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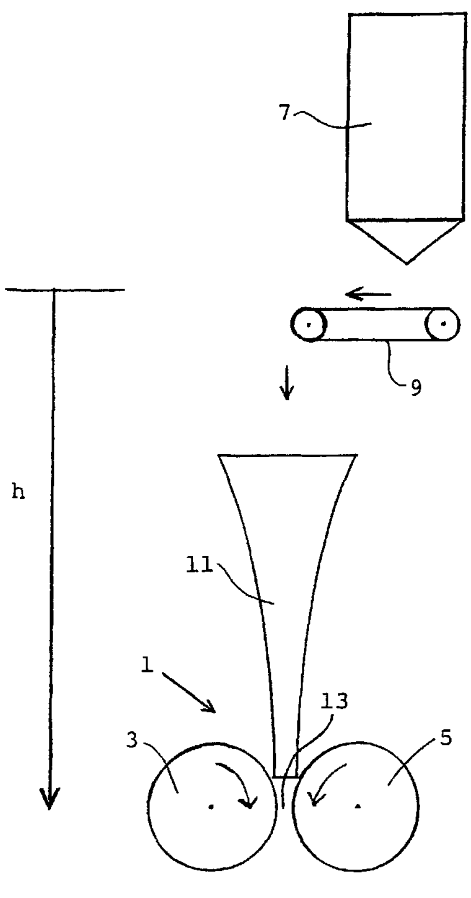
(54) Title: METHOD AND APPARATUS FOR GRINDING OF PARTICULATE MATERIAL



(57) Abstract: A description is provided of a method as well as an apparatus for grinding particulate material, such as cement raw materials, cement clinker or similar materials, in a roller mill (1) by subjecting the material to pressing action in a zone (13) between opposite, rotating surfaces where the material is directed to the grinding zone via a feed shaft (11). The method is peculiar in that the material in the feed shaft (11) is accelerated through the action of gravity to a desired velocity without involving essential air admixture, whereas the apparatus is peculiar in that the feed shaft is essentially of a vertical configuration, with a downwardly reduced cross-section, where the reduction of the shafts cross-sectional circumference per height unit is downwardly decreasing. The described configuration of the feed shaft has, surprisingly, proved that the material over a given height of fall may attain high velocities and that this is achievable without involving admixture of air into the material. It has thus been established that it will be possible for the material to attain velocities which are close to the velocity achievable in connection with the free fall of individual particles.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

METHOD AND APPARATUS FOR GRINDING OF PARTICULATE MATERIAL

The present invention relates to a method for grinding of particulate material such as cement raw materials, cement clinker or similar materials, in a roller mill, such as a roller press, ring-roller mill, vertical mill or a similar unit, by subjecting the material to pressing action in a zone between opposite, rotating surfaces where the material is directed to the grinding zone via a feed shaft. The invention also relates to an apparatus for carrying out the method according to the invention.

The methods as well as apparatuses of the aforementioned kind are prior art.

In recent years, developments in grinding technology have primarily been devoted to improving the cost efficiency of the grinding process. In this context, the primary focus has been to improve the operating economy of the grinding process and to reduce the capital cost of the grinding machines relative to their capacity ratings. A method widely used to lower the investments costs involves uprating of the operating speed of a machine, and hence its productivity. Needless to say, the operating speed of a machine can only be increased up to a certain point, and, furthermore, it is a recognized fact that problems are likely to occur in connection with the operation of, for example, a roller press if the peripheral velocity of the rollers is increased arbitrarily.

Such operating problems may be ascribable to many different causes. One explanation could be the difficulty of achieving an acceleration of the material which is to be ground in the roller press to an extent which corresponds to the peripheral velocity of the rollers. Such acceleration of the material is usually achieved by means of the rollers by physical contact with the latter and/or through the action of gravity. However, the capability of the rollers is restricted to a very short range of operation, thereby severely limiting the rate of acceleration, and in a shaft the force of gravity will either be counteracted by the friction of the material against the shaft and/or the friction present in the material itself. Also, acceleration accomplished in a traditional shaft will also entail significant admixture of air, which is undesirable, and this will also adversely affect the grinding process. Use of a vertical shaft with a circular or rectangular cross-section and with an identical cross-sectional area across the entire length will enable the force of gravity to accelerate the material to a high velocity, but in this scenario there will be a simultaneous increase in the distance between the particles, thereby decreasing the density of the material and involving air admixture. By using a shaft of a pyrimidal or conical configuration, it will be possible to maintain the distance between the particles, but in a shaft of this type the material will be influenced by forces of friction which are so substantial that the terminal velocities attainable are quite small. In such ordinary shafts the cross-sectional circumference is a linearly decreasing function of the height. The reduction of the cross-sectional circumference per height unit thus remains constant for these shafts.

It is the objective of the present invention to provide a method as well as a plant for remedying the aforementioned deficiencies.

This is achieved by a method of the kind mentioned in the introduction, and being characterized in that the material in the feed shaft is accelerated by means of the force of gravity to a desired velocity without involving essential admixture of air. The plant according to the invention is characterized in that the reduction of the shaft´s cross-sectional circumference per height unit is downwardly decreasing.

The described configuration of the feed shaft has, surprisingly, proved that the material over a given height of fall may attain high velocities, and that this is feasible without involving admixture of air into the material. It has thus been established that it will be possible for the material to attain velocities which are close to the velocity achievable in connection with the free fall of individual particles.

The material can be accelerated to a velocity of more than 1.5 m/s. However, it is preferred that the material be accelerated to a velocity of more than 5 m/s, and preferably of more than 10 m/s.

An example of the cross-sectional characteristics according to the invention is known from the form of a free-falling water jet, for example from a slow-running water tap. At the top, at the outlet of the water tap, the water flow rate is quite small, with the width of the water jet corresponding roughly to the outlet. Further downstream of the jet the force of gravity has increased the water flow rate, but since the water flow throughout the jet is the same, and since the density throughout the jet is also the same, this means that the cross-section of the water jet is smaller. In this way the water jet will attain an almost hyperbolic shape and the characteristics of the cross-sectional area as a function of the height of fall can be expressed by means of the formula:

(1) $$A = (1+\Delta)\frac{\dot{V}}{\sqrt{2gh}},$$ where

A is the cross-sectional area

$\dot{V}$ is the volume flow

g is the gravity acceleration

h is the height of fall

Δ is a correction element which describes the friction in the material, assuming for water a small value which is close to 0

The water jet must be assumed to roughly circular and, therefore, its circumference can be calculated on the basis of the formula:

(2) $$O = \pi D = \pi \sqrt{\frac{4}{\pi}(1+\Delta)\frac{\dot{V}}{\sqrt{2gh}}}$$, where

O is the circumference
D is the diameter of the water jet

As it appears from the aforementioned formula, the circumference is proportional not to the height of fall but to the height of fall to power ÷¼.

According to the invention it is preferred that the shaft be configured so that its cross-sectional area as a function of the fall of height is essentially as defined in the formula above. To make allowance for the friction which occurs when feeding particulate material via a shaft according to the invention, the correction element Δ must be within the range 0 and 0.2, preferably lower than 0.1.

The shaft may, for example, be made up of a number of pyramidal or conical sections so that the reduction of the cross-sectional circumference of the shaft exhibits a gradual, downwardly decreasing trend. To ensure that the shape of such a shaft does not deviate too much from the formula (1) indicated above, it is preferred that the number of sections incorporated is at least 3, but preferably at least 5, and most preferably at least 10.

However, it is preferred that the reduction of the cross-sectional circumference of the shaft exhibits a continuous downwardly decrease, and that for example the shaft is of a trumpet-shaped configuration.

In principle, it will be possible to use the shaft according to the invention for conveying any particulate material from one level to a lower level by the action of gravity, and for this purpose the shaft should be of a substantially vertical configuration, with a downwardly reduced cross-section where the reduction of the cross-sectional circumference of the shaft is downwardly decreasing.

The invention will be explained in further details in the following with reference being made to the drawing, which is diagrammatical, and where

Fig. 1 shows a roller press installation comprising a feed shaft according to the invention.

In Fig. 1 is seen a roller press installation comprising a roller press 1 with two oppositely rotating rollers 3 and 5. During the operation of the roller press, the material to be ground is fed from a bin 7 via a feed conveyor 9 and a feed shaft 11 to a grinding zone 13 between the rollers 3 and 5.

According to the invention the depicted shaft is formed with a downwardly reduced cross-section in such a way that the reduction of the shaft´s cross-sectional circumference per height unit is also downwardly decreasing. Ideally the shaft is formed with a downwardly decreasing cross-section which is inversely proportional to the steadily downwardly increasing velocity of the material due to the gravity-induced acceleration. Hence it will be possible for the material to achieve a velocity close to the velocity of a free fall without admixture of air, allowing the roller press to be operated at higher roller velocities, thereby increasing its rate of production.

The applicant filing the present patent application has conducted tests with a shaft configured in accordance with the aforementioned guidelines, with a final cross section of 0.1 x 0.1 metres and a height of 5 metres, and has recorded a material velocity which is close to 10 m/s without air admixture.

Claims

1. A method for grinding of particulate material such as cement raw materials, cement clinker or similar materials, in a roller mill (1) by subjecting the material to pressing action in a zone (13) between opposite, rotating surfaces where the material is directed to the grinding zone via a feed shaft (11) **characterized in** that the material in the feed shaft (11) is accelerated by means of the force of gravity to a desired velocity without involving essential admixture of air.

2. A method according to claim 1 **characterized in** that the material is accelerated to a velocity of more than 1.5 m/s.

3. A method according to claim 1 **characterized in** that the material is accelerated to a velocity of more than 5 m/s.

4. A method according to claim 1 **characterized in** that the material is accelerated to a velocity of more than 10 m/s.

5. An apparatus for carrying out the method according to any of the aforementioned claims, which apparatus comprises a roller mill (1) as well as a shaft (11) for feeding particulate material to the grinding zone (13) of the roller mill, the shaft (11) being of a substantially vertical configuration and with a downwardly reduced cross-section **characterized in** that the reduction of the shaft´s cross-sectional circumference per height unit is downwardly decreasing.

6. An apparatus according to claim 5 the cross-sectional area of the shaft as a function of the height of fall is in accordance with the formula

$$A = (1+\Delta)\frac{\dot{V}}{\sqrt{2gh}},$$ where

A is the cross-sectional area
V is the volume flow
g is the gravity acceleration
h is the height of fall
Δ is within the range 0 and 0.2, preferably lower than 0.1.

7. An apparatus according to claim 5 **characterized in** that the shaft is made up of at least 3 pyramical or conical sections.

8. An apparatus according to claim 5 or 6 **characterized in** that the reduction of the cross-sectional circumference of the shaft exhibits a continuous downwardly decrease.

9. An apparatus according to claim 8 **characterized in** that the shaft is of a trumpet-shaped configuration.

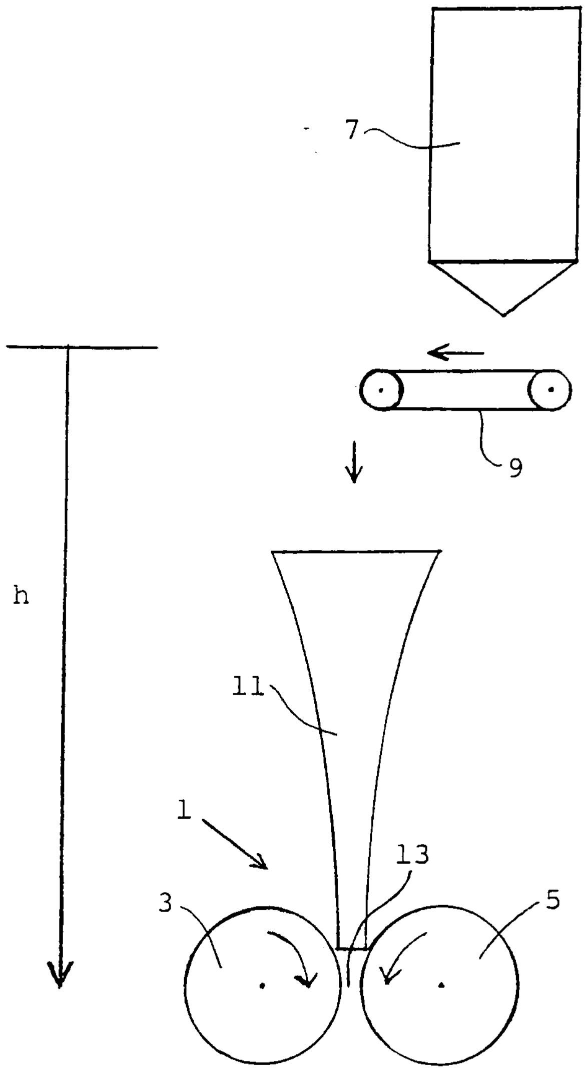

Fig. 1.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 01/00057

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B02C 4/02, B02C 4/28
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 963088 A (POLSKA AKADEMIA NAUK INSTYTUT BADAN JADROWYCH), 8 July 1964 (08.07.64), page 2, line 59 - line 103, figures 1-3	1-4
A		5-9
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 May 2001	04 -05- 2001
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Wiva Asplund/ELY Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

02/04/01

International application No.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 963088 A	08/07/64	CH 386214 A	31/12/64
		SE 318769 B	15/12/69