A process and apparatus for reducing $\text{SO}_x$ emissions from kiln systems for calcium-containing material. In a duct for passage of a stream of exhaust products from a calcining reaction of the kiln to pollution control equipment, a portion of the stream is diverted and hydrated. The hydrated portion is then returned to the stream at a location upstream from the diverting point.
PROCESS AND APPARATUS FOR REDUCING SO\textsubscript{x} EMISSIONS FROM KILN SYSTEMS FOR CALCIUM-CONTAINING MATERIALS

FIELD OF THE INVENTION

The present invention is concerned with reducing emissions of SO\textsubscript{x} in a process for producing lime or cement products by calcination of limestone or other calcium-containing materials.

BACKGROUND OF THE INVENTION

Emissions of SO\textsubscript{x} and the like into the atmosphere are regulated by various regulatory agencies and means for controlling and reducing such emissions must be implemented by processors generating such emissions. In the production of lime, for example, in which limestone is calcined in high-temperature kilns, emissions of SO\textsubscript{x} are found. The source of sulfur in the process can be from both the fuel used for providing heat for the calcining reaction and the limestone material itself which can contain sulfur compounds. In a typical lime kiln system, hot combustion gases are used to contact limestone, which is in pebble form, in order to promote the calcining reaction. During such process, any sulfur present in the hot combustion gases or the limestone material can combine with oxygen to result in the SO\textsubscript{x} gases. The SO\textsubscript{x} gases, along with other gases of the process and fine particulate matter, are carried through process conveying means to pollution control equipment such as a baghouse, electronic precipitation device, and/or scrubber. In such equipment the fine particulate matter and air polluting gases are removed prior to releasing exhaust gases to the atmosphere.

Purchase, installation and operation of such pollution control equipment is very costly and any means which can be employed to decrease the amount of pollutants to be removed can
reduce the cost of controlling emissions. In view of lower levels of acceptable emissions, reducing the amount of pollutants to be handled by existing pollution control equipment, by implementing processes carried out upstream of the pollution control equipment, could result in compliance with lower level emission regulations, with use of existing pollution control equipment.

It is an object of the invention to reduce the level of SO$_x$ pollutants in exhaust gases of calcining systems.

It is another object of the invention to reduce the level of SO$_x$ pollutants in gases of calcining systems prior to such gases entering pollution control equipment of the kiln system.

It is still another object of the invention to reduce the level of SO$_x$ pollutants without the expense of adding costly reactant materials to the kiln system.

SUMMARY OF THE INVENTION

The present invention is preferably for use in a system for calcining limestone, having a calcining kiln, pollution control equipment at an exhaust end thereof, and a conveying system therebetween, for directly conveying a stream of exhaust products of the calcining reaction from the calcining kiln to the pollution control equipment. The apparatus and process of the invention are for reducing SO$_x$ levels. The apparatus and process divert a portion of the directly conveyed stream from the conveying system, at a diverting point, and hydrates the diverted portion. The hydrated diverted portion is returned back to the directly conveyed stream at a point upstream from the diverting point and upstream from the pollution control equipment.
BRIEF DESCRIPTION OF THE DRAWINGS

The invention will become more readily apparent from the following description of a preferred embodiment thereof shown, by way of example only, in the accompanying drawing.

The drawing is a schematic diagram of the apparatus and process of the invention.

DETAILED DESCRIPTION OF THE INVENTION

In the typical process for producing lime, limestone in particulate form is subjected to a calcining reaction resulting in the formation of lime. When the process is carried out in a rotary kiln, for example, the limestone is introduced at a charging end of the kiln and conveyed to a discharge end. During the conveyance a counterflow of hot combustion gases, introduced near the discharge end, contacts the limestone to provide the heat necessary for the calcining reaction. A rotary kiln typically operates in a temperature range of 1,900 - 2,400 °F. In addition to the calcining reaction taking place, sulfur found in the limestone, or in the fuel for providing the hot combustion gases, is combined with oxygen to form the SO\textsubscript{x} pollutant gases.

Lime, resulting from the calcining reaction, is collected near the discharge end of the kiln, and gases of the process, along with fine particulate matter, such as residual limestone and lime, which remains suspended in the gases, pass through duct work to be removed by pollution control equipment such as baghouses, precipitators, scrubbers and the like. Such pollution control equipment is provided in order to remove both the fine particulate matter and the pollutant gases.

The drawing is a schematic diagram for use in describing the apparatus and process of the invention. Indicated at 1, is a kiln, such as previously described, or any other system for calcining lime, cement type materials, or any calcium-containing material which would result in
the above-described gases and particulate matter. Also indicated in the drawing, at 2, is any pollution control equipment such as a baghouse, electronic precipitator, scrubber or the like which is typically located near a final stage of the process, just prior to releasing exhaust gases through an exhaust duct 3 to the atmosphere.

At 4 is indicated a conveying system, for directly conveying gases and fine particulate matter, resulting from the calcining reaction, from the calcining kiln 1 to the pollution control equipment 2. Such a conveying system typically is made up of metal ducts 5, or the like and can also include cooling equipment for cooling the gases.

The above-described components of a "typical" calcining system are provided as examples only, and are not to be limiting in regards to a calcining system on which the process of the invention may be used.

The process of the invention is carried out by diverting a portion of the exhaust products of the calcining reaction, which include gases and fine particulate matter which are suspended in the gases. The exhaust products of the calcining reaction are conveyed in the system from the calcining kiln 1, to the pollution control equipment 2 through a duct 5 of direct conveying system 4. Indicated at diverting point 6 is a diverting duct 7 for diverting a portion of the directly conveyed stream of the exhaust products of the calcining reaction, from the directly conveyed stream. The portion of the directly conveyed stream which is diverted is preferably about 5 - 30% by volume. The diverted stream can be achieved with use of a cyclone or by reducing gas velocity as depicted at 8. In a hydrating vessel 9, water is added to the diverted stream in order to hydrate the fine particulate matter suspended in the gases of the diverted stream. The hydrating is preferably carried out using water spray nozzles 10. A rate of hydration is about 1 - 1.5 unit weights of water per unit weight of particulate matter being conveyed in the diverted
stream. Following such hydration the diverted stream is returned to the directly conveyed stream at a point 11 upstream of the diverting point 6 with use of an air lock device 12 or a blower (not shown), although in some systems a negative pressure exists at the point where the diverted stream is returned to the directly conveyed stream, and such equipment may not be needed. The point 11 at which the hydrated diverted portion of the exhaust products is returned to the directly conveyed stream in duct 5 is upstream of the point 6 at which it was diverted. Preferably, flow of the diverted stream is a continuous flow.

It has been found that the fine particulate matter being conveyed with the exhaust gases in a lime producing process comprises lime (calcium oxide) and limestone (calcium carbonate). In the hydrating portion of the system the lime is hydrated to a form having an affinity to react with SO\textsubscript{x} to form calcium sulfate and oxygen. The formed calcium sulfate, a solid, is then removed with the pollution controlling equipment 2 leaving substantially an exhaust gas very low in sulfur content. In the system, as described, the hydrated lime reacts with the SO\textsubscript{x} gases of the diverted stream of exhaust products as well as the SO\textsubscript{x} gases in the directly conveyed stream 4 of the exhaust products, into which the diverted hydrated stream is returned.

In carrying out the process of the invention, the temperature of the directly conveyed stream of exhaust product at point 11, where the hydrated portion of the exhaust products is returned to duct 5, is preferably between 800 than 1200°F. As mentioned above, cooling of the exhaust products can take place in duct 5, however such cooling should not result in a temperature of less than 800°F at the point where the hydrated portion of the exhaust product is returned to duct 5.

While specific materials, equipment, etc. have been set forth for purposes of describing embodiments of the invention, various modifications can be resorted to, in light of the above
teachings, without departing from applicant's novel contributions; therefore in determining the scope of the present invention, reference shall be made to the appended claims.
What is Claimed is:

1. In a system for calcining solid calcium-containing material, having a calcining kiln, pollution control equipment at an exhaust end thereof, and a conveying system therebetween for directly conveying a stream of exhaust products of a calcining reaction from the calcining kiln to the pollution control equipment, a process for reducing $SO_x$ levels in the stream, the process comprising:

   diverting a portion of the directly conveyed stream from the conveying system, at a diverting point;

   hydrating the diverted portion; and

   returning the hydrated diverted portion back to the directly conveyed stream at a point upstream from said diverting point and upstream of the pollution control equipment.

2. The process as defined in claim 1, wherein the calcining reaction is in calcining of limestone to produce lime.

3. The process as defined in claim 1, wherein the calcining reaction is in calcining for the production of cement.

4. The process as defined in claim 2, wherein the exhaust products of the calcining reaction include particulate residual limestone and lime.
5. The process as defined in claim 1, wherein the temperature of the directly conveyed stream at the point at which the hydrated diverted portion is returned back to the directly conveyed stream is greater than 800°F.

6. The process as defined in claim 1, wherein the temperature of the directly conveyed stream at the point at which the hydrated diverted portion is returned back to the directly conveyed stream is between 800 and 1200°F.

7. The process as defined in Claim 1, wherein the portion of the directly conveyed stream diverted from the conveying system is 5 - 30% by volume.

8. In a system for calcining solid calcium-containing material, having a calcining kiln, pollution control equipment at an exhaust end thereof, and a conveying system therebetween for directly conveying a stream of exhaust products of a calcining reaction from the calcining kiln to the pollution control equipment, a process for reducing $\text{SO}_x$ levels in the stream, the process comprising:
   diverting a portion of the directly conveyed stream from the conveying system, at a diverting point;
   hydrating the diverted portion; and
   returning the hydrated diverted portion back to the directly conveyed stream at a point upstream from said diverting point and upstream of the pollution control equipment, wherein
   the portion of the directly conveyed stream diverted from the conveying system is 5 - 30% by volume, and
the temperature of the directly conveyed stream at the point at which the hydrated diverted portion is returned back to the directly conveyed stream is between 800 and 1200 °F.

9. An apparatus for reducing SO\textsubscript{x} levels in a stream of exhaust products of a system for calcining solid calcium containing materials wherein the apparatus includes:

a direct conveying duct for passage of exhaust products of a calcining reaction from a calcining kiln to pollution control equipment;

a diverting duct communicating at two points with said direct conveying duct for removing a portion of the exhaust products at a diverting point and then returning the portion to the direct conveying duct at a point upstream of said diverting point; and

means for injecting water to hydrate the diverted portion of the exhaust products.

10. The apparatus as defined in Claim 9, further comprising at least one of a cyclone and a gas velocity reducing device, for diverting the exhaust products into the diverting duct.

11. The apparatus as defined in Claim 9, further comprising at least one of a blower and an air lock device, for returning the diverted portion of the exhaust products to the duct.

12. The apparatus as defined in Claim 9, wherein said means for injecting water comprises a hydrating vessel in communication with a section of the diverting duct.

13. The apparatus as defined in claim 9, wherein said pollution control equipment is at least one of a baghouse, a precipitator, and a scrubber.
14. The apparatus as defined in claim 9, wherein said calcining kiln is one of a lime calcining kiln and a cement calcining kiln.
INTERNATIONAL SEARCH REPORT

International application No.
PCT Λ J S 07/16704

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B01D 53/62 (2007.10)
USPC - 432/15; 106/739

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)
USPC: 432/15; 106/739

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 432/15; 106/739; 432/105

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
USPTO WEST (USPT, PG PUB, EPAB, JPAB); -calcium, calcining, kiln, exhaust, pollution, emission, stream, product, hydrat$, SOx, SO, sub, x, div$, volume
Google Scholar; ‘process and apparatus for reducing SOx emissions from kiln systems for calcium materials’

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>X</td>
<td>US 2004/0018133 A1 (RADWAY) 29 January 2004 (29 01.2004), [Abstract], para[0002], [0004], [0006], [0012], [0033], [0039], [0044], [0059], [0061], [0068], [0072], [0074], Figs. 1-5</td>
<td>1, 5, 6</td>
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<td>2-4, 7, 8, 11</td>
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<td>Y</td>
<td>US 4,915,914 A (MORRISON) 10 April 1990 (10.04.1990), [Abstract], col 1, ln 14-17; col 1, ln 20-34; col 1, In 45-56; col 1, In 65-68 to col 2, ln 1-2; col 2, In 43-55; col 4, In 6-25; col 5, In 20-34; Fig. 1</td>
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<td>2-4, 11</td>
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D. Further documents are listed in the continuation of Box C.

* 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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  "O" document referring to an oral disclosure, use, exhibition or other means
  "P" document published prior to the international filing date but later than the priority date claimed
  "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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  "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

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