A preheater for particulate material comprising a cylindrical refractory lined vessel with top feed and exhaust offtake. The preheater diameter is enlarged below the offtake so that the sloping material forms an area surrounded by ports which receive hot gases from the kiln. The lower portion of the preheater is conical, leading toward a small central discharge point. This portion constitutes a soaking zone in which heat is allowed to penetrate the material.
PREHEATER FOR LIME KLN

BACKGROUND AND BRIEF SUMMARY OF THE INVENTION

The invention relates to the preheating of stone or sized particulate material such as limestone which is being fed to a rotary kiln calcining system. The invention is also applicable to similar calcining or gas/solid heat transfer processes.

A rotary kiln calcining device has relatively low thermal efficiency, particularly with highly endothermic processes such as the burning of lime. Rising fuel costs have increased the economic feasibility of preheating devices for commercial rotary kilns.

These preheating devices are based on convection heat transfer with the hot gases exhausting from the kiln being passed through voids in the feed material as in a vertical shaft kiln. Because of the relatively small size of rotary kiln feeds and the large volume of combustion gases, impractically high pressure drops will be developed in the system unless the beds are relatively wide and shallow. The gases should have uniform motion across the entire bed to avoid overheating or fusing.

Because of the relatively higher heat transfer efficiency of preheaters, the calcining reaction tends to move from the rotary kiln into the preheater resulting in higher kiln exhaust gas temperatures. These high temperature gases result in high surface temperatures on the stone feed fed to the kiln, with the result that the preheater has little cooling effect on the gases. The cumulative effect is that a circulating heat stream is set up at the juncture of the preheater and kiln outlet, the high temperatures increasing heat losses and mechanical difficulties.

In the conventional preheater the kiln exhaust gases are introduced directly to the preheater discharge area. The resulting high temperatures create great radiation and efficiency losses. A cumbersome feeding mechanism is required to be effective over the major portion of the bed area, this mechanism operating at unusually high temperatures. Furthermore, the short time interval during which the feed material is subjected to high temperature results in only the outer surface portions of the stone being heated, the centers remaining at comparatively low temperatures.

It is a general object of the present invention to overcome the above difficulties of conventional preheating devices. Briefly, the invention comprises a moving bed of material so arranged that the kiln exhaust gases are introduced at a level in the preheater considerably above the feeder which discharges the stone to the rotary kiln. This creates a "soaking" or holding zone between the gas entry and discharge levels which may have a sufficient retention time to allow the high surface temperatures developed on each particle to be diffused substantially into its entire volume. The result is a preheated material of more uniform temperature with a lower surface temperature but a greater stored heat content. When this material is fed to the rotary kiln it will not have the tendency to return heat to the gas stream but will absorb some heat, maintaining gas temperatures at a lower level.

It is a further object of the invention to provide a novel and improved preheater in which the soaking zone portion couples the entire cross-sectional area of the preheater stone beds to a relatively small and sim-
cause of the angle of repose of frustoconical surface 26 of stone bed 14 as it leaves section 15 and spreads out to section 20, an annular space 27 will be created below ledge 21. A plurality of ports 28 are provided in the upper edge of section 20 immediately below ledge 21, and hot gases will be drawn inwardly from duct 23 through these ports to the stone bed 14. The flow of hot gases as they pass through the ports will be generally in an inward radial direction, and transverse to the downward movement of material. The hot gases will thus be evenly distributed over the relatively large frustoconical area of the material which is symmetrical with respect to the outtake area. The gases will flow upwardly through the voids in the material as they pass through section 15 to the outtake. Duct 23 will allow dust entrained in the gases to settle, the dust being removable through drains 29.

A soaking or holding chamber 30 is formed on the preheater extending below section 20. This portion of the preheater is formed conically at a relatively steep angle, leading downwardly to a single centrally located discharge port 31 of relatively small area. A feeding device indicated schematically in dot-dash lines at 32 is attached to outlet 31 and dispatches the material through a conventional feed pipe or chute indicated in dot-dash lines at 33 to the rotary kiln (not shown). To assure movement of the material over the entire cross-section of the preheater, a baffle 34 is mounted inwardly of conical section 30, this baffle having a conical shape along the major portion of its length which is complementary to section 30 and a reverse conical shape 35 in its upper portion. The baffle, which is supported by a plurality of radially extending beams 36, will thus insure movement of the material over the entire cross-section of preheater section 30 to outlet 31. Little gas flow will take place in this zone because of the high resistance of the deep beds and the relatively small cross-sectional area, and the section will thus constitute a holding zone in which heat will be absorbed by the interiors of the particles.

The dimensions of holding section 30 and particularly the retention time of stone therein, will vary to suit requirements. These will be governed by three main factors:

a. Temperature of the gases entering section 20.

b. Average size of the stone particles.

c. Thermal conductivity of the stone.

Basically, the stone which has just exited gas-stone section 20 has a surface temperature equal to the gas temperature. Let us assume for example that it is 2,000°F on the surface of a 1½ inch spherical lump, but only 1,200°F at the center. At a thermal conductivity in the expected range of slate or shale (for lightweight aggregate kilns) the thermal diffusion might almost equalize the temperature over the outer three-eighths inch (or seven-eighths of the total lump volume) in 7 to 11 minutes.

In limestone there is some difference in that there is heat used in the contact zone to make a thin film of lime on the stone surface, so that the inside of the stone will not have absorbed as much heat. As this passes through holding section 30, the surface may recarbonate making limestone and give off heat. This will delay the achievement of relative equilibrium and require a longer time in the holding section.

In operation, hot gases 24 will flow upwardly through ports 28 and passing through the voids in material 14. These gases will flow upwardly through cylindrical section 15 of the preheater to exhaust outtake 16. As the material moves downwardly through this zone, it will spread out against vessel section 20, this section, like section 15, being an active heating area in which the hot gases flow through the material voids. Because the heating area is relatively close to feed device 18 through which the particles enter at ambient temperatures, there will be large temperature differentials between the hot gases and the surfaces of the particles. This will result in immediately high rates of heat absorption, contributing to higher production for a given amount of fuel, or less fuel per unit of productivity.

As the heated material continues to descend, it will enter holding section 30 where it will gradually be narrowed down to a relatively small cross-sectional area so as to be discharged at central opening 31. During the time the material is in the holding zone, the heat absorbed by the outer portions of the particles will soak into their interiors to create a more uniform temperature throughout.

I claim:

1. In a preheater for particulate materials such as limestone, a refractory lined vessel having an upper material intake section, an exhaust outtake concentrically mounted in said section, means for feeding material into said section, a gas intake section below said material intake section, a plurality of circumferentially arranged ports around said gas intake section, means feeding hot gases to said ports, whereby the gases will flow radially inwardly through said material, a material holding section extending downwardly from said gas intake section, said material holding section being entirely below said ports and being sufficiently deep to permit heat to be absorbed by the interiors of the particles of material, and a material discharge port at the bottom of said material holding section.

2. The combination according to claim 1, said material intake section being cylindrical, said exhaust outtake being circular, said material feeding means being so arranged that the level of material is maintained above said outtake.

3. The combination according to claim 1, said gas intake section being of larger diameter than said material intake section and so shaped that the angle of repose of descending material will form an inclined frustoconical surface around its periphery.

4. The combination according to claim 3, said gas feeding means comprising an annular distribution duct around said ports, the ports being located adjacent the top of said enlarged section.

5. The combination according to claim 1, said material holding section being conical, said material discharge port being centrally located and of relatively small area.

6. The combination according to claim 5, further provided with a conical lower baffle concentric with and spaced inwardly from said conical holding member, whereby the entire cross-sectional area of said holding zone will be coupled to said discharge port.

7. In a preheater for particulate materials such as limestone, a refractory lined vessel having a cylindrical section, a circular exhaust outtake concentrically mounted in said section, means for feeding material into the top of said vessel so that the level of material is maintained above said outtake, a section of larger di-
ameter than said cylindrical vessel section below the offtake and so shaped that the angle of repose of descending material will form an outwardly and downwardly inclined frustoconical surface around its periphery, a plurality of circumferentially arranged ports adjacent the top of said enlarged section, means feeding hot gases to an annular distribution duct around said ports, a conical material holding section extending downwardly from said enlarged section, said material holding section being entirely below said ports and being sufficiently deep to permit heat to be absorbed by the interiors of the particles of material, and a single centrally located material discharge port of relatively small area at the bottom of said holding section.

8. The combination according to claim 7, further provided with a conical lower baffle concentric with and spaced inwardly from said conical holding chamber, whereby the entire crosssectional area of said holding zone will be coupled to said discharge port.

9. The combination according to claim 8, said offtake comprising a downwardly open frustoconical member connected to a horizontal duct passing through said cylindrical vessel section.

10. In a preheater for particulate materials such as limestone, a refractory lined vessel having a cylindrical section, a circular exhaust offtake concentrically mounted in said section, means for feeding material into the top of said vessel so that the level of material is maintained above said offtake, a section of larger diameter than said cylindrical vessel section below the offtake and so shaped that the angle of repose of descending material will form an inclined frustoconical surface around its periphery, a plurality of circumferentially arranged ports adjacent the top of said enlarged section, means feeding hot gases to an annular distribution duct around said ports, said annular distribution duct being so formed as to allow settling of dust entrained in said gases, means to allow dust in the bottom of said duct, a conical material holding section extending downwardly from said enlarged section, and a single centrally located material discharge port of relatively small area at the bottom of said holding section.

11. In a preheater for particulate materials such as limestone, a refractory lined vessel having an upper material intake section, an exhaust offtake in said section, means for feeding material into said section, a gas intake section, means feeding hot gases to said gas intake section, a material holding section extending downwardly from said gas intake section, and a material discharge port at the bottom of said material holding section, said material intake section being located a substantial distance above said discharge port whereby the hot gases will flow across stone having a relatively low surface temperature, said material holding section being entirely below said gas intake section and of sufficient dimensions to allow time for substantial inward diffusion of the surface heat on particles descending therethrough.

12. The combination according to claim 11, said material intake section being cylindrical, said material holding section being conical.

13. The combination according to claim 12, said gas intake section being disposed between said material intake and holding sections and having an annular gas distribution duct.

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