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[54] **KILN PREHEAT AND DRYING SECTION**
7 Claims, 2 Drawing Figs.

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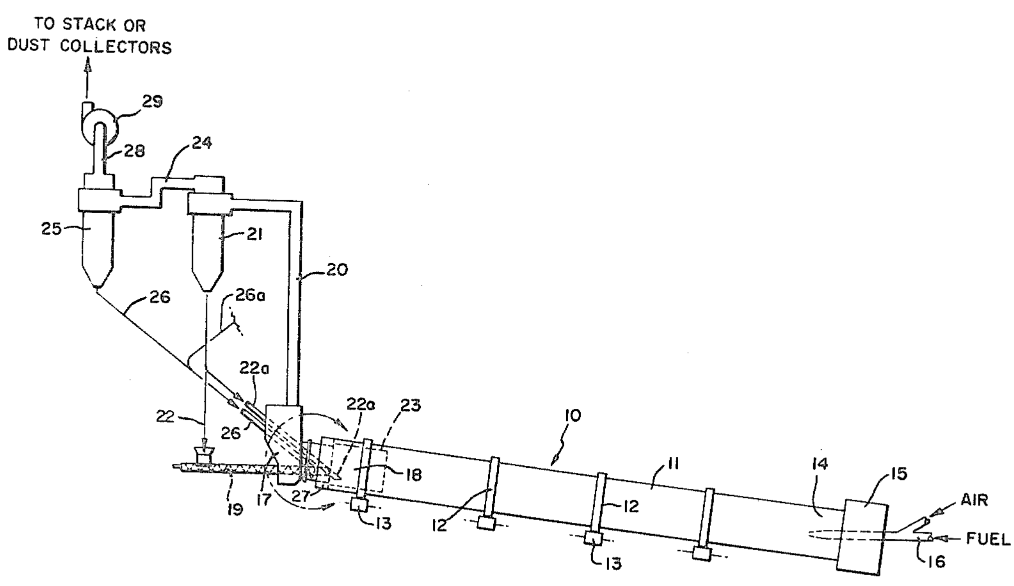
ABSTRACT: An improved kiln preheat and drying section comprising an inner shell concentric and axially aligned with the kiln shell, and provided with a means to feed raw material to be processed into the inner shell and means to feed dust into the annular space defined by the inner shell and kiln shell; and a process for operating the improved preheat and drying section.



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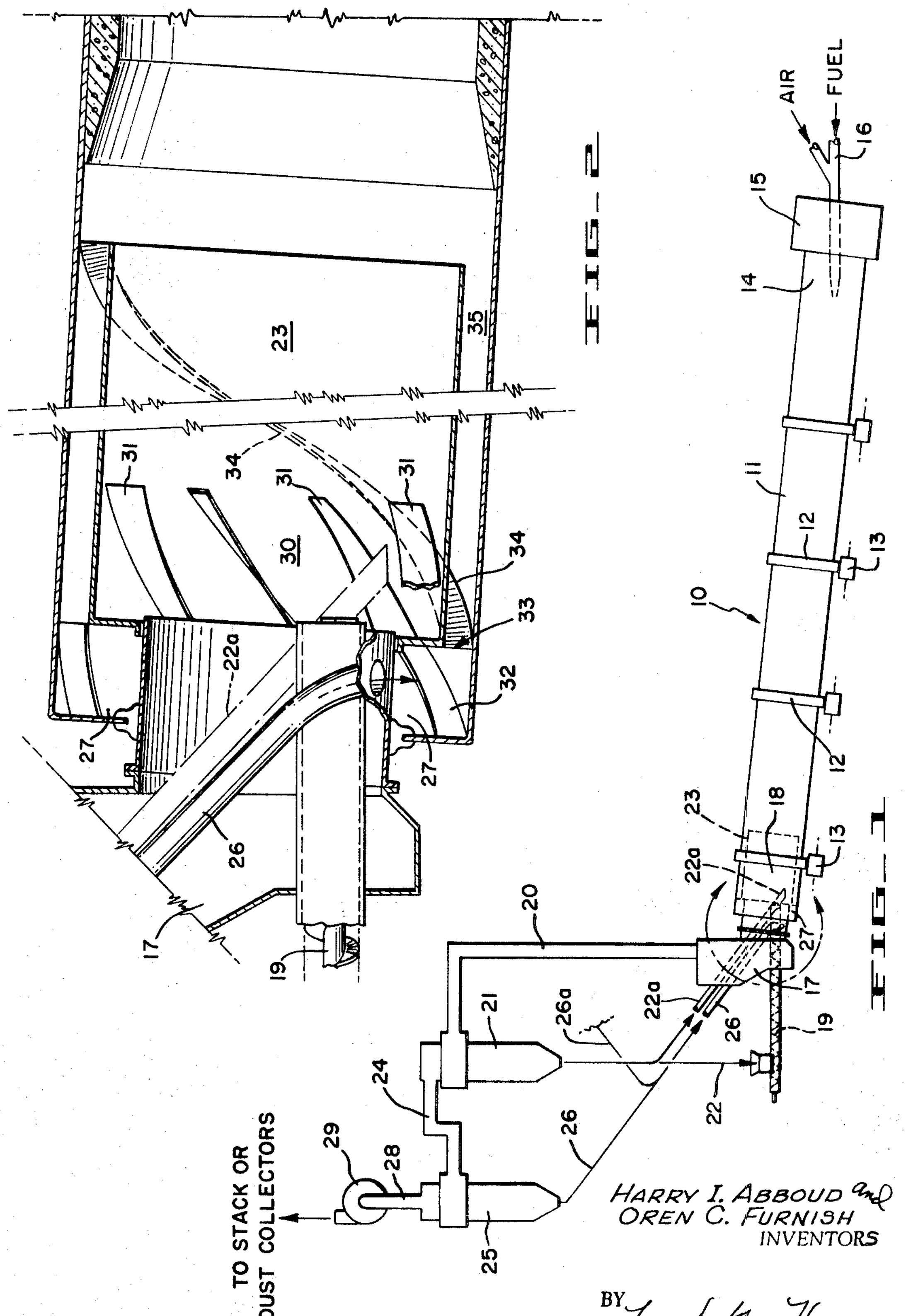

FIG. 2

FIG. 1

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KILN PREHEAT AND DRYING SECTION

BACKGROUND

This invention relates to an improved preheat and drying section for inclined rotary kilns for pyroprocessing of alumina, lime, cement and the like. Rotary kilns generally comprise a long cylindrical steel shell inclined toward the discharge end. The shell is provided with circumferential tires at spaced intervals along the length thereof and suitably supported by rolls. Usually the shell is lined in whole or in part by refractory material such as brick and the like.

The raw material to be processed is fed into the relatively cold upper or feed end of the kiln; and, due to the rotating action of the kiln, slowly moves toward the relatively hot discharge end. Fuel such as pulverized coal, natural gas and fuel oil is burned at the discharge end, and the hot gases are passed countercurrent to the raw material flow through the kiln, and then usually directed through one or more dust-collecting means before being discharged into the atmosphere. The dust removed from the hot gases can be recycled to the kiln or disposed of as waste, depending upon process economics. Due to waste disposal problems, most present-day processes recycle the dust to the kiln.

Because of the high temperature of the gas exiting from the kiln and the resultant heat losses, many kilns have chains, grates and the like to effect a greater heat transfer from the gases to the incoming cooler raw material. To further increase the heat transfer, many have attempted to increase the time as well as the intimacy of the contact between the hot gases and the incoming cooler raw material in the preheat and drying section of the kiln, such as is shown in U.S. Pat. No. 2,259,702, U.S. Pat. No. 1,766,453 and U.S. Pat. No. 3,396,953. Although most of these attempts have been theoretically sound, these prior art devices have been highly impractical and most, if not all, of these prior art designs have failed to become a commercial reality.

DESCRIPTION OF THE INVENTION

The present invention provides an improved design and operating process for the preheat and drying section of an inclined rotary kiln for the pyroprocessing of alumina, lime, cement clinker and the like. The improved feed section design of the present invention comprises a concentric cylindrical shell (hereinafter referred to as the inner shell) spacially disposed and axially aligned within the outer shell of the kiln. A means is provided to feed the raw material to be processed into the inner shell. The dust entrained in the exiting gases is removed by any suitable dust-collecting means and is fed by suitable means to the annular space between the inner and outer shells. Preferably, means are disposed within the annulus such as plows, spiral flights and the like to move the dust toward the discharge end of the kiln.

It is preferred to split the dust into a coarse fraction and a fine fraction, recycling the coarse fraction with the raw material feed to the inner shell and recycling the fine dust fraction to the annular space between the two shells. A suitable coarse fraction is one, 80 percent of which will have a mean particle diameter greater than 20 microns. It is preferred to maintain this coarse fraction 90 percent + 20 micron. In most operations the fine dust fraction will have a mean particle diameter less than 20 microns. In installations where there are primary and secondary dust-collecting means, it is advantageous to recycle dust from the primary dust collectors, which is relatively coarse, to the inner shell along with the raw material to be processed and the dust from the secondary and subsequent dust collectors, which is relatively fine, to the annular space between the two shells. It is most advantageous to mix the coarse dust fraction with the incoming raw material prior to feeding the raw material to the inner shell.

By introducing the dust into the annular space between the shells, out of contact with the high velocity gases which are exiting from the kiln, the entrainment of the fine dust particles by the gases is substantially eliminated. Moreover, because there is substantially no gas flow through the annulus, little or no dust entrainment is experienced when the raw material is discharged from the hotter end of the inner shell on top of the dust continuously exiting from the annular space. The continuous discharge of dust from the annulus substantially eliminates the dust surges experienced with conventional dust return systems which adversely affect the performance of air pollution control equipment and product recovery. Most conventional dust return systems periodically (usually once or twice per kiln revolution) discharge dust into the kiln. The annular space and the dust contained therein also have an insulating effect, reducing the heat loss through the shell.

Most effective, however, is the feeding of the coarse dust fraction, for example from the primary dust collector, into the inner shell with the raw material feed and the fine dust fraction from the secondary and subsequent dust collectors into the annular space. The coarse dust fraction contains considerable heat and by introducing this dust with the raw material, considerable heat transfer can be effected. By mixing the coarse dust fraction with the raw material before feeding to the inner shell a substantial increase in heat transfer can be obtained. Moreover, if the raw material is moist particulate matter, the premixing substantially reduces the scaling of lifters and heat exchange grates in the inner shell resulting in further substantial increases in heat transfer. By recycling the coarse and fine dust as set forth above, the material throughput can be increased up to 30 percent or more over the conventional designs with substantial increases in thermal efficiency—i.e., large decreases in B.t.u./lb. of product.

The dimensions of the inner shell with respect to the outer shell depend on many factors such as the material being treated, material throughput, gas velocity and temperature and the like. The only requirement is that the annular space be of sufficient size to handle the dust returned. The diameter of the inner shell should not be reduced to such an extent that the gas velocity is substantially increased, resulting in substantially increased draft fan requirements. The length of the inner shell with respect to the total length of the kiln will depend considerably upon the form of the raw material; i.e., whether it is a slurry, moist nodules or a dry particulate matter, and the type of processing desired; e.g., dehydration, decarbonation, or pyrochemical reactions between the components of the raw materials as in cement clinker manufacture.

For improved thermal efficiency, heat exchange grates, lifters and dams may be provided on the inner surface of the inner shell.

Reference is made to the drawings which further illustrate the improved kiln feed section. In all drawings the corresponding parts are numbered the same.

FIG. 1 is a sectional elevation view of an inclined rotary kiln and the dust collectors associated therewith.

FIG. 2 is a detailed cross-sectional drawing of the preheat and drying zones of the kiln.

With reference to the drawings, the kiln is generally shown at 10. It comprises a cylindrical shell 11 which is suitably supported by tires 12 and rolls 13. At the discharge end 14 of the kiln and encased by a hood 15 is a burner 16. A hood or dust chamber 17 covers the feed end 18 of the kiln. Screw conveyor 19 is provided for feeding the raw material into the feed end 18 of the kiln. A duct 20 connects the dust chamber 17 with the primary dust collector 21. Conduit 22 is provided at the discharge of dust collector 21 for returning the coarse dust fraction to the screw conveyor, or as shown in phantom, conduit *22a* is provided for returning the dust to the inner shell 23 of the kiln. Duct 24 is provided to connect the primary dust collector gas discharge outlet with the gas inlet of the secondary dust collector 25. Conduit 26 is provided to connect the dust discharge outlet of the secondary dust collector with the doughnut-shaped feed chamber 27. Conduit *26a* is provided for the dust returned from dust collectors subsequent to the secondary dust collector. Attached to the gas discharge exit of the secondary dust collector 25 is conduit 28, which connects the secondary dust collector with the fan **29** and subsequent dust collector means (not shown).

Referring particularly to FIG. **2**, the inner shell **23** is axially aligned with the kiln shell **11** and suitably supported and fixedly attached therein by supports (not shown). Some compensation usually must be given for the longitudinal expansion of inner shell with respect to the kiln shell which occurs during the operation of the kiln. This can be accomplished by fixably attaching the cooler end of the inner shell and slidably supporting the hotter end of the inner shell. Also, the supports may all be slidably attached to the kiln shell, but slidable only in the longitudinal direction (i.e., axially with the kiln shell). At the cool end **18** of the inner shell, plows **31** are provided to move the raw material into the area of the inner shell containing heat exchange grates, lifters, dams and the like (not shown). Integral with the feed end of the kiln is a doughnut-shaped chamber **27** containing plows **32** for moving the dust returned therein into the annulus **35** through apertures **33**. Within the annulus is provided a means **34**, a spiral flight, for moving dust through the annular area toward the discharge end of the kiln upon the rotation thereof.

In the operation of the apparatus shown in FIGS. **1** and **2** hot gases are provided by burner **15** which may burn fuels such as pulverized coal, natural gas, and fuel oil. Primary and/or secondary air may be provided for combustion. The gases are passed through the kiln by the action of a draft fan **29**. The raw material is introduced into the inner shell **23** by the feed means **19**. Although a screw conveyor is shown in the drawings, any suitable feed means may be used; for example, a conduit if the raw material is a slurry, and vibrating or belt conveyors and the like if the raw material is relatively dry. The dust-laden gases pass from the kiln into the dust chamber **17** and then into the primary dust collector **21** through conduit **20**. The coarse fraction of dust is separated from the gases and is returned to the inner shell of the kiln by conduit **22** or conduit **22*a***. The dust-laden gases from the primary dust collector **21** are passed to the secondary dust collectors through conduit **24** for further separation. The fine dust fraction from the secondary dust collector is returned to the doughnut-shaped chamber **32** through conduit **26**. The gases from the secondary dust collectors pass through conduit **28** to the draft fan **29** and then to the stack or other dust collectors (not shown). The plows **32** move the fine dust fraction into the annulus space **35** through apertures **33**. Spiral flight **34** moves the fine dust fraction through the annulus toward the discharge end of the kiln.

Typical Kiln Operating Data Before and After Conversion of Preheat and Drying Zone to the design of Invention

	Gas fuel rate CFH	Fuel heat value BTU/ft³	Gas disch. temp °F	Production tons/hr
Before Conversion	68,000	1,050	540	13
After Conversion	69,000	1,050	515	18

The above table provides typical operating data of a commercial-size kiln before and after its modification in accordance with the present invention. The kiln was employed to calcine alumina trihydrate from the Bayer process for the production of aluminum reduction cell feed. The kiln was 250 feet long and 9.5 feet in diameter. The kiln before its conversion was of conventional construction for this particular industry in that the dust recycled to the kilns was passed through a conduit inside the feed end of the kiln so that all the dust bypassed the preheat and drying sections and was mixed with the raw material feed after the feed had passed through the preheat and drying sections. As is evident from the data contained in this table, the throughput was increased by more than 30 percent, and the thermal efficiency (B.t.u./lb. of product) was increased approximately the same amount. The product quality before and after the conversion was essentially the same.

It will be understood by those skilled in the art that various elements described in the embodiment of the present invention have many equivalents and that the only limitations on the present invention are those set forth in the appended claims.

What is claimed is:

1. In an inclined rotary kiln having a relatively cold feed end and a relatively hot discharge end, said kiln inclined toward the discharge end and having dust collector means associated therewith, the features comprising:

a. Concentrically disposed and spacially arranged inner and outer shells at the feed end of the kiln, the inner shell defining an annular space with the outer shell of the kiln;
b. means for splitting the dust from the dust collector means into a coarse dust fraction and a fine dust fraction;
c. dust-feeding means associated with said dust-splitting means and disposed at the feed end of the kiln, said dust-feeding means arranged in a manner so as to feed the coarse dust fraction into said annular space and said fine dust fraction into said inner shell; and
d. means disposed at the feed end of the kiln to feed raw material to said inner shell.

2. The inclined rotary kiln of claim **1** having means to mix the coarse dust fraction with the raw material before said raw material is fed to the inner shell.

3. In the method of heating raw material in an inclined rotary kiln wherein hot gases are passed through said kiln in countercurrent flow to the raw material and thereafter through dust-collector means, wherein the dust from said collector means is returned to the kiln and wherein the raw material and returned dust are moved to the discharge end of said kiln by the rotation thereof, the steps comprising:

a. Feeding the raw material into an inner shell, spacially disposed and axially aligned within the feed end of the kiln,
b. passing substantially all of said gases through the inner shell,
c. returning dust from said dust-collector means to the annular space defined by the outer surface of the inner shell in the inner surface of the kiln shell.

4. The method of claim **3** wherein the dust from said dust-collector means is separated into a coarse fraction and a fine fraction, and wherein the coarse fraction is returned to the inner shell and the fine fraction is returned to the annular space between the inner and outer shells.

5. The method of claim **4** wherein the coarse fraction of dust is mixed with the feed material prior to feeding the raw material to the inner shell.

6. The method of claim **4** wherein at least about 80 percent of the coarse dust fraction has a mean particle diameter greater than 20 microns.

7. The method of claim **5** wherein at least about 90 percent of the coarse dust fraction has a mean particle diameter greater than 20 microns.