

PATENT SPECIFICATION

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(54) PROCESS AND APPARATUS FOR CALCINATION OF CEMENT RAW MATERIALS TO PROVIDE CLINKERS

(71) We, KAWASAKI JUKOGYO KABUSHIKI KAISHA, a Japanese Company, of No. 14, Higashi-kawasaki-cho, 2-chome, Ikuta-ku, Kobe-shi, Hyogo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improvements in a process and apparatus for calcination of cement raw materials to provide clinkers.

As is well known, it is necessary to perform at least two operations to produce cement clinkers, namely calcination (decomposition) to CaO of limestone — an endothermic reaction — and sintering (melting the CaO and combining this with other materials to produce a calcium aluminoferrite) — an exothermic reaction. A major part of the heat consumed in the calcination of cement is occupied by the first-mentioned calcination including the heating of the raw materials to the calcination temperature.

Now, according to the cement producing process carried out by means of a combination consisting of a so-called suspension type raw material preheating apparatus and a rotary kiln, the cement raw material is preheated before being fed into the rotary kiln, while the calcination of the limestone in the raw material is simultaneously effected in some degree, the remainder of the calcination and all the sintering taking place in the rotary kiln. Therefore it is true that a fairly good economy of combustion heat can be attained in the said producing process, and the specific efficiency of the rotary kiln is improved.

In this producing process, however, the quantity of heat of the rotary kiln exhaust gas introduced into the raw material preheating apparatus is limited in relation to the temperature in the interior of the rotary kiln and to the problem of adhesion and growth of molten substances, and so, it is in general difficult to make the percentage of

calcination of the raw material in the said preheating apparatus above 40%, and the calcination of the remaining non-decomposed raw material of about 60% or more has to be effected in the rotary kiln or in a fluidized bed calcining device.

Accordingly, the calcination zone for effecting the supply of heat for the calcination reaction must inevitably be made long, and thus the size of the rotary kiln is necessarily made long to prolong the retention time of raw material therein. This calcination process is defective and disadvantageous because the operation is often interrupted or even made impossible due to various unfavourable phenomena connected with the prolonged retention time, such as increase of combustion heat, evaporation of alkali content, adhesion, growth and condensation of molten raw material in the flue and on the wall of the apparatus.

Therefore, the present invention provides a process for calcining cement raw materials to provide clinkers by using a calcination apparatus having a generally cylindrical calcining furnace which includes in ascending order a combustion zone having a heat source, a throat part, a spouted bed and an uppermost zone, the furnace being disposed in a flow path between a raw material preheating device and a kiln or other sintering device; the process comprising partly calcining cement raw materials in the raw material preheating device, feeding the partly calcined materials to the upper end of the said spouted bed while a jet of high-temperature flue gas passing at high speed through the throat part from the combustion zone is admixed with a tangential flow of high-temperature exhaust gas introduced to the lower end of the uppermost zone, whereby there are formed in the central part of the calcining furnace a region of vigorously admixed gases and spiral gas flow where the calcination and heat exchange of the cement raw materials are carried out and, in the vicinity of the

surface of the inner wall of the said calcining furnace a returning flow of a lower temperature falling downwards together with non-calcined cement raw materials, powder of substantially completely calcined cement raw materials being selectively exhausted together with the exhaust flue gas from the vicinity of the top part of the said calcining furnace and being transported to the rotary kiln or other sintering device.

Now, the present invention will be explained by way of example with reference to the accompanying drawing, the single figure of which shows one embodiment of apparatus according to the invention.

Referring to the drawing, 1 is a raw material hopper feeding a suspension type raw material preheating apparatus SP, 2A—2D cyclones, 3A—3D exhaust flue gas ducts, 4A—4D raw material inlet ducts, 5 an exhaust gas outlet duct, 6 a rotary kiln for sintering, 7 and 8 burners, 9 a clinker cooler, 10 a duct for feeding combustion air, and 11 a nearly cylindrical spouted bed type calcining furnace. The furnace 11 has (in ascending order) a combustion zone 11A provided with a separate heat source of the burner 8 and the duct for feeding combustion air 10, and of a throat part 11B, a spouted bed 11C provided with burners 14 and an uppermost zone 11D, all connected. 12 is an outlet duct for exhausting a mixture consisting of raw material powders which have been calcined in the calcining furnace 11 and gas; the duct 12 connects the top part of the uppermost zone 11D with the inlet side of the lowermost cyclone 2D, which is disposed nearest to the inlet of the rotary kiln 6 for sintering.

Cement raw material powders which have been previously well admixed and which have been fed to the preheating apparatus SP from the raw material hopper 1 are transported to the vicinity of the upper end portion of the spouted bed 11C of the said furnace 11, via the course of exhaust flue gas passing in turn through duct 3A, cyclone 2A, raw material duct 4A, exhaust gas duct 3B, cyclone 2B, raw material duct 4B, exhaust gas duct 3C, cyclone 2C, and raw material duct 4C, as shown by the full arrows in the drawing, while the thus fed cement raw material powders are preheated to about 600—700°C in the said raw material preheating apparatus SP, due to heat exchange with the high temperature exhaust flue gas which passes through the outlet duct 12, cyclone 2D, exhaust gas duct 3C, cyclone 2C, exhaust gas duct 3B, cyclone 2B, exhaust gas duct 3A, and cyclone 2A, as shown by the dotted arrows in the drawing, and is finally exhausted to air via the exhaust gas outlet duct 5, an inducing blower 13 and a Cottrell precipitator (not shown), and the limestone content in the raw material is

calcined to the degree typically of 20—40%.

To the combustion zone 11A of the calcining furnace 11, which is disposed between the rotary kiln 6 and the suspension type raw material preheating apparatus SP, is fed a fuel such as heavy oil or gas, which is pumped via the burner 8 together with combustion air of relatively high temperature (about 350—800°C) extracted from the clinker cooler 9 and transported under pressure through the pipe 10.

Flue gas of about 1300—1700°C generated in the combustion zone 11A after complete combustion passes at high speed through the throat part 11B, and the major flow thereof further passes through the central part of the enlarged part or the spouted bed 11C and rises upwards while a part thereof often recirculates as a turbulent flow. In more detail, the raw material particles in such flow do circulate in the zone 11, that is, the particles are thrown up at the central portion of the zone 11 and fall back at the peripheral portion of the zone 11, hence the name spouted bed.

During the passing of the high temperature flue gas, the said gas is efficiently brought into contact with the raw material powders which, as mentioned above, have been preheated to about 600—900°C in the raw material preheating apparatus SP and have been fed in the vicinity of the upper end part of the spouted bed 11C via the raw material duct 4C in the appropriately calcined state and are falling downwards.

In the central part of the said enlarged part 11C is formed a vigorous jet zone layer, and so the raw material powders falling therethrough are fully contacted with and heated by the high temperature flue gas to an optimum temperature (about 850—950°C) for carrying out the calcination reaction and kept at this temperature. Accordingly the calcination reaction of the raw material powders proceeds rapidly with the result that the temperature of the major flow of the flue gas which rises upwards is lowered in the vicinity of the upper end part of the spouted bed 11C to become about 900—1050°C which is near to the temperature of the raw material powders.

The said major flow of the flue gas is admixed with the exhaust flue gas (temperature about 900—1100°C) of the rotary kiln 6 introduced through the exhaust gas duct 3D which is disposed to the wall of the calcining furnace in the vicinity of the lower end portion of the uppermost zone 11C and opened tangentially to the said wall and almost perpendicular to the central axis of the said furnace, to form a rapid spiral flow of about 800—1000°C. Afterwards, the thus formed gas mixture flow being accompanied with the raw material powders, which have

been almost completely calcined mainly in the spouted bed 11C provided with the burners 14 and whose particle size and specific gravity have thus been reduced, rises further upwards, and thereafter is exhausted from the outlet previously provided on the wall of the calcining furnace in the vicinity of the top end portion of the uppermost zone 11D thereof, at a high flow rate in the tangential direction almost perpendicular to the central axis of the said furnace, and then finally is introduced into the lowermost cyclone 2D via the duct 12. In the said cyclone 2D the raw material powders are separated from the gas mixture and are introduced to be sintered into the rotary kiln 6 via the raw material duct 4D, while the exhaust flue gas from which the raw materials have been removed rises, as mentioned above, upwards in the raw material preheating apparatus passing through the exhaust gas duct 3C from the cyclone 2D. During the rising of the said flue gas in the said preheating apparatus, the said gas is brought into contact with the cement raw material powders fed from the raw material hopper 1 to preheat the same and then is finally exhausted in air via the exhaust gas outlet duct 5, the inducing blower 13 and the Cottrell precipitator or the like.

Thus, the cement raw material powders introduced into the rotary kiln 6 (in place of which a fluidized bed sintering device could be used) after substantially complete calcination are finally fully calcined and sintered with a high temperature combustion gas blown from the burner 7 to form clinkers, while being granulated, and cooled in the clinker cooler 9 and taken out therefrom as final products. Almost all the air used for cooling is blown as combustion air together with a fuel to the combustion zone 11A of the calcining furnace 11 from the burner 8 via the duct 10. The major flow of the high temperature flue gas passing through the throat part 11B under high speed after complete combustion in the combustion zone 11A and rising upwards in the calcining furnace 11 straightforwardly rises, as mentioned above, through the central part of the enlarged part or the spouted bed 11C almost without directly contacting with the inner wall of the said zone and therefore, the cement raw material powders which have not as yet been calcined so much, or in other words, those of a relatively low temperature as yet having large specific gravity and particle size, ride the falling flow through the spiral flow formed in the uppermost zone 11D and accompanied with an admixed and dispersed eddies, to fall downwards to the vicinity of the upper end part of the throat part 11B along the inner wall of the

calcining furnace 11 while forming a layer. The particles are then admixed with the high temperature ascending jet flow emerging from the throat part 11B. This is the flow pattern in the calcining furnace.

Accordingly, the inner wall of the furnace in the upper part to the vicinity of the upper end part of the throat part 11B is protected with a gas flow of a relatively low temperature containing cement raw material powders, and thus any adhesion and growth of molten substances in the said inner wall may completely be prevented thereby.

In this connection, since the cement raw material is not introduced in the combustion zone 11A (nor in the throat part 11B), it is unnecessary to control the temperature therein below the melting point of the raw material (about 1100°C), and after all, even if the said temperature is elevated to about 1300—1700°C or so for effecting and achieving complete combustion reaction therein, any unfavourable phenomena do not occur at all such as melting and evaporation of raw material and alkali content.

In the spouted bed type calcining furnace 11 of the present invention, it is easy (and preferable) to control the time necessary for the calcination reaction, by appropriately adjusting the flow rate and the flow speed of the high temperature flue gas which passes under high speed through the throat part 11B from the combustion zone 11A and rises upwards.

By the way, it is known that the powders are in the form of separate individual granules after complete calcination, due to disappearance of the original aggregation state thereof, and thus not only is the particle size of the (originally agglomerated) powder reduced but also the weight thereof is reduced to about 50—60% of the original weight, due to release of carbon dioxide gas, and further the specific gravity is also fairly reduced. In the present invention, various merits are attained, in addition to the said known effects, such as improvements on heat exchangeability between gas and cement raw material powders and prevention of short path of raw material powders as well as extremely high sieving efficiency, due to the use of the spouted bed type calcining furnace 11 having the specific construction such that the enlarged part or the spouted bed 11C and the uppermost zone 11D are longitudinally connected with each other where the flowing state of each of gas and raw material powders as well as the temperature of atmosphere is different from each other, and therefore it is easy selectively to take out only the completely calcined raw material powders from the top

of the calcining furnace 11, while surely retaining the other non-calcined powders in the said calcining furnace until the determined reaction has been completely effected therein, in the form of combination with spiral flow, swirl (eddy) flow and falling (return) flow.

In addition, the spouted bed type calcining furnace 11 of the present invention can have other various merits such as good heat exchangeability, compactness and flexibility of operation.

As apparent from the above explanation, it is possible according to the process and apparatus of the present invention efficiently to carry out the calcination of limestone without any obstruction such as adhesion and growth of molten substances, and to transport only the cement raw material of high temperature which has been almost completely calcined to the rotary kiln or other sintering device, and therefore various economies in operation may be effected such as reduction in size of the rotary kiln to be used for the sintering stage in the formation of clinkers, reduction of the necessary retention time for the raw material, economy of motive power and heat to be used and reduction of evaporated alkali content in the rotary kiln.

WHAT WE CLAIM IS:—

1. A process for calcining cement raw materials to provide clinkers by using a calcination apparatus having a generally cylindrical calcining furnace which includes in ascending order a combustion zone having a heat source, a throat part, a spouted bed and an uppermost zone, the furnace being disposed in a flow path between a raw material preheating device and a kiln or other sintering device; the process comprising partly calcining cement raw materials in the raw material preheating device, feeding the partly calcined materials to the upper end of the said spouted bed while a jet of high-temperature flue gas passing at high speed through the throat part from the combustion zone is admixed with a tangential flow of high-temperature exhaust gas introduced to the lower end of the uppermost zone, whereby there are formed in the central part of the calcining furnace a region of vigorously admixed gases and spiral gas flow where the calcination and heat exchange of the cement raw materials are carried out and, in the vicinity of the surface of the inner wall of the said calcining furnace, a returning flow of a lower temperature falling downwards together with non-calcined cement raw materials, powder of substantially completely calcined cement raw materials being selectively exhausted

together with the exhaust flue gas from the vicinity of the top part of the said calcining furnace and being transported to the sintering device.

2. An apparatus for calcination of cement raw materials to provide clinkers, comprising a generally cylindrical calcining furnace which includes in ascending order a combustion zone having a separate heat source, a throat part, a spouted bed provided with burners where a calcination reaction is mainly effected with a flue gas rising upwards and/or with the heat emanating from burners, and an uppermost zone, admixture, dispersion and heat exchange being possible in the uppermost zone with a tangential flow of an exhaust flue gas introduced from a kiln or other sintering device, the calcining furnace being disposed in a flow path between the sintering device and a raw material preheating device, the combustion zone being provided with a burner and an inlet line for feeding preheated air under pressure, the apparatus further comprising a duct line for introducing exhaust flue gas from the calcining device into the calcining furnace tangentially in the vicinity of the lower end portion of the uppermost zone and substantially perpendicular to the upright axis of the furnace, a raw material inlet line for introducing powders of the raw materials which have been preheated in the said preheating device and have been partly decomposed into the lower part of said uppermost zone, and an outlet line for transporting a mixture of the exhaust flue gas from the combustion zone and from the sintering device and the powder of substantially completely calcined raw materials to a cyclone from the calcining furnace, the outlet line being tangential to the uppermost zone near the top thereof and substantially perpendicular to the upright axis of the furnace.

3. A process or apparatus as claimed in claim 1 or 2, wherein the raw material preheating device is of the suspension type.

4. A process as claimed in claim 1 or 3 or an apparatus as claimed in claim 2 or 3, wherein the sintering device is a rotary kiln or a fluidized bed sintering device.

5. A process for calcining cement raw materials to provide clinkers, substantially as hereinbefore described with reference to the accompanying drawing.

6. An apparatus for calcination of cement materials to provide clinkers, substantially as hereinbefore described with reference to the accompanying drawing.

7. Calcined cement-clinkers when produced by a process or in apparatus as claimed in any preceding claim.

of the calcining furnace 11, while surely retaining the other non-calcined powders in the said calcining furnace until the determined reaction has been completely effected therein, in the form of combination with spiral flow, swirl (eddy) flow and falling (return) flow.

In addition, the spouted bed type calcining furnace 11 of the present invention can have other various merits such as good heat exchangeability, compactness and flexibility of operation.

As apparent from the above explanation, it is possible according to the process and apparatus of the present invention efficiently to carry out the calcination of limestone without any obstruction such as adhesion and growth of molten substances, and to transport only the cement raw material of high temperature which has been almost completely calcined to the rotary kiln or other sintering device, and therefore various economies in operation may be effected such as reduction in size of the rotary kiln to be used for the sintering stage in the formation of clinkers, reduction of the necessary retention time for the raw material, economy of motive power and heat to be used and reduction of evaporated alkali content in the rotary kiln.

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together with the exhaust flue gas from the vicinity of the top part of the said calcining furnace and being transported to the sintering device.

2. An apparatus for calcination of cement raw materials to provide clinkers, comprising a generally cylindrical calcining furnace which includes in ascending order a combustion zone having a separate heat source, a throat part, a spouted bed provided with burners where a calcination reaction is mainly effected with a flue gas rising upwards and/or with the heat emanating from burners, and an uppermost zone, admixture, dispersion and heat exchange being possible in the uppermost zone with a tangential flow of an exhaust flue gas introduced from a kiln or other sintering device, the calcining furnace being disposed in a flow path between the sintering device and a raw material preheating device, the combustion zone being provided with a burner and an inlet line for feeding preheated air under pressure, the apparatus further comprising a duct line for introducing exhaust flue gas from the calcining device into the calcining furnace tangentially in the vicinity of the lower end portion of the uppermost zone and substantially perpendicular to the upright axis of the furnace, a raw material inlet line for introducing powders of the raw materials which have been preheated in the said preheating device and have been partly decomposed into the lower part of said uppermost zone, and an outlet line for transporting a mixture of the exhaust flue gas from the combustion zone and from the sintering device and the powder of substantially completely calcined raw materials to a cyclone from the calcining furnace, the outlet line being tangential to the uppermost zone near the top thereof and substantially perpendicular to the upright axis of the furnace.

3. A process or apparatus as claimed in claim 1 or 2, wherein the raw material preheating device is of the suspension type.

4. A process as claimed in claim 1 or 3 or an apparatus as claimed in claim 2 or 3, wherein the sintering device is a rotary kiln or a fluidized bed sintering device.

5. A process for calcining cement raw materials to provide clinkers, substantially as hereinbefore described with reference to the accompanying drawing.

6. An apparatus for calcination of cement materials to provide clinkers, substantially as hereinbefore described with reference to the accompanying drawing.

7. Calcined cement-clinkers when produced by a process or in apparatus as claimed in any preceding claim.



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