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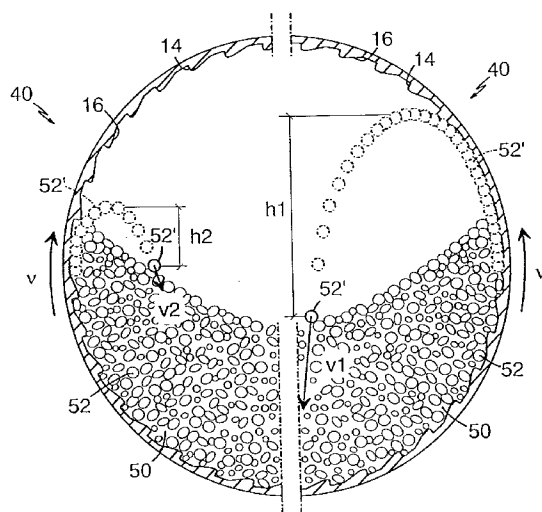
(54) A grinding process and a drum lining

(57) A method of grinding a batch of material, particularly ceramic material, together with a multiple of grinding media in a rotary mill drum which includes a polymer lining having elongated lifting devices which are positioned axially in the drum and which protrude radially into the drum interior. With the intention of making grinding more effective and of reducing grinding time, it is proposed in accordance with the invention that the method will comprise the steps of:
rotating the drum at a constant speed in a first direction of rotation during a first time interval, so that grinding media from said grinding media multiple are brought into contact with a high-lifting side of the lifting devices as

the drum rotates, to grind or disintegrate the material with a larger crush proportion and a smaller fine-grinding proportion; and

- rotating the drum at said constant speed in a rotational direction opposite to the first rotational direction in a second time interval following said first time interval, so that grinding media in said grinding media multiple are brought into contact with a low-lifting side of said lifting devices opposite to the high-lifting side thereof, so as to grind the material with a smaller crush proportion and a larger fine-grinding proportion.

The invention also relates to a mill lining for use with such a method.

**FIG.3****EP 0 714 703 A1**

Description

The present invention relates to a method of grinding a batch of process material, particularly ceramic material, together with a multiple of grinding media in a rotary, drivable mill drum which has a lining comprised of polymeric material and which includes lifting devices which are orientated axially in the drum and which project radially down into the drum interior. The invention also relates to a drum lining for use in such grinding methods.

It is known that considerable time and energy can be saved in grinding processes, particularly when grinding ceramic materials, by rotating the mill drum during a preceding time interval at a higher speed than that at which the drum is rotated in a subsequent time interval in one and the same pass through the drum. This is thought to be due mainly to the division of the mill pass into a coarse grinding interval in which coarser parts of the process material broken down more effectively by virtue of the more pronounced crushing effect obtained by grinding media falling from a greater height in the process material, and a fine grinding interval in which the remaining finer fragments of the process material are disintegrated effectively by virtue of the grinding action of material falling from a smaller height and therewith acting with the process material over a longer period of time.

One object of the present invention is to develop this known technique, so that it can also be applied to existing grinding mills, particularly mills intended for grinding ceramic materials, which lack the possibility of adjusting the rotational speed of the mill drum or cylinder. This object is achieved by the features set forth in the characterizing clauses of the following dependent Claims.

According to one aspect of the invention, the method is characterized by

- rotating the drum at a constant speed in a first direction of rotation during a first time interval, so that grinding media from said grinding media multiple are brought into contact with a high-lifting side of the lifting devices as the drum rotates, to grind or disintegrate the material with a larger crush proportion and a smaller fine-grinding proportion; and
- rotating the drum at said constant speed in a rotational direction opposite to the first rotational direction in a second time interval following said first time interval, so that grinding media in said grinding media multiple are brought into contact with a low-lifting side of said lifting devices opposite to the high-lifting side thereof, so as to grind the material with a smaller crush proportion and a larger fine-grinding proportion.

An inventive mill lining made of polymeric material

and intended for a rotary, drivable mill drum for grinding a batch of process material together with a grinding media multiple and including lifting devices which are positioned axially in said drum and project radially down into the drum interior is characterized in that each lifting device includes a high-lift side which as the drum rotates at a constant speed in a first direction during a first time interval is brought into contact with grinding media from said grinding media multiple, such as to grind or disintegrate the process material with a larger crush proportion and a smaller fine-grinding proportion, and further includes a low-lift side which lies opposite to said high-lift side, wherein as the drum rotates at said constant speed in a direction opposite to said first rotational direction in a second time interval following said first time interval, said low-lift side is brought into contact with grinding media in said grinding media multiple so as to grind or disintegrate the process material with a smaller crush proportion and a larger fine-grinding proportion.

The invention is based on the concept that, in principle, the same effect as that achieved when rotating the mill at varying speeds can also be achieved by varying the direction of drum rotation and by providing the drum lining with double-acting asymmetric lifting devices which lift the grinding media to different heights in respective directions of rotation. Although asymmetric lifting devices are known to the art, it is not known to drive such devices in different directions during one and the same mill pass so as to achieve an intentional difference in lifting height in the two different directions of rotation, particularly in mills for grinding ceramic materials.

Other features of the invention and advantages afforded thereby are made apparent in the remaining Claims and in the following detailed description.

Exemplifying embodiments of the invention will now be described in more detail with reference to the accompanying drawings, in which FIG. 1 is a cross-sectional view of part of a mill drum equipped with an inventive mill lining; FIG. 2 illustrates the geometrical configuration of a lifting device for an inventive mill lining in larger scale; and FIG. 3 is a schematic cross-sectional view of an inventive batch mill drum, showing the drum operating in both directions of rotation.

FIG. 1 shows part of a mill drum 40 of a batch mill including a lining made of polymeric material and further including a plurality of elongated lining elements 10 which are positioned axially in the drum 40 and placed so as to cover the inner periphery of the drum 40.

When seen in cross-section, each lining element 10 has formed on one side thereof a lifting device 12 which projects radially down into the interior of the drum 40. At one end of the lining element 10, the lifting member 12 is delimited by a high-lift side 14, while the opposite end of said element is delimited by a low-lift side 16. The lifting member 12 has a generally flat upper surface 18 extending between said sides 14 and 16.

A fastener profile 28 of a bolt attachment arrangement, generally referenced 30, is inserted into the lining

element 10 on the underside of the lifting member 12. The fastener profile 28 has a downwardly facing, elongated slot or channel having flanges which are angled in towards each other, such as to enable the head of a bolt included in said fastener arrangement 30 to be pushed into the slot or channel and there held firmly so as to anchor the lining element 10 to the drum 40, in the manner shown in FIG. 1.

Beneath a flange on the fastener profile 28 facing towards the high lift side 14, the lining element 10 is provided with a recess 26 which lies adjacent the inner surface of the mill drum 40 and which is adapted to overlap and act clampingly in a region 24 of an adjacent end of a nearby lining element 10. The remaining part of the lining element 10 between the region 24 and the lifting member 12 has a generally flat upper side 20 and an upwardly angled side 22 adjacent the region 24.

As will be seen from FIG. 2 in particular, the extension of the recess 26 in the peripheral direction of the drum 20 is such as to enable overlapping of the firmly clamped region 24 located therebetween to be varied. This adjustability permits a given lining element 10 to be given a variable active width which constitutes an integer multiple of the internal periphery of the mill drum. In other words, a lining element 10 of one single dimension can be used to line drums of mutually different diameters, by adapting the overlap of the recess 26 so that a given number of lifting devices will be distributed uniformly in the drum 40.

It will also be seen from FIG. 2, that the high-lift side 14 has a normal direction N1 which deviates negligibly from a first rotational direction D1 by an angle α , or which coincides generally with said first rotational direction. The low-lift side 16 opposite to the side 14 has a normal direction N2 which deviates from the opposite rotational direction D2 by an angle β . It has been found that an angle β of between about 64 and 84 degrees, and particularly about 74 degrees, is advantageous.

FIG. 3 illustrates principally two halves of a mill drum 40 according to the invention in operation with a batch of process material 50 and grinding media 52, wherein the right half of the Figure shows the drum 40 rotating in a first direction at a constant speed v , while the left side of the Figure shows the drum 40 rotating in an opposite direction, also at the constant speed v . As indicated in the foregoing, when grinding a batch of process material, the drum 40 is rotated in a first direction in the initial time interval or in a time interval which precedes a following time interval, and is then driven in the opposite direction during a terminating time interval or a time interval following said preceding time interval. The duration of the time interval can be determined on the basis of the composition of the process material, and the time intervals may thus vary in relation to one another.

It will be seen from FIG. 3 that when the drum 40 is rotated in said first direction, the high-lift sides 14 of respective lining elements will face in this direction. The

process material 50 and the grinding media 52 that are located nearest the periphery of the drum 40 will thus be entrained by the high-lift sides 14 of said lining elements and fall or be slung therefrom into the interior of the drum 40 from a relatively large height h_1 , such that when the process material and the grinding media meet the grinding charge, they will have a relatively high impact energy and impact speed v_1 and therewith exert a relatively large crushing effect on the still coarse process material. On the other hand, as the drum 40 rotates in the opposite direction, the low-lift sides 16 of the lining elements face in this direction. The process material and the grinding media entrained by these low-lift sides 16 will not be lifted as high as they were in the earlier case and will slide quickly from the low-lift sides or possibly be rejected thereby, from a much lower height h_2 , so that they will have a far lower impact energy or impact speed v_2 when they again meet the grinding charge. This results in a smaller crushing effect, such that the material being ground and the grinding media will obtain a tumbling motion resulting in more pronounced attrition for fine-grinding of the material that was partially crushed or completely crushed in the preceding time interval.

Rotation of the batch mill in the opposite direction can easily be achieved with the aid of solutions well known in the field of electric motors, these solutions requiring no modification to existing mechanical drive transmissions, for instance.

It will be obvious to one of normal skill in this art that the described and illustrated embodiments can be modified in various ways. The description is not intended to restrict the scope of the invention, but rather to illustrate an embodiment which is preferred at this moment in time.

Claims

1. A method of grinding a batch of material, particularly ceramic material, together with a number of grinding media in a rotational, drivable mill drum having a lining of polymer material and including elongated lifting devices positioned axially in the drum and protruding radially into the drum interior, **characterized** by rotating the drum at a constant speed in a first direction of rotation during a first time interval, so that grinding media from said grinding media multiple are brought into contact with a high-lifting side of the lifting devices as the drum rotates, to grind or disintegrate the material with a larger crush proportion and a smaller fine-grinding proportion; and
 - rotating the drum at said constant speed in a rotational direction opposite to the first rotational direction in a second time interval following said first time interval, so that grinding media

in said grinding media multiple are brought into contact with a low-lifting side of said lifting devices opposite to the high-lifting side thereof, so as to grind the material with a smaller crush proportion and a larger fine-grinding proportion.

2. A polymer lining (10) for a rotary mill drum (40) intended for grinding a batch of process material (50), particularly ceramic material, together with a multiple of grinding media (52, 52'), wherein the lining includes elongated lifting devices (12) which are positioned axially and which protrude radially into the drum, **characterized** in that each lifting device (12) includes a high-lift side (14) which as the drum (40) is rotated in a first rotational direction (D1) at a constant speed during a first time interval is intended to come into contact with grinding media (52') of said grinding media multiple to grind with a larger crush proportion and a smaller fine-grinding proportion, and further includes a low-lift side (16) which lies opposite to the high-lift side (14) and which is intended to come into contact with grinding media (52') of grinding media multiple as the drum (40) is rotated in a second direction (D2) opposite to the first direction (D1) and at said constant speed during a second time interval following said first time interval, such as to grind the material (40) with a smaller crush proportion and a larger fine-grinding proportion.
3. A mill lining according to Claim 2, **characterized** in that the high-lift side (14) of respective lifting devices (12) has a normal direction (N1) which deviates negligibly from or essentially coincides with the first rotational direction (D1); and in that the opposite low-lift side (16) of said lifting devices (12) has a normal direction (N2) which defines an angle of between 64 and 84 degrees, particularly about 74 degrees, with the second rotational direction (D2).
4. A mill lining according to Claim 2 or Claim 3, **characterized** in that each lifting member (12) is formed integrally with a lining element (10) having an effective width which constitutes an integer multiple of the active inner periphery of the drum (40).
5. A mill lining according to Claim 4, **characterized** in that the high-lift side (14) forms a terminating first side of the lining element (10).
6. A mill lining according to Claim 5, **characterized** in that the lining element (10) has at said terminating first side a recess (26) which lies adjacent the inner surface of the drum (40) and overlaps the inner surface of a region (24) on an opposite adjacent second side of an adjacent lining element (10) and in which said region is firmly clamped by means of a

bolt fastener arrangement (30) mounted on the underside of the lifting member.

7. A mill lining according to Claim 6, **characterized** in that the tangential extension of the recess (26) is such as to enable a given lining element (10) to have several effective widths, each of which constitutes an integer multiple of an active inner periphery of the mill drum.

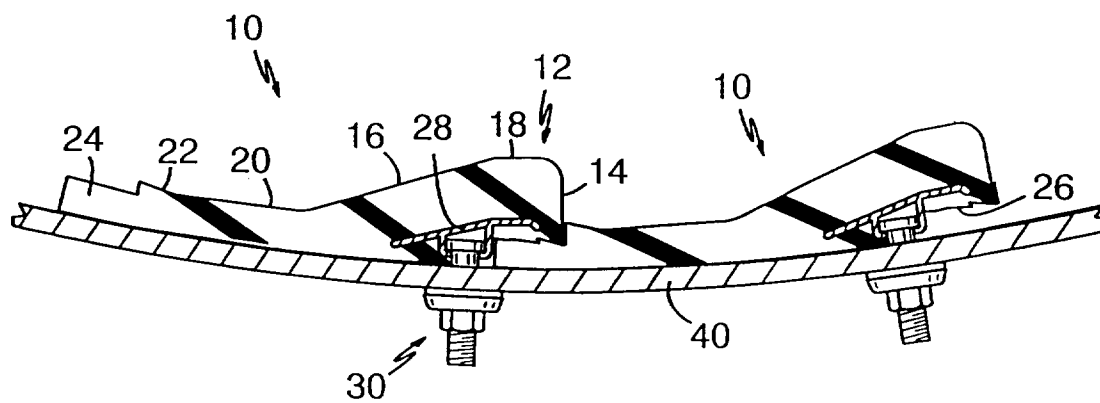


FIG.1

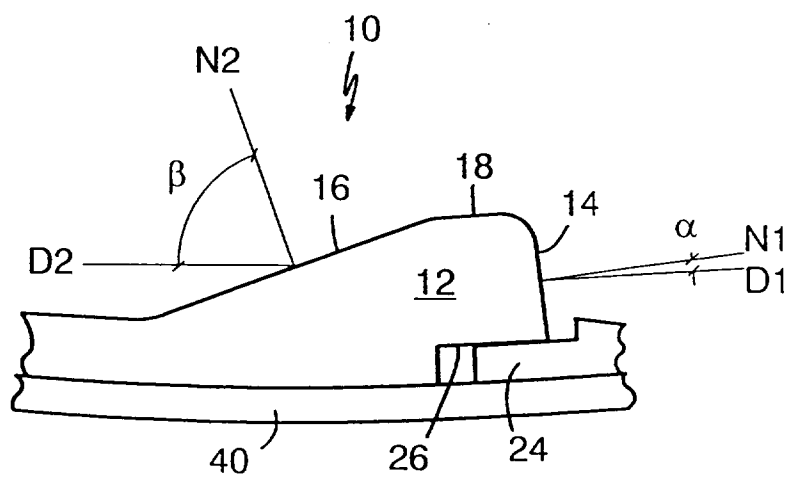


FIG.2

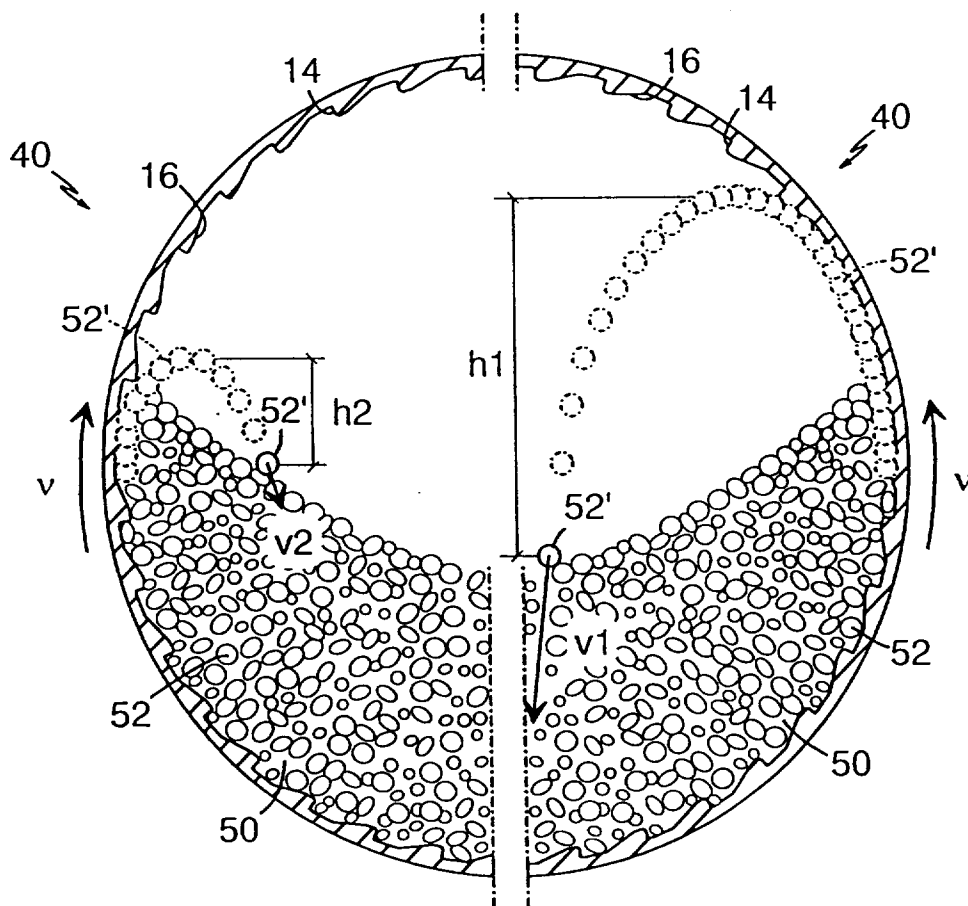


FIG.3



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EUROPEAN SEARCH REPORT

Application Number
EP 95 85 0200

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)
A	GB-A-200 220 (G.T. MITCHELL) * the whole document *	1,2	B02C17/24 B02C17/22
A	DE-C-155 919 (H. LÖHNERT) * the whole document *	1,2	
A	DE-B-11 26 709 (MIAG) * the whole document *	1,2	
A	DE-A-18 10 920 (TRELLEBORGS GUMMIFABRIKS AKTIEBOLAG) * claim 1; figure 8 *	1,2	
A	DE-U-89 12 950 (INTERTHAL ARNO) * claims 1,5 *	1,2	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B02C
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 March 1996	Examiner Verdonck, J
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