive means for generating a rotational movement of said shafts about said axis of symmetry and relative to said die member. Each die-roller (18,19) is fixedly attached to its respective shaft (14,15) and that each shaft is rotatably mounted for rotation about the respective axis of rotation by means of additional drive means. Further it is proposed that the die member (1) at its opposite ends is limited by stationary end walls (9,11) having openings through which said shafts extend, wherein said shafts are journalled in bearings positioned outside of the die member. The bearings may be adjustable.

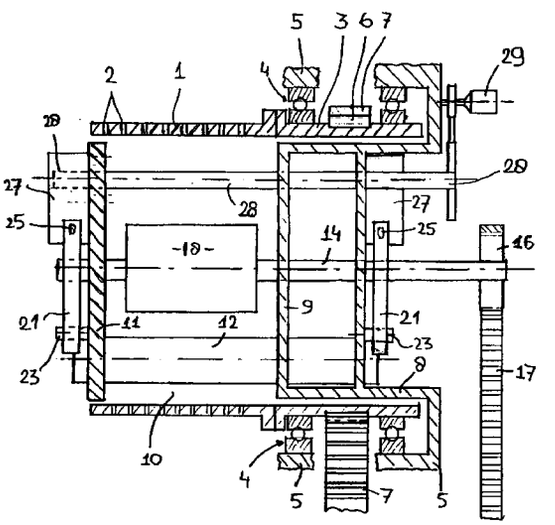

FIG. 1

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Description

[0001] The invention relates to a pellet mill, comprising a cylindrical die member with die passages therethrough and having an axis of symmetry, a plurality of die-rollers located within said die member, each mounted on a shaft for rotation about a respective axis of rotation, said shafts extending in parallel with and spaced from said axis of symmetry, and further comprising drive means for generating a rotational movement of said shafts about said axis of symmetry and relative to said die member.

[0002] In a known pellet mill of said type, the die member rotates about the axis of symmetry relative to the die-rollers, of which the axes of rotation are stationary. The rotation of the die-rollers about their respective axes of rotation depends upon the tangential force applied via the layer of product to be pelleted between the outer circumference of the die-rollers and the inner circumference of the die member. For a proper operation of the pellet mill a rotation of the die-rollers is required.

[0003] The tangential force applied via the layer of product and driving the die-rollers depends on many factors. such as the distance between the die-rollers and die member, wear of the components, variations of the composition of the product, temperature variations, feed rate of the product to be pelleted, wherin not all of these factors may be controlled during the pelleting operation. In practice this often leads to a defective tangential force, also referred to as "choke ups", requiring cleaning, re-adjusting and re-starting procedures. Further some compositions may result in firmer pellets with a larger gap between die-rollers and die member, increasing the risk of choke up. The same applies when pre-conditioning the fed product in expanders from which the product reaches the pellet mill with high levels of moisture and with increased temperature. The high entrance temperature and the temperature increase due to frictional forces in the product and in rotating components of the pellet mill further worsen the circumstances for the life span of the die-roller bearings and the seals of the die-rollers within the die member cavity. Over-lubrication of the bearings for increasing the life span, however, may lead to the escape of grease and undesired contamination of the product.

[0004] It is an object of the invention to provide a pellet mill of the type referred to above obviating the disadvantages encountered with the state of the art pellet mills.

[0005] According to the invention there is provided a pellet mill comprising a cylindrical die member with die passages therethrough and having an axis of symmetry, a plurality of die-rollers located within said die member, each mounted on a shaft for rotation about a respective axis of rotation, said shafts extending in parallel with and spaced from said axis of symmetry, and further comprising drive means for generating a rotational movement of said shafts about said axis of symmetry and relative to said die member, characterised in that each die-roller is fixedly attached to its respective shaft and that each shaft is rotatably mounted for rotation about the respective axis of rotation by means of additional drive means.

[0006] The pellet mill according to the invention yields excellent results while compacting powdery materials into pellets. The additional drive means rotate the die-rollers via the rotatably mounted shafts. Thus the rotation of the die-rollers no longer depends on tangential forces applied via the layer of product. By regulating the additional drive means, optionally in combination with a regulation of the drive means causing the rotational movement of said shafts relative to the die member, the obtained pellets may be optimised and the results are far less dependent on the factors mentioned before.

[0007] Although principally a pellet mill is conceivable, in which the die member is stationary and wherein the shafts, apart from their rotation about the axes of rotation of the die-rollers, rotate about the axis of symmetry and thus follow circular tracks, constructively it is preferred that the position of the axis of rotation of each of said shafts is stationary, wherein the die member is driven by said drive means for rotation about its axis of symmetry.

[0008] As mentioned before, the drive means and additional drive means preferably may be regulated both, and this may occur independently. However, in certain cases it suffices, when the drive means and additional drive means are synchronised.

[0009] Further a preferred embodiment of the pellet mill according to the invention is mentioned, in which the drive means and additional drive means comprise toothpulleys attached to said die member and to said shafts cooperating with toothed belts driven by motors. When, as mentioned before, a synchronisation is desired, the toothed belts all may be driven by one single common intermediate shaft provided with a toothed gear. Also other drive means and additional drive means are conceivable, such as V-belts with corresponding pulleys.

[0010] Next, an embodiment is mentioned, according to which the die member at its opposite ends is limited by stationary end walls having openings through which said shafts extend, wherein said shafts are journalled in bearings positioned outside of the die member. By positioning the bearings of the shafts outside of the die member cavity, which becomes possible because the die-rollers are fixedly attached to said shafts, a contamination of the product by lubricating grease is certainly avoided.

[0011] The operating range of the pellet mill according to the invention may further be increased, when the bearings are adjustable such as to set the distance between the outer circumference of the die-rollers and the inner circumference of the die member. Among a series of possible solutions for obtaining said adjustability, a special solution is mentioned, according to which

the bearings are carried by pivot arms which are drivable through driving mechanisms. While adjusting the position of the bearings, and thus of the shafts supporting the die-rollers, the shafts follow limited curved tracks. The openings in the end walls limiting the die member cavity should have corresponding shapes for allowing such an adjustment.

[0012] Further it offers constructive advantages, when the stationary end walls are interconnected by means of connecting rods extending inside of the die member in parallel with said axis of symmetry, whereas further a driven shaft extends between said end walls for driving said driving mechanisms for pivoting said pivot arms. Constructively uniting both end walls and providing the drive mechanism for the adjustment of the bearings thus is combined effectively.

[0013] Although the pivotal movement of the pivot arms may be realised in many ways, it is proposed that the driving means each comprise an assembly of worm gears driving plungers connected with the pivot arms. Such an assembly per se is known to experts in this field, and thus does not need any further explanation.

[0014] When, in accordance with yet a further embodiment of the pellet mill according to the invention, the die member at one of its ends is prolonged beyond the respective end wall and wherein said end wall is part of a cylindrical body positioned concentrically within the die member prolongation, a compact constructive solution for the pellet mill is provided.

[0015] Finally, the inventive concept offers excellent results when the die member axis of symmetry extends horizontally. This means, that the pellet mill is of the type with vertically arranged die member.

[0016] The invention will now be elucidated referring to the drawings, in which

Fig. 1 is a partly vertical section, partly side elevational view, of an embodiment of the pellet mill according to the invention, wherein only parts essential for understanding the inventive concept are illustrated in a schematical manner, and
Fig. 2 is a frontal view from the left in fig. 1.

[0017] Referring to the figures, part of a pellet mill is illustrated, comprising a cylindrical die member 1 with die passages 2 therethrough. In the illustrated embodiment the pellet mill is of the type with vertically arranged die member 1. As shown in fig. 2, the cylindrical die member has an axis of symmetry 31 extending horizontally.

[0018] A hollow cylindrical prolongation 3 is, by means not shown further, connected to one of the ends of the die member 1. The prolongation 3 is located and rotatable in bearings 4 which further are connected with the structural body 5 of the pellet mill. The prolongation 3 carries at its circumference a toothpulley 6 cooperating with a toothed belt 7. The toothed belt 7 is driven by drive means not shown in detail (for example an electric motor).

[0019] It will be clear to an expert, that the bearings 4, together with parts yet to be described, may be provided with seals known per se for preventing the entrance of dirt.

[0020] Within the cylindrical prolongation 3 a cylindrical body 8 is positioned which at its rear side (at the right in fig. 1) is connected to the structural body 5, and which at its forward side ends in an end wall 9 limiting the die member cavity 10. Not shown are bearings interpositioned between the outer circumference of the cylindrical body 8 and the inner circumference of the prolongation 3.

[0021] The die member cavity 10 is at its side opposite the end wall 9 limited by another end wall 11. Not shown are provisions for ensuring that products to be pelleted can be fed into the die member cavity 10.

[0022] The end walls 9, 11 and cylindrical body 8 are structurally connected by means of a number of connecting rods 12, of which only one is represented.

[0023] In each of the end walls 9 and 11 openings 30, illustrated in dotted lines in fig. 2, are provided through which shafts 14 and 15 (fig. 2) extend. Said shafts 14 and 15 are positioned at 180° opposite each other (fig. 2). The shafts 14 and 15 extend beyond the cylindrical body 8 and each carry a toothpulley 16 cooperating with a toothed belt 17. Again, said toothed belt 17 is driven by a drive means, such as an electric motor.

[0024] Fixedly attached to each shaft 14 and 15 are die-rollers 18 and 19. Thus, driving the shafts 14 and 15 by means of the toothed belts 17 will lead to a rotation of the die-rollers 18 and 19 about respective axes of rotation 20 coinciding with the centre line of the shafts 14 and 15.

[0025] Each shaft 14 and 15 is near to its opposite ends journalled in pivot arms 21 and 22 pivoting about pivots 23 and 24 respectively. The free ends of the pivot arms 21 and 22 are engaged by plungers 25, 26 driven by an assembly of worm gears 27 only shown schematically and driven by a driven shaft 28 extending between and beyond the end walls 9, 11. The driven shaft 28 is driven by a drive means, such as an electric motor 29 or alike.

[0026] When the assembly of worm gears 27 is activated, the plungers 25 and 26 adjust the position of the pivot arms 21 and 22, and thus the position of the shafts 14 and 15 together with the die-rollers 18 and 19. Thus the distance between the outer circumference of the die-rollers 18 and 19 and the inner circumference of the die member 1 can be adjusted.

[0027] Because of the pivotal movement of the shafts 14 and 15 the openings 30 in the end walls 9 and 11 are correspondingly shaped in a curved manner. Appropriate sealing devices may be provided.

[0028] In operation the prolongation 3, and therefor the die member 1, is driven by means of the toothed belt 7 and toothpulley 6. Further the die-rollers 18 and 19 are driven by means of the toothed belts 17 and tooth-

pulleys 16. The drive means driving the toothed belts 7 and 17 may or may not be synchronised. By means of the driven shaft 28 and assembly of worm gears 27 it is possible to adjust the position of the die-rollers 18 and 19 during the operation of the pellet mill.

[0029] From the above it appears, that the shafts 14 and 15 are journalled outside of the die member cavity 10. Thus, a contamination of product to be pelleted by grease can be avoided effectively.

[0030] Due to the fact, that the die member 1 as well as the die-rollers 18 and 19 are positively driven, at all circumstances an optimal relation between the movements of the die member 1 and the movements of the die-rollers 18 and 19 may be chosen.

[0031] Because of the pivotal movement of the pivot arms 21 and 23 tensioning devices for the toothed belts 17 should be provided. Further it may be preferred to provide slip couplings for disengaging the drive means in case of a sudden overload.

[0032] Although in the present embodiment the die member 1 is rotating relative to the structural body 5, whereas the cylindrical body 8 with components attached thereto is stationary it will be immediately clear to an expert, that also the die member 1 may be stationary, whereas the cylindrical body 8 with components attached thereto may be rotating relative to the structural body 5. This does not change the inventive concept.

Claims

1. Pellet mill, comprising a cylindrical die member with die passages therethrough and having an axis of symmetry, a plurality of die-rollers located within said die member, each mounted on a shaft for rotation about a respective axis of rotation, said shafts extending in parallel with and spaced from said axis of symmetry, and further comprising drive means for generating a rotational movement of said shafts about said axis of symmetry and relative to said die member, **characterised** in that each die-roller is fixedly attached to its respective shaft and that each shaft is rotatably mounted for rotation about the respective axis of rotation by means of additional drive means.

2. Pellet mill according to claim, **characterised** in that the position of the axis of rotation of each of said shafts is stationary, wherein the die member is driven by said drive means for rotation about its axis of symmetry.

3. Pellet mill according to claim 1 or 2, **characterised** in that the drive means and additional drive means are synchronised.

4. Pellet mill according to one of the previous claims, **characterised** in that the drive means and additional drive means comprise toothpulleys attached to said die member and to said shafts cooperating with toothed belts driven by motors.

5. Pellet mill according to one of the previous claims and claim 2, **characterised** in that the die member at its opposite ends is limited by stationary end walls having openings through which said shafts extend, wherein said shafts are journalled in bearings positioned outside of the die member.

6. Pellet mill according to claim 5, **characterised** in that the bearings are adjustable such as to set the distance between the outer circumference of the die-rollers and the inner circumference of the die member.

7. Pellet mill according to claim 6, **characterised** in that the bearings are carried by pivot arms which are drivable through driving mechanisms.

8. Pellet mill according to claim 7, **characterised** in that the stationary end walls are interconnected by means of connecting rods extending inside of the die member in parallel with said axis of symmetry, whereas further a driven shaft extends between said end walls for driving said driving mechanisms for pivoting said pivot arms.

9. Pellet mill according to claim 7 or 8, **characterised** in that the driving means each comprise an assembly of worm gears driving plungers connected with the pivot arms.

10. Pellet mill according to one of the claims 5-9, **characterised** in that the die member at one of its ends is prolonged beyond the respective end wall and wherein said end wall is part of a cylindrical body positioned concentrically within the die member prolongation.

11. Pellet mill according to one of the previous claims, **characterised** in that the die member axis of symmetry extends horizontally.

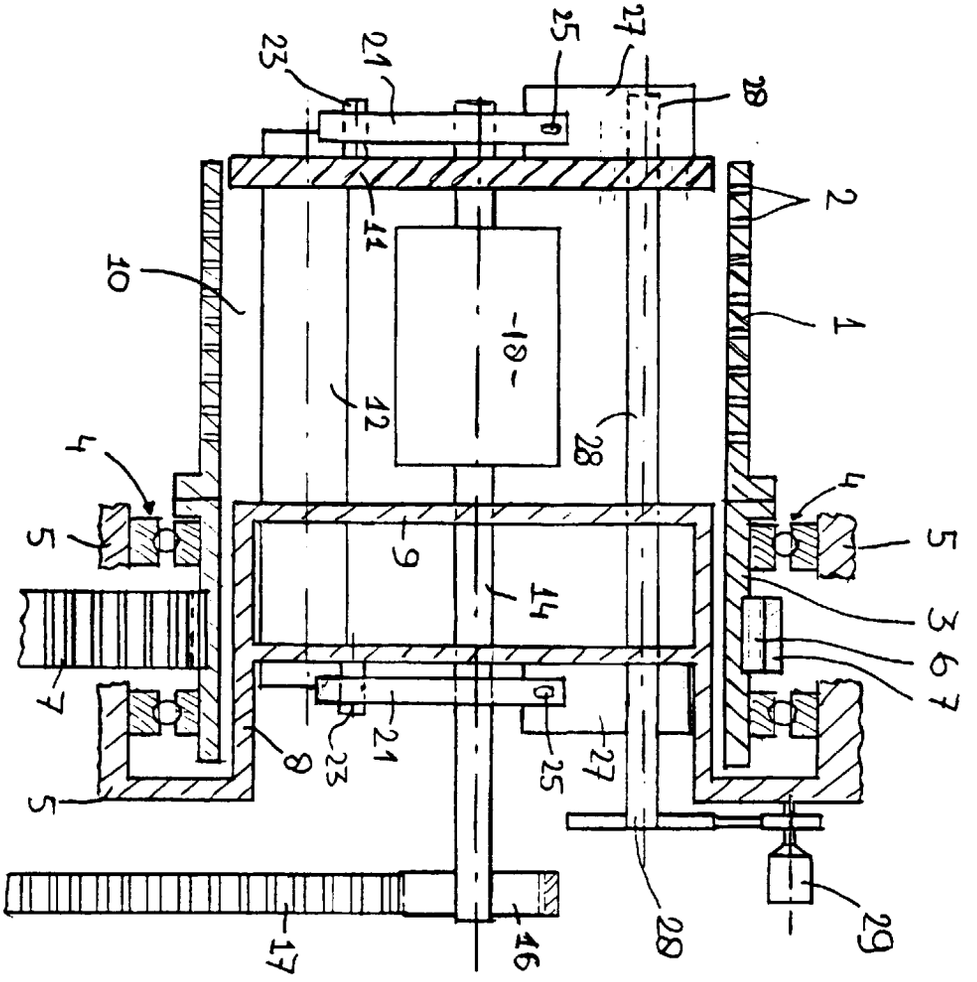
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FIG.1

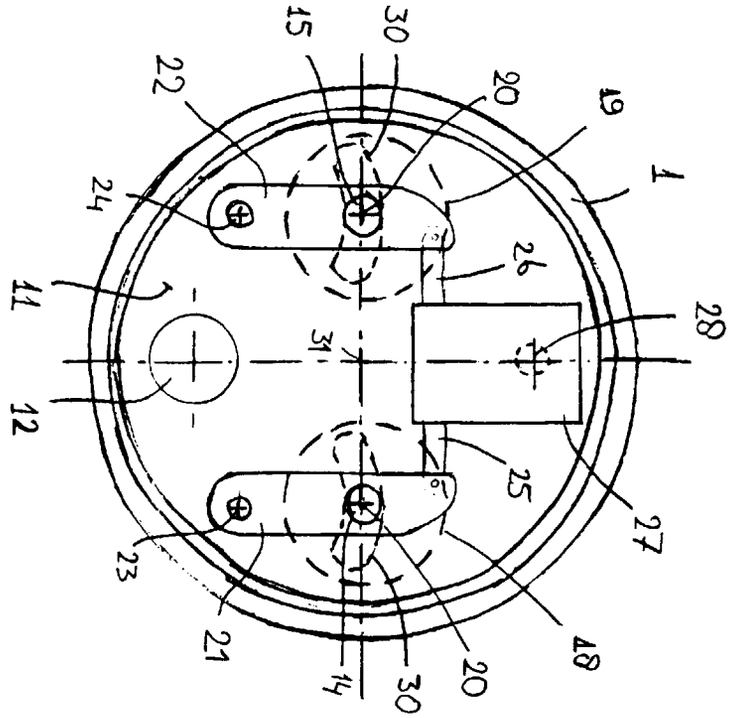
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FIG.2

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EUROPEAN SEARCH REPORT

Application Number
EP 98 20 1551

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	GB 2 130 959 A (RU KORREL PTY LTD) 13 June 1984 * abstract; figures 1-3 *	1-6,10, 11 7-9	B30B11/20
Y	GB 989 603 A (VEB MUHLENBAU DRESDEN) 22 April 1965 * figures 1,2 *	7-9	
X	EP 0 694 380 A (SALZHAUSENER MASCHINENBAUTECHN) 31 January 1996 * claims 4-6; figures *	1-3,10, 11	
X	WO 91 02644 A (TNO) 7 March 1991 * claims 1-6; figures *	1-4,6,11	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B30B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	1 October 1998	Belibel, C

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