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⑤④ **Apparatus for preparing coal slurry of high concentration.**

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DE-A-1 507 650
GB-A-2 112 807

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an apparatus for preparing coal slurry, wherein fine powder of coal is mixed with a liquid to form a slurry of such a high concentration as to permit transportation and direct burning in a furnace.

Description of the Prior Art

A transportation method has been known in which powder of a solid material is mixed with a liquid to form a slurry which is easy to handle and transport. In recent years, proposals are made to improve the efficiency of transportation of coal by using the slurry transportation method. From the view point of transportation efficiency, the coal concentration in the slurry is preferably high. In addition, coal slurry having high concentration can be directly burnt as it is, without necessitating removal of the liquid after the transportation. For these reasons, various attempts have been made to develop a method for preparation of coal slurry having a high concentration and a low viscosity of such a level as to allow transportation by pipelines.

In order to prepare coal slurry having high concentration and low viscosity of such a level as to permit transportation by pipelines, it is necessary that the particle-size distribution is determined such as to minimize the voidage of the crushed coal, as disclosed in the specification of the US—A—4,282,006. This essentially requires a wide distribution of coal particle sizes. More specifically, representing the greatest and the smallest sizes of coal particles in the slurry by D_L and D_S , respectively, it is required to maximize the ratio D_L/D_S and to uniform distribution of particle size within the range between D_L and D_S . It is to be noted also that addition of an additive (mainly surfactant) is essential for reducing the viscosity of coal slurry of high concentration to a level suitable for transportation by pipeline. The main function of the additive is that the additive adsorbed by the particle surfaces improves the wettability of the coal to the liquid thereby enhancing the dispersibility of the coal particles. Thus, the preparation of coal slurry having high concentration and large fluidity essentially requires both an appropriate particle size distribution and application of a suitable additive. The preparation of coal slurry by such a technique is usually carried out by means of a ball mill as suggested, for example, in the above-mentioned US—A—4,282,006.

As shown in Fig. 6 of the above-mentioned US—A—4,282,006 the ball mill has a cylindrical drum which is supported rotatably. The drum is provided at its one end with a coal feed port and with a slurry outlet port at its other end. A multiplicity of metallic balls for finely crushing the coal into particles are charged in the drum. In this conventional ball mill, coarse particles of coal which have been crushed by a coarse crusher (not

shown) are fed continuously into the rotating drum through the coal feed port. The coal particles are then finely crushed by the balls and are mixed with a liquid such as to form a slurry which is then discharged through the slurry outlet port. In order to attain a high efficiency of fine crushing of the coal in the mill, it is necessary that the slurry as the mixture of the coal particles, liquid and additive has a fluidity sufficiently high to allow the crushing balls to move freely in the slurry thus enhancing the chance of collision between the coal particles and the balls. In this conventional ball mill, since the crushing of coal particles and the mixing of the coal particles with the liquid take place simultaneously, the coal particles in the region near the coal feed port generally have large particle sizes, so that the particle size distribution suitable for the coal slurry of high concentration is failed in a certain region within the mill. When the coal concentration in the mill is increased, therefore, the fluidity of the slurry as the mixture of the coal particles, liquid and the additive may be lowered to reduce the efficiency of crushing the coal. In the worst case, the fluidity of the mixture is totally lost to make the crushing materially impossible. In order to obviate this problem, it has been proposed to adjust the fluidity of the mixture in the mill by adding a liquid and an additive into the mixture. In such a case, however, it is necessary either to reduce the coal concentration to such a level as to permit the crushing or to add a large quantity of additive such as to increase the fluidity of the slurry. The reduction of the coal concentration, however, lowers the transportation efficiency, while the addition of large quantity of additive raises the preparation cost undesirably.

GB—A—2 112 807 discloses a process for preparing a coal slurry which comprises the steps of a) coarsely crushing coal in a coarse crusher, b) passing through a sieve which selects the coarser fraction to be passed through a dry ball-mill, c) mixing the coal fractions coming from the dry ball-mill and directly from the sieve, respectively, d) passing the mixture through a wet ball mill in which water and dispersant are added thereto in order to obtain a highly concentrated slurry of coal particles having a specific particle size distribution. The step b) may be omitted if more dispersant is used.

SUMMARY OF THE INVENTION

Object of the Invention

Accordingly, an object of the invention is to provide an apparatus for preparing coal slurry of high concentration with minimized consumption of additive.

Brief Summary of the Invention

The present inventors have made an intense study for developing a technique for preparation of coal slurry having high concentration. In this study, the present inventors have tried a method in which coal particles in various mills are mixed to allow an adjustment of particle size distribution

and water and an additive are added to the coal particles of the adjusted particle size distribution such as to form a slurry. The inventors have found that the slurry prepared by this method exhibits a viscosity which is much lower than that of the slurry prepared by the conventional mill with the addition of the same quantities of water and additive. The inventors found also that the above-mentioned preparation method permits a reduction of the additive consumption down below a half of that in the conventional process for attaining the same level of viscosity and concentration.

On the basis of these knowledges, the present invention provides an apparatus for preparing a coal slurry of a high concentration having a substantially cylindrical mill supported rotatably, pulverizing balls charged in said mill, a coal feed port provided on one end of said mill and adapted for continuously supplying coarsely crushed coal into said mill therethrough, a slurry outlet port provided on the other end of said mill, and a liquid supply pipe for continuously supplying a liquid and an additive into said mill, characterized by at least one partition wall provided in said mill and disposed substantially normally to the axis of said mill such as to divide the space in said mill into a plurality of chambers, said partition wall being provided in the center thereof with a passage hole through which the adjacent chambers are communicated, the size of said passage hole being smaller than that of the slurry outlet port and the lowest portion of said passage hole being higher than the lowest portion of the slurry outlet port, said pulverizing balls being charged in said chambers, and said liquid supply pipe being communicated with the chamber adjacent to said slurry outlet port.

Preferably said pulverizing balls charged in said chamber adjacent to said coal feed port have a size which is greater than that of said pulverizing balls in said chamber adjacent to said slurry outlet port.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an illustration of a slurry preparation apparatus in accordance with the invention;

Fig. 2 is a sectional view of a pulverizing mill incorporated in an apparatus of the invention for preparing a coal slurry of high concentration; and

Fig. 3 is a chart showing the relationship between the quantity of additive used and the viscosity of the coal slurry.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the apparatus of the invention for forming a coal slurry of high concentration will be explained hereinafter with reference to the accompanying drawings.

Fig. 1 illustrates an invented apparatus for preparing a coal slurry of a high concentration. Referring to this Figure, coal in a silo 18 is fed by a feeder 20 to a coarse crusher 22 so as to be coarsely crushed by the latter, and the thus coarsely crushed coal is sent to a hopper 24. The

crushed coal in the hopper 24 is fed continuously by a feeder 26 into a mill 10 through a coal feed port 12 formed in one end of the mill 10. As will be described later in detail, the mill 10 has a partition wall 28 which is normal to the axis of the mill 10. The partition wall 28 divides the space in the mill into two sections or chambers: namely, a first mill chamber 30 and a second mill chamber 32. The first and second mill chambers are communicated with each other through a passage hole 34 formed in the partition wall 28. The mill 10 is provided with a slurry outlet port 14 to which is led a liquid supply pipe 36. The liquid supply pipe 36 is connected, respectively, to a liquid tank 46 and an additive tank 48, through pipes 38 and 40 which are provided with pumps 42 and 44. A slurry pipe 50 connected to the slurry outlet port 14 is arranged such that the slurry is put into the slurry tank 54 through a screen 52. The coal which have been checked by the screen 52 are dried and returned to the coal feed port 12 of the mill 10 by a suitable means 56 such as a conveyor.

As will be seen from Fig. 2, the coal feed port 12 and the slurry outlet port 14 are formed in axial hubs on respective axial end surfaces of the mill 10, and is supported at these hubs by support members 58, 60 through respective bearings. The mill 10 is provided on the outer peripheral surface thereof with a gear 62 which meshes with a gear 68 fixed to the shaft 66 of a motor 64.

The first mill chamber 30 and the second mill chamber 32 of the mill 10 are charged with metal balls 70 and 72. The balls 72 in the second mill chamber 32 have a smaller size than the balls 70 in the first mill chamber 30, so that the coal pulverized in the first chamber is further pulverized into smaller size upon collision with the balls 72 in the second mill chamber 32. The passage hole 34 is formed in the central portion in of the partition wall 28 and has a size which is greater than that of the coal feed port 12 but smaller than that of the slurry discharge port 14. The liquid supply pipe 36 led to the slurry outlet port 14 is extended into the second mill chamber 32 nearly to the partition wall 28.

The operation of this embodiment will be described hereinafter. The mill 10 is rotated about its axis as the gear 62 on its peripheral surface is driven by the motor 64 through the shaft 66 and the gear 68. Meanwhile, the coal in the coal silo 18 is coarsely crushed by the coarse crusher 22 and is fed continuously to the coal feed port 12 of the mill 10 through the hopper 24 and by means of the feeder 26. The thus fed coal is introduced into the first mill chamber 30 in which it is pulverized in a dry condition upon collision with the balls 70 as a result of rotation of the mill 10, and is progressively moved towards the partition wall 28 while being pulverized into smaller sizes gradually, and is moved into the second mill chamber 32 through the passage hole 34.

On the other hand, the liquid such as water or an oil in the liquid tank 46 and in the additive tank 48 are forwarded by respective pumps 42 and 44 at constant rates such as to form a mixture liquid

which is supplied to the portion of the second mill chamber 32 near the partition wall 28. The pulverized coal introduced into the second mill chamber 32 is further pulverized by the balls 72 into smaller sizes, while being mixed with the mixture liquid coming from the liquid supply pipe 36, thus forming a coal slurry which is then discharged to the screen 52 through the slurry outlet port 14 by way of the slurry pipe 50. The slurry which has passed the screen 52 is stored in the slurry tank 54. The unpulverized large particles of coal are arrested by the screen 52 and are dried and returned to the coal feed port 12 by a suitable conveyor means 56. The particle size distribution of the slurry thus prepared is determined optimally in view of factors such as the kind of coal, rotation speed of the mill, sizes of the mill chambers, sizes of the balls 70, 72, quantity of balls, pulverizing time, and so on. Preferably, the pulverization in the first mill chamber 30 is conducted to such an extent as to permit an easy formation of the slurry in the second mill chamber. Since the formation of the slurry is facilitated when the mixture contains particles of minimum size below 3 μm , it is desirable that the pulverization in the first mill chamber is effected such that the coal particles introduced into the second mill chamber contains fine particles of sized below 3 μm .

Practical examples of the preparation method, which employs the above-explained apparatus, will be described hereinunder.

Example 1

Coal was coarsely crushed into particles of sizes less than 5 mm and was changed into coal-water slurry of high concentration by the following process which employed the mill as shown in Fig. 2.

The mill 10 was made from stainless steel, in a cylindrical form having an inside diameter of 500 mm and a length of 1010 mm. The passage hole formed in the center of the partition wall had a diameter of 200 mm. The first and second mill chambers 30 and 32 had lengths of 700 mm and 300 mm, respectively. The first mill chamber 30 was charged with 3000 pieces of stainless steel balls of 20 mm dia., while the second mill chamber 32 was charged with 1000 pieces of the same ball. While rotating the mill at 40 rpm, the coarsely crushed coal was fed into the mill through the coal feed port 12 at a constant rate of 10 kg per hour. Meanwhile, mixture of water and a cation surfactant was supplied into the second mill chamber 32 through the liquid supply pipe 36 at a constant rate of 5.38 litres per hour, while varying the surfactant content. The coal was supplied to the portion in the first mill chamber near the coal feed port 12, while the water containing the surfactant was charged to the portion of the second mill chamber near the partition wall 28, such that the coal is sufficiently pulverized within the period of its stay in the mill. The coal slurry prepared by this process showed a coal concentration of 65 wt%. Viscosities of differ-

ent coal slurries prepared with different additive contents were measured by a rotary viscometer, in order to examine the relationship between the quantity of the additive, i.e., surfactant, and the viscosity.

For the purpose of comparison, coal slurries were prepared under the same condition using a mill which is identical to that used in the slurry preparation of the invention except that the partition wall 28 is removed, and the relationship between the quantity of the additive and the viscosity was examined. The results of the tests are shown in Fig. 3 from which it will be understood that the slurry preparation method in accordance with the invention permits the quantity of the additive to be reduced almost to a half of that required in the conventional slurry preparation method for attaining the same level of viscosity of the slurry. This means that the cost for the preparation of coal slurry having high concentration can be reduced remarkably.

Example 2

A coal slurry was prepared by the same apparatus as that used in Example 1 under the same pulverizing condition as Example 1 except that the rate of feed of coarsely crushed coal was increased to 14 kg per hour and that water containing 0.3 wt% of a cation surfactant with respect to coal was charged into the second mill chamber 32 through the liquid supply pipe 36 at a rate of 5.38 litres per hour. The thus prepared coal slurry showed a concentration of 72.2 wt%. The viscosity of the slurry was measured by the same method as Example 1 and a high fluidity of about 1.8 Pa S was confirmed.

For the purpose of comparison, an attempt was made to form a slurry by the conventional ball mill used in Example 1 having no partition wall, under the same pulverizing condition as that explained above. In this case, however, the mixture of the coal, water and the additive did not show substantial fluidity, so that the balls in the mill could not move at all, thus failing to pulverize the coal. This is attributable to the fact that the particle size distribution of the material in the mill inadequate for the slurry of high concentration is temporarily formed in the mill so that the fluidity of the materials lost in the mill.

Advantages of the Invention

As has been described, according to the invention, it is possible to reduce the quantity of the additive required in the preparation of coal slurry of high density.

Claims

1. An apparatus for preparing a coal slurry of a high concentration having a substantially cylindrical mill (10) supported rotatably, pulverizing balls (70, 72) charged in said mill (10), a coal feed port (12) provided on one end of said mill (10) and adapted for continuously supplying coarsely crushed coal into said mill (10) therethrough, a

slurry outlet port (14) provided on the other end of said mill (10), and a liquid supply pipe (36) for continuously supplying a liquid and an additive into said mill (10), characterized by at least one partition wall (28) provided in said mill (10) and disposed substantially normally to the axis of said mill (10) such as to divide the space in said mill (10) into a plurality of chambers (30, 32), said partition wall (28) being provided in the center thereof with a passage hole (34) through which the adjacent chambers (30, 32) are communicated, the size of said passage hole (34) being smaller than that of the slurry outlet port (14) and the lowest portion of said passage hole (34) being higher than the lowest portion of the slurry outlet port (14), said pulverizing balls (70, 72) being charged in said chambers (30, 32), and said liquid supply pipe (36) being communicated with the chamber (32) adjacent to said slurry outlet port (14).

2. An apparatus for preparing a coal slurry of a high concentration according to claim 1, wherein said pulverizing balls (70) charged in said chamber (30) adjacent to said coal feed port (12) have a size which is greater than that of said pulverizing balls (72) in said chamber (32) adjacent to said slurry outlet port (14).

Patentansprüche

1. Vorrichtung zur Herstellung einer hochkonzentrierten Kohlesuspension mit einer praktisch zylindrischen, drehbar gelagerten Mühle (10), in der Mühle (10) vorhandenen Mahlkugeln (70, 72), einer Kohlezufuhröffnung (12) an einem Ende der Mühle (10), die für die kontinuierliche Zufuhr von grob zerkleinerter Kohle in die Mühle (10) angepaßt ist, einer Suspensionsauslaßöffnung (14) am anderen Ende der Mühle (10) und einem Rohr (36) für die kontinuierliche Zufuhr einer Flüssigkeit und eines Zusatzmittels in die Mühle (10), gekennzeichnet durch mindestens eine Trennwand (28) in der Mühle (10), die im wesentlichen senkrecht zur Achse der Mühle (10) angeordnet ist, so daß der Raum in der Mühle (10) in mehrere Kammern (30, 32) geteilt wird, wobei die Trennwand (28) in der Mitte eine Öffnung (34) aufweist, durch die benachbarte Kammern (30, 32) kommunizieren, die Öffnung (34) kleiner als die Suspensionsauslaßöffnung (14) und der tiefste Teil dieser Öffnung (34) höher als der tiefste Teil der

Suspensionsauslaßöffnung (14) ist, die Mahlkugeln (70, 72) sich in diesen Kammern (30, 32) befinden und das Flüssigkeitszufuhrrohr (36) mit der der Suspensionsauslaßöffnung (14) benachbarten Kammer (32) kommuniziert.

2. Vorrichtung zur Herstellung einer hochkonzentrierten Kohlesuspension nach Anspruch 1, in der die Mahlkugeln (70) in der der Kohlezufuhröffnung (12) benachbarten Kammer (30) größer als die Mahlkugeln (72) in der der Suspensionsauslaßöffnung (14) benachbarten Kammer (32) sind.

Revendications

1. Appareil pour préparer une suspension de charbon à haute concentration avec un broyeur (10) pratiquement cylindrique, pivotant, des boulets de pulvérisation (70, 72) chargés dans le broyeur (10), un orifice d'alimentation (12) en charbon à une des extrémités du broyeur (10) et adapté à l'alimentation continue du broyeur (10) en charbon grossièrement concassé, un orifice de sortie (14) à l'autre extrémité du broyeur (10) et un tube d'alimentation (36) pour l'alimentation continue du broyeur (10) en un liquide et un additif, caractérisé par au moins une paroi de séparation (28) dans le broyeur (10), disposé pratiquement perpendiculairement à l'axe du broyeur (10) de sorte à diviser le volume du broyeur (10) en une pluralité de chambres (30, 32), la paroi de séparation (28) ayant au centre un orifice de passage (34) par lequel les chambres avoisinantes (30, 32) communiquent, l'orifice de passage (34) étant plus petit que l'orifice de sortie (14) de la suspension et la partie la plus basse de cet orifice de passage (34) étant plus haute que la partie la plus basse de l'orifice de sortie (14) de la suspension, les boulets de pulvérisation (70, 72) étant chargés dans les chambres (30, 32) et le tube d'alimentation en liquide (36) communiquant avec la chambre (32) voisine de l'orifice de sortie (14) de la suspension.

2. Appareil pour préparer une suspension de charbon à haute concentration selon la revendication 1, dans lequel les boulets de pulvérisation (70) chargés dans la chambre (30) avoisinante de l'orifice d'alimentation (12) en charbon sont plus grands que les boulets de pulvérisation (72) dans la chambre (32) voisine de l'orifice de sortie (14) de la suspension.

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FIG. 1

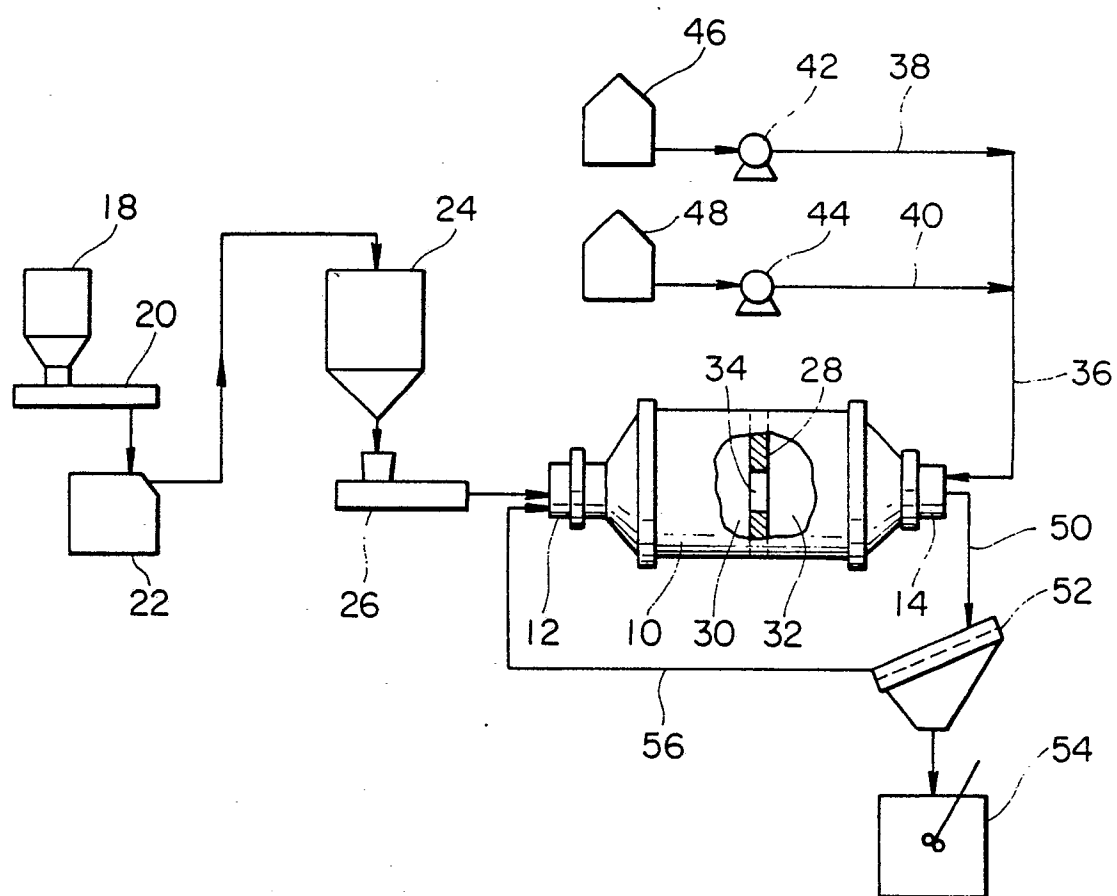


FIG. 2

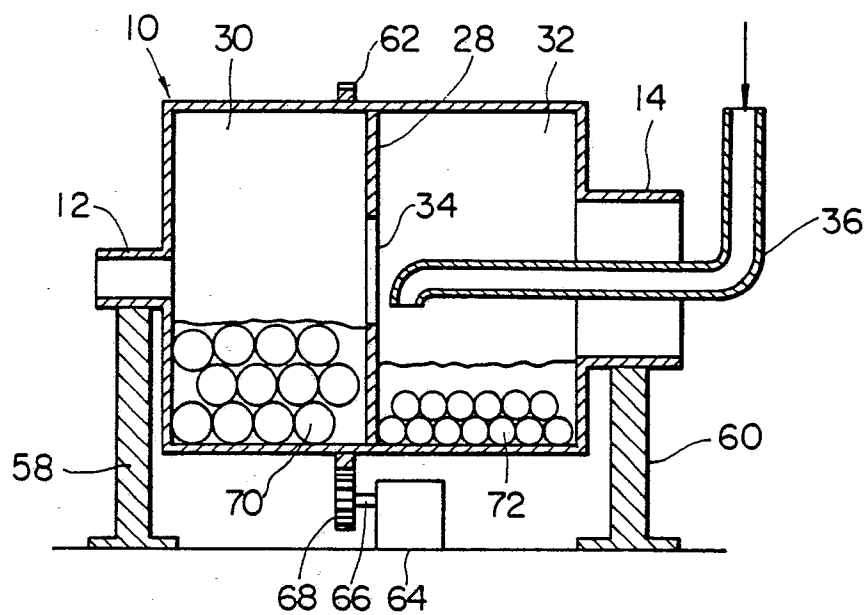


FIG. 3

