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SUSPENSION FIRING OF HOG FUEL, OTHER BIOMASS OR PEAT.

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Description

Background of the Invention

This invention deals with heat recovery from wet wood waste or other biomass material and certain fuels such as peat. Of particular interest is wood waste generated by wood processing facilities, commonly called "hog fuel".

As fossil fuel costs have escalated, operators processing wood as a raw material, especially in sawmills, pulp and composite wood products operations, have become more interested in recovering the heat energy value of wood wastes that are otherwise unsuitable for conversion into salable products. Many facilities generate a sufficient amount of such waste to meet significant portions of their energy requirements. Others have access to supplies of peat which, if a suitable means of heating value recovery was available, could constitute a low cost replacement for fuel oil or natural gas.

Wood wastes from sawmilling and related raw wood handling operations have a number of characteristics that make efficient recovery of heating values difficult. Hog fuel is generally wet, usually in excess of 50 percent by weight moisture and often in excess of the 69% moisture limit of self-sustaining combustion. Each mill source of waste has its own characteristic moisture content. Much sawmill and pulp mill wood waste is accumulated and stored out in the weather where it soaks up rainwater during wet periods of the year.

A second problem with hog fuel is that it varies greatly in size. Hog fuel wastes are generated from every wood handling and processing operation. The wastes range from sander dust of 0.1—3 mm diameter particle size to bark and log yard debris which may exceed dimensions of 200 mm in diameter and be over a meter in length.

A common practice in the past has been to burn wet hog fuels on a grate in a combination oil-wood waste boiler. Supplemental oil is generally used to sustain combustion and permit the boiler to follow process demands for steam. Peat and other biomass matter are similar to hog fuel in that they are wet and of unsuitable physical form or size. Thus, these potential fuels are generally not utilized in many parts of the world. While the discussion here focuses upon wet wood waste or hog fuel, the invention is applicable to any wet organic matter and vegetable material.

Recent improvements in heat recovery from hog fuel require a reduction in moisture content of the hog fuel before it is fed to the boiler. Studies show that reducing the initial moisture content of the fuel improves steam production and reduces boiler stack emissions. The hog fuel burning process need no longer supply all the latent heat necessary to dry the fuel. The dry fuel requires less excess air and thus boiler heat losses are reduced, improving overall thermal efficiency. The resulting high combustion zone temperatures apparently insure incineration of most particulate matter before it escapes out the stack.

US—A—4 492 171 discloses a process for burning an organic fuel by means of a solid fuel burner into which air is introduced to cause rotation of powdered fuel. The fuel is to be pulverized and dehydrated to a desirable overall moisture content of approximately 20%. The size of the particles is not relevant. Both powdered particles as well as pallets of about 6 mm in diameter and about 18 mm long may be used. An adjustable gas nozzle is provided within the centre of the burner for burning additional fossil or other fuels (gas or oil) in order to sustain the flame.

US—A—433 405 discloses an improved burner for burning powdered coal. Nowhere in the publication is it shown how to size and treat powdered particles of wet organic materials other than coal for providing a self-sustaining flame without the need of burning additional fuel.

A state-of-the-art process that successfully accomplishes the pre-drying and burning of hog fuel is described by Spurrell in U.S. Patent No. 4,235,174. In this process a portion of the largest size material from the hog fuel pile is burned in a fluid bed burner. The products of combustion from the fluid bed are then used to dry the balance of the hog fuel pile in a rotary dryer before it is fed into a combination oil-wood waste boiler. The dried fuel is separated by size. The coarse fraction, at about 35 percent moisture burns on a furnace grate while a fines fraction at 15 percent moisture and a particle size of less than 3.2 mm diameter is injected in air suspension into the boiler.

The Spurrell process, however, requires an oil pilot on the injected fines portion of the fuel in order to sustain stable combustion. The oil pilot represents a substantial use of fossil fuel, up to 30% of the total burner rating in terms of BTUs per hour at full burner loads. This usage of expensive fossil fuel is particularly unsatisfactory since it is not needed for its energy value per se but only to serve as an ignition energy source to achieve stable burning of the hog fuel material.

Attempts to burn the dried fines stream produced in the Spurrell process in air suspension without pilot or fire on the grate have been generally unsuccessful. Trial burns of this material, which is about 100 percent less than 3.2 mm in size, would not sustain stable combustion without an oil pilot. Even with the pilot, overall furnace conditions were unstable, producing large swings in boiler pressures, unless a grate fire was present.

Certain wood wastes have in the past been recognized as burnable in furnaces without oil support or grate. For example, sander dust which is of very fine particle size distribution and about 5% moisture content has been burned successfully in air suspension. Schwieger, in an informative survey article entitled "Power from Wood", Power, 124(2) S1—S32 (1980), describes sander dust, at about 12% moisture, as being fired to a backage boiler. The average size of this material is said to be about 0.8 mm. Even so an oil
Energy technology involving direct combustion of hog fuel for heat and power generation has generally required the use of a fossil fuel pilot to provide continuous ignition energy to raise the inherently more difficult to pulverize than coal, for example. Eneroth, et al. in U.S. Patent 4,229,183 teach a pilot equivalent to 5% of the burner rating is required for flame control. Fagerlund expresses the hope that for stabilized combustion.

Industry, because of lower capital costs of construction and lower maintenance costs, favors the use of “water wall” boilers wherein the flame is substantially surrounded by water tubes which generally reach only about 320°C. In these boiler configurations, the walls are relatively cold compared to the flame and are more efficient heat absorbers. There is reduced radiation assistance from firebox ceramics to help sustain the ignition process. As a result, suspension firing of water wall boilers with conventionally available hog fuel has generally required the use of a fossil fuel pilot to provide continuous ignition energy to raise the fuel to ignition temperature. Ignition occurs when a sufficient level of volatiles is generated from the fuel by pyrolysis.

The most recent approach to burning the larger fraction of the hog fuel pile has involved pulverizing the hog fuel to a smaller particle size range. However, because of its wood fiber content hog fuel is inherently more difficult to pulverize than coal, for example. Eneroth, et al. in U.S. Patent 4,229,183 teach improved hog fuel burning by simultaneously grinding and drying the fuel to 10—15% moisture content. The flow from the pulverizer enters a cyclone which separates the fuel from the air flow. The fuel is then re-suspended in air and injected into a boiler. No grate is required. Fagerlund, Tappi 63(3): 35—36 (1980) further describes the Eneroth method as grinding the wood fuel down to a particle size of 1—3 mm. An oil pilot equivalent to 5% of the burner rating is required for flame control. Fagerlund expresses the hope that control systems in the future will be developed so that no auxiliary oil will be needed.

In another hog fuel burning system described by Baardson in U.S. Patent No. 3,831,535, wood waste is dried and pulverized to a maximum particle size of 7.9 mm. This material is accumulated in a bin and injected for combustion in a refractory lined chamber where radiation from the refractory provides support for stabilized combustion.

Summary of the Invention

The present invention converts the entire hog fuel pile or any other coarse or poorly graded biomass or even peat into a fuel that burns in air suspension in a boiler without the necessity for supplemental supporting fossil fuels, hot refractories or grate burning, in contrast to the prior art. The fuel preparation and method of burning the resulting fuel system can be used to fire kilns, product dryers, and particularly water wall furnaces or any other “cold” wall type of heat recovery processes.

A principal object of the fuel preparation method of this invention is to provide a properly dried and sized hog fuel which upon discharge from a pulverizer may be fed to an air suspension burner of the swirl stabilized type and efficiently burned therein. The invention permits a steam boiler to follow varying energy process demands as effectively as with oil or pulverized coal firing. In fact, the method of the invention compares substantially more favorably with firing #6 oil than coal because of wood’s greater volatile content and volatility rate. The ash produced is somewhat greater in amount but sulfur dioxide emissions are relatively insignificant, a major advantage in view of concerns about acid rain. NOx emissions are also less than for coal or oil which is a concern of the utilities and other boiler operators subject to environmental scrutiny and regulation.

A principal advantage of the invention is elimination of the oil pilot necessary to provide ignition energy to sustain stable combustion of wood wastes in water wall boilers. Present commercial wood burners specify that 5—15% of the burner BTU design load must be met by oil or other conventional fossil fuel in order to maintain flame stability.

Another primary advantage of the invention is the elimination of the grate required by prior art boilers to burn oversize material that does not burn in suspension. All of the hog fuel may be burned in air suspension. The system has an excellent capability for turning up or down to meet changing process demands. A burner turn down of at least 2.5:1 is attained.

It is an object of this invention to be able to retrofit the methods of the invention to existing hog fuel boilers or pulverized coal boilers with resultant fuel cost and capital savings. The burning process and apparatus of this invention will operate similarly to a utility boiler burning pulverized lignite or oil.

The system of this invention permits a substantial savings in operating costs over conventional systems through substitution of cheaper wood for oil or coal. Also, elimination of the need for a grate eliminates an industry restriction on maximum size of boilers due to grate size limits. Also, boiler size may
be reduced because the fuel is dried prior to firing.

The invention requires drying the hog fuel, which in general has an initial moisture content of 50% or more. Drying may involve mechanical or thermal processes so long as a moisture content of less than about 30% by weight results. No more than about 15—20% weight moisture content is preferred.

The hog fuel is then pulverized to a particle size distribution so that: (a) no particles are larger than will substantially burn within the confines of the heat recovery boiler; and (b) there is a fines portion of such particle size and in such amount that the fines portion ignites to provide sufficient ignition energy to sustain stable combustion of the entire fuel flow.

All drying is substantially accomplished prior to the pulverizing step since it is easier to pulverize dry wood to the degree required in the later step.

The upper size limit of the pulverized wood is a function of the specific boiler employed to burn the prepared fuel and the emission limitations prevalent. An upper limit of 85—100% less than 1 mm has been found suitable for hog fuels burning in a boiler without a grate. Where the boiler includes a grate the upper size limitation is less strict. Most oversize in such case will just fall to the grate.

The characteristics of the necessary fines portion of the pulverized fuel are a function of the moisture content of the fuel and the type of burner employed in combusting the fuel in the boiler. A higher moisture content will require more time to dry, delaying ignition. A wetter hog fuel will, in such cases, have to have more fines content, if time to ignition is limiting. The fuel of the invention is specifically designed for use in a swirl stabilized air suspension burner which is well known commercially, particularly for burning pulverized coal.

A fines portion including at least 15% by weight less than 150 μm was found suitable for the burner shown in Figure 2. The fuel size distribution is a critical element of the invention. A distribution of about 100% less than 1 mm and 50% less than 150 mm is a preferred fuel specification where burner characteristics are not optimized for operation on wood.

The sum of fuel moisture content, particle size distribution, and the manner in which fuel is mixed with combustion air and injected into the furnace, e.g. burner type, defines a method of fuel preparation and burning which eliminates any need for supporting fossil fuel for stability. This is a prime limiting characteristic of the prior art. Moisture content and size distribution are not independent, but may be adjusted so long as reactive fuel is produced that is adequate for the burner utilized. The complete air suspension burning of the fuel permits furnace operation without the necessity of a grate and has good capability to follow boiler load demand variations. The process is operable for all furnace configurations, kilns and the like, but is most particularly suitable for use with water wall furnaces and boilers, in contrast to prior art systems.

Brief Description of the Drawings

Figure 1 is a schematic diagram of the method of invention for burning pulverized hog fuel in a water walled heat recovery means.

Figure 2 is a schematic drawing of a swirl stabilized burner suitable for combusting the dried, pulverized fuel.

Figure 3 is a series of particle size distribution curves characterizing a range of dried, pulverized fuels suitable for use in the process of this invention with a burner of the type shown in Figure 2 compared with some prior art fuels.

Figure 4 is a schematic embodiment of the invention wherein pulverized fuel is temporarily held in storage before combustion.

Figure 5 shows an alternative arrangement of the invention wherein a separator is used to concentrate the fuel and a portion of the separated air is used for secondary air makeup.

Description of the Preferred Embodiments

Referring to Figure 1, hog fuel from the mill pile, typically at about 60% moisture content, comprising a mixture of wood ranging from sander dust through large log handling debris and bark, is fed to a drying and screening process 10. A drying process similar to that disclosed by Spurrell in U.S. Patent 4,335,174, cited and outlined above, may be used. The Spurrell process is exemplary of a suitable drying process for this invention but other methods are equally suitable. The Spurrell process is operated to produce a hog fuel having less than about 30% moisture content as required by the present invention. Final moisture content is a function of the operation of the dryer and the average particle size of the resulting dried fuel. In general, the Spurrell process produces material ranging from about 40 mm by 100 mm chips to fines less than 3.2 mm in diameter. The moisture content of these particles may range from about 10% for the finer material up to about 30% for the larger chips.

The dried hog fuel is conveyed to a temporary surge storage and metering unit 11 which may be similar to a pulverized coal feeder. The hog fuel is initially held in a bin 12 designed to avoid "bridging" flow interruptions.

From the bin 12, the hog fuel is discharged through a column 13 onto a weighing belt means 14. Column 13 is of such a length as to impose a 550 kPa explosion protection on the bin system 12. In other words, an explosion at the pulverizer would not propagate into the bin 12 because of the dimensions of the column 13. The fuel is transported through line 16 to a pulverizer 15. The metering system 14, in contrast to
volumetric systems, provides a consistent, measured weight of hog fuel to the pulverizer, which weight of fuel may be varied over a wide range.

Pulverizer 15 is a high speed rotary hammer mill. A preferred machine is manufactured by Pulverizing Machinery Division of Mikropul Corp., Summit, New Jersey and is described by Duychinck, et al. in U.S. Patent 3,285,523.

The fuel preparation and burning methods of this invention are designed to burn the fuel in air suspension, using a swirl stabilized burner. In such a system the amount of air for pulverizing, provided by a fan 17, is preferably limited to just that amount necessary to transport the fuel into the furnace ignition zone. Thus, a preferred pulverizer would produce the pulverized fuel suspended in a minimal amount of air, about 0.6—2 kilograms air per kilogram of fuel, to match fuel burner needs. The transport of primary air carries the fuel through a burner 18 injecting it into the boiler 20 combustion zone 21. Secondary air is introduced by blower 19 into the burner 18 along with the fuel. Boiler load or mill demand is provided for by water-filled heat transfer tubes 22 which in actual construction substantially surround the burner flame 21.

A key parameter of the process of the invention is the burner 18 which injects the dried pulverized hog fuel into the furnace and mixes it with air such that the fuel is substantially completely burned in suspension. A swirl stabilized burner, of the type used to burn pulverized coal in air suspension, was the starting point for the design of a burner suitable for burning the pulverized hog fuel. Some routine modification of the coal burner geometry was necessary to derive proper velocities, moments and trajectories to insure complete suspension burning for the substantially different hog fuel feed.

Figure 2 depicts a swirl stabilized burner 18 of the type generally suitable for use with the fuel prepared by the methods of this invention. The burner 18 is installed in an aperture in the wall 23 of boiler 20. An oil nozzle igniter 24 is provided for flame initiation and start-up. A pipe 25 concentric about the oil pipe 24 transports dried, pulverized hog fuel and primary combustion air from the pulverizer into the boiler. Primary swirler vanes 26 impart angular momentum to the fuel and primary air stream as it leaves the burner 18 and is injected into the boiler 20.

Secondary combustion air generated by blower 19 (see Figure 1) enters the burner 18 through an air register 27 which can vary the amount of air admitted and the degree of swirl imparted to the air. Secondary swirler vanes 28 also impart angular momentum to the secondary air. The ratio of the opening area between the burner fuel pipe 25 and the boiler entry wall tiles 29, commonly called “blockage”, also partly determines secondary air flow characteristics into the boiler. The impact of swirl and blockage on this secondary air flow results in creation of a recirculation zone (see Figure 2) where combustion products and heat flow back into contact with fresh fuel discharging from the fuel pipe 24. The high heat level of the combustion products raises the temperature of part of the entering fuel, primary and some secondary air to ignition temperature. The fines portion of the fuel ignites, providing ignition energy for the balance of the fuel before it can leave the flame area.

The presence of the fines portion as an ignition energy source imparts stability to the flame. The presence of the fines portion is the heart of the invention. The fines portion eliminates the requirement for continual running with supplemental oil in order to obtain burner stability.

A preferred burner is characterized as having a high blockage ratio, i.e., the ratio of primary burner area to throat area, and low swirl. For the present purpose “high blockage” is considered to be a burner area to throat area ratio of 0.5 or greater. The principal goal of the combination of swirl and blockage is generation of the recirculation zone. Also, mixing of secondary air with the primary stream occurs only as fast as needed for combustion. Limiting secondary air mixing avoids adding an excessive amount of “cold” air which would delay ignition.

A major advantage of the process and equipment of this invention is the ability of the system to respond to varying mill stream or other heat load demands. The burners of the invention may be turned down below 100% capacity. The system of the invention is capable of at least a 2.5:1 turndown ratio. That is, the burner, in response to load changes, may be turned down to 100/2.5 or 40% of maximum output. Below the 2.5 turndown level the burner operation is generally unstable as the recirculation zone collapses.

The primary air to fuel ratio at 100% load of 0.6—2 kilograms air per kilogram of fuel or 16—32% of stoichiometric air for complete combustion is required for best combustion of the dry pulverized fuel in the boiler. At low load or fuel flow the ratio of air to fuel increases to 3:1. It is preferred to use the minimum amount of primary air to minimize the amount of “cold” air which must be heated with the fuel to reach ignition temperature.

Prior to this invention, a bin system would be interposed between the pulverizer 15 and the burner 18 to provide the required primary air/fuel ratios. This was true because all existing pulverizing designs required air to fuel ratios on the order of 3 kg air/kg fuel at high load and 8 kg air/kg fuel at low load or 50—150% of stoichiometric. Such high air to fuel ratios render a burner directly connected to such a pulverizer incapable of adequate turndown.

The principal critical element of this invention is the particle size distribution of the dried hog fuel fed to the burner. Figure 3 shows a series of pulvreted hog fuel particle size distributions, including a range of fuels that are embodiments of this invention, and three lettered prior art fuel distributions. A basic conclusion established by this invention is that hog fuels must be substantially reduced in size to provide an ignition energy source in order to burn in suspension without oil support. A further discovery reached
through experimentation was that all the dried, pulverized wood fuels described in the prior art are too coarse to burn in a water wall or cold boiler without supporting fossil fuels.

Referring to Figure 3, curve A is the fines portion of the hog fuel produced by the drying and screening process of Spurrell, described in U.S. Patent 4,235,174. Attempts to burn this fuel in a water wall boiler without some oil fuel to support combustion were unsuccessful. Thus, curve A fuel is somewhat finer than the pulverized hog fuel of Baardson described in U.S. Patent 3,831,535 as successfully burned in a refractory lined combustion chamber. The Baardson fuel was characterized as having a maximum particle size of 7.9 mm in diameter igniting due to the high temperature at the wall's surface, which may be in the range between 1200—1315°C. If Baardson's fuel were plotted on Figure 3, it would fall somewhat to the left of curve A which is believed is representative of the prior art fuels. These are incapable of combustion in air suspension in a cold wall combustion chamber without supporting fossil fuel.

Curve B is another prior art fuel, described by Fagerland, cited above at page 4, as typical of the Eneroth (Flakt, Inc.) and ASSI fuels. This fuel also proved unstable in combustion trials as it was too coarse.

Curve C is a pulverized coal sample of the prior art. This is substantially finer than hog fuels.

In experiments, various mixtures of wood fiber and bark were pulverized at various levels of moisture. Grinding performance was measured by the pulverizing industry's method of determining the amount of new particle surface area generated per unit power input, that is m²/MJ. Achieving the fuel distribution of this method by practicable means requires first drying and then pulverizing.

A key advantage of the process of this invention is the arrangement whereby the fuel is first dried to less than 30% moisture by weight and then pulverized. The reverse arrangement, as adopted, for example, by Eneroth and described by Fagerland, cited above, requires twice the size or number of machines to accomplish a given production rate and even more importantly four times the power, which is a critical operating expense in the pulverizing arrangements.

Figure 4 shows a schematic of an operating hog fuel heat recovery process in which there is intermediate storage of dry pulverized hog fuel prior to firing into the boiler. The hog fuel, dried according to the Spurrell process, for example, is collected in a first storage bin 30. From bin 30 the material is mixed with air provided by blower 31 for transport in line 32 into a pulverizer 33. Make up air 34 is drawn into the pulverizer 33 by a fan 37 as needed to satisfactorily move the hog fuel through the pulverizing process. The
pulverized hog fuel and air discharges through a transport line 35 to a bag house dust collector 36. The carrier air is discharged through fan 37. The pulverized dried hog fuel drops into conveyor 40 which delivers the fuel to storage/surge bin 38. Hog fuel is then fed to boiler 44 as needed by mill process heat demands. Fuel, as required, is combined with air 41 supplied by primary air fan 39. The air-fuel mixture 42 is injected into boiler 44 through a suspension burner 45. Such secondary air as is necessary for combustion is supplied by conventional boiler air system 47.

In certain retrofit situations, it may be necessary to use the intermediate bin storage process of Figure 4 which may require additional capital cost. A disadvantage of the bin system is that it presents a much higher dust explosion hazard than the direct fire approach. Thus, explosion detection and suppression instrumentation and equipment are necessary parts of the bin approach. The bin-firing system is actually an intermediate step in developing a system which would permit firing pulverized fuel directly from the pulverizer.

Example

The following tables describe typical fuel, air flows and certain other conditions characteristic of the operation of the process shown in Figure 4. The process operates completely without oil support.

The drying process described by Spurrell in U.S. 4,235,174 provides, dry, screened feed for this heat recovery process production run.

The system provides fuel to two burners, similar to the burner 45 shown in Figure 4.

The boiler is a water wall furnace wherein the heat recovery portion of the boiler comprises surrounding the combustion zone with water filled elements for capturing the heat.

The pulverizer was a standard Mikro-ACM™ Pulverizer, Model 200 with internal classifier manufactured by Pulverizing Machinery Division of MikroPul, U.S. Filter Corporation of Summit, New Jersey. The pulverizer machine was fitted with a 225 kW motor producing air to fuel ratios of 2.8:1 at high pulverizer loads and 8.1:1 at low loads. With these air flows, the intermediate bin was necessary to obtain turndown capability of the boiler.
Table: Suspension Burning of Pulverized Hog Fuel - Summary of Process Flows Referring to Figure 4.

<table>
<thead>
<tr>
<th>Location - Figure 4</th>
<th>Parameter</th>
<th>Relative Fuel Feed Rate, Single Burner</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low Rate</td>
</tr>
<tr>
<td>Pulverizer Feed Streams</td>
<td>Moisture (% , wt. H₂O/wt. H₂O + wt. wood)</td>
<td>Low Moisture</td>
</tr>
<tr>
<td>Pulverizer Feed at 32 - Hog Fuel</td>
<td>Mass Rate (kg/h)</td>
<td>15</td>
</tr>
<tr>
<td>Blower Outlet at 31 - Air</td>
<td>Low Moisture</td>
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<tr>
<td>Blower Outlet at 31 - Air</td>
<td>Mass Rate (kg/h)</td>
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<td>Blower Outlet at 31 - Air</td>
<td>Volume Rate (m³/min.)</td>
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<tr>
<td>Blower Outlet at 31 - Air</td>
<td>Temperature (°C)</td>
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<tr>
<td>Blower Outlet at 31 - Air</td>
<td>Velocity (m/s)</td>
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<td>Pulverizer Inlet at 34 - Air</td>
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<td>Pulverizer Inlet at 34 - Air</td>
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<td>Pulverized Streams</td>
<td>Volume Rate (m³/min.)</td>
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<tr>
<td>Pulverizer Outlet at 35 - Hog Fuel and Air</td>
<td>Velocity (m/s)</td>
<td>25</td>
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<td>Baghouse Outlet at 37 - Air</td>
<td>Mass Rate of Gas Dry Air (kg/h)</td>
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<td>Baghouse Outlet at 37 - Air</td>
<td>Dew Point (°C)</td>
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<tr>
<td>Baghouse Outlet at 40 - Hog Fuel</td>
<td>Mass Rate (kg/h)</td>
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Table: Cont.

**Burner Streams**

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<th>Flow to Burner at 42 - Hog Fuel</th>
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<th>2,325*</th>
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<td>Volume Rate (m³/h)</td>
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<tr>
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<td>Temperature (°C)</td>
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<td>Velocity (m/s)</td>
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<td>Flow to Burner at 42 - Primary Air After Heating</td>
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<td></td>
<td>Velocity (m/s)</td>
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<td>250</td>
</tr>
<tr>
<td></td>
<td>Velocity (m/s)</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

**Steam Production**

| Total steam from pulverized fines (kg/h) | 4,210 | 12,630 | 12,460*** |
| Swing load range with pulverized fines (kg/h) | - | 8,420 | 8,420 |
| As % of boiler rating | 10 | 10 |

*Note: In high rate high moisture case, pulverizer cannot meet capacity of burner. Starting with a full bin, the burn can be operated at full load for only 2.5 hours.

**Note: This is the velocity before mixing with fuel. A T across mixing tee is approximately 170°C. At the burner inlet, the temperature is 80°C, And the velocity has dropped to 29.3 m/s.

***Note: 75% efficiency; 74% efficiency for high rate, high moisture case.
Figure 5 shows an alternative arrangement wherein high air flow pulverizer 59 discharges a fuel-air mixture 60 to a baghouse or cyclone 36'. A portion of the air stream exiting the baghouse or cyclone 36' is used as secondary air 64 for the burner 45'. Fuel discharges from bin or cyclone 36' and is entrained with air provided by the primary air fan 63.

It is to be understood that a number of parallel dryers, pulverizers and burners may be needed to meet the entire load of a boiler energy recovery system. For example, it is contemplated that one pulverizer will be required for every 100—200 million kJ per hour of hog fuel burned.

Claims

1. A process for burning a wet organic fuel in a water well or other cold type boiler (20, 44, 44') which comprises:
   providing at least one swirl stabilized burner (18, 45, 45') for burning a powdered fuel;
   drying the wet fuel to an average moisture content less than about 30% with at least a portion of the finer particles having a moisture content not exceeding about 20%;
   pulverizing the dried fuel so that at least 60% by weight of the particles are finer than about 1000 microns and at least 15% of the particles are finer than about 150 microns;
   adjusting the fraction of the less than about 150 micron particles in the pulverized portion so that the fuel will produce a self-sustaining flame;
   conveying the dried and ground particles to the burner while suspended in a stream of primary air; and
   igniting the particles, whereby the less than about 150 micron fraction provides sufficient ignition energy to sustain stable combustion of the entire fuel.

2. The process of claim 1 in which essentially all of the particles are less than 1000 microns and at least 50% by weight are less than about 150 microns.

3. The process of claim 1 in which the average fuel moisture is less than about 20%.

4. The process of claim 1 in which the burner has a high blockage ratio to minimize mixing of secondary air with the primary air-fuel stream.

5. The process of claim 1 in which the organic fuel is wood waste comprising wood and bark particles.

6. The process of claim 1 in which the organic fuel is peat.

7. The process of claim 1 employing a weight ratio of primary air to fuel in the range of 1—3 kg of air for each 1 kg of fuel.

8. The process of claim 1 in which the wet fuel is first screened prior to drying so that the largest particles being dried do not exceed more than about 100 mm in any dimension.

Patentansprüche

1. Verfahren zum Verbrennen eines nassen organischen Brennstoffes in einem Wasserwand- oder einem anderen Boiler (20, 44, 44') kalter Art, das umfaßt:
   die Verwendung von mindestens einem wirbelstabilisierten Brenner (18, 45, 45') zum Verbrennen eines pulverisierten Brennstoffes;
   Trocknen des nassen Brennstoffes auf einen mittleren Feuchtegehalt von weniger als etwa 30%, wobei mindestens ein Teil der feineren Teilchen einen Feuchtegehalt nicht über etwa 20% aufweisen;
   Pulverisieren des getrockneten Brennstoffes, so daß mindestens 60 Gew.-% der Teilchen feiner als etwa 1000 Mikron und mindestens 15% der Teilchen feiner als etwa 150 Mikron sind;
   2. Verfahren nach Anspruch 1, bei dem die mittlere Brennstofffeuchte geringer als etwa 20% ist.
   3. Verfahren nach Anspruch 1, bei dem die mittlere Brennstofffeuchte geringer als etwa 20% ist.
   5. Verfahren nach Anspruch 1, bei dem der organische Brennstoff Holzabfall ist, der Holz- und Rinden-teilchen enthält.
   6. Verfahren nach Anspruch 1, bei dem der organische Brennstoff Torf ist.
   7. Verfahren nach Anspruch 1, in dem ein Gewichtsverhältnis von Primär Luft zu Brennstoff im Bereich von 1 bis 3 kg Luft für jedes kg Brennstoff verwendet wird.
   8. Verfahren nach Anspruch 1, bei dem der organische Brennstoff vor dem Trocknen zunächst gesiebt wird, so daß die größten getrockneten Partikel etwa 100 mm in jeder Dimensionsrichtung nicht übersteigen.
Revendications

1. Procédé pour brûler un combustible organique humide dans une chaudière (20, 44, 44') à paroi remplie d'eau ou d'un autre type à froid qui comprend:
   - l'agencement d'au moins un brûleur stabilisé à troublonnement (18, 45, 45') pour brûler un combustible réduit en poudre;
   - le séchage du combustible humide jusqu'à une teneur moyenne en humidité inférieure à 30% environ avec au moins une partie des plus fines particules ayant une teneur en humidité ne dépassant pas 20% environ;
   - la pulvérisation du combustible séché pour qu'au moins 60% en poids des particules soient inférieures à 1000 microns environ et qu'au moins 15% des particules soient inférieures à 150 microns environ;
   - le réglage de la fraction des particules inférieures à 150 microns environ dans la partie pulvérisée pour que le combustible produise une flamme auto-entretenue;
   - le transport des particules séchées et broyées vers le brûleur tout en étant en suspension dans un courant d'air primaire; et
   - l'inflammation des particules, de sorte que la fraction inférieure à 150 microns environ fournisse une énergie d'inflammation suffisante pour entretenir une combustion stable de tout le combustible.

2. Procédé selon la revendication 1, dans lequel pratiquement toutes les particules sont inférieures à 1000 microns et au moins 50% en poids sont inférieures à 150 microns environ.

3. Procédé selon la revendication 1, dans lequel l'humidité moyenne du combustible est inférieure à 20% environ.

4. Procédé selon la revendication 1, dans lequel le brûleur a un rapport de blocage élevé pour minimaliser le mélange d'air secondaire avec le courant de combustible-air primaire.

5. Procédé selon la revendication 1, dans lequel le combustible organique est composé de déchets de bois comprenant des particules de bois et d'écorce.

6. Procédé selon la revendication 1, dans lequel le combustible organique est de la tourbe.

7. Procédé selon la revendication 1 employant une proportion en poids d'air primaire par rapport au combustible de l'ordre de 1—3 kg d'air pour chaque 1 kg de combustible.

8. Procédé selon la revendication 1, dans lequel le combustible humide est d'abord tamisé avant d'être séché pour que les plus grosses particules qui sont séchées ne dépassent pas 100 mm environ dans n'importe quelle dimension.
Fig. 3

Cumulative of mass through each screen, percent.