THE FUEL VALUE OF BAGASSE PITH AND DEVELOPMENTS
IN PITH BURNING AT LEADING BAGASSE PULP AND
PAPER MILLS AND/OR SUGAR MILLS

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ABSTRACT

In view of the rapid increase in the use of bagasse for manufacture
of pulp, paper, paperboard and composition panel-board in recent years,
combined with the necessity to depith the bagasse thoroughly for pro-
duction of top quality products, large quantities of this pith have be-
come available. Therefore, its utilization for some purpose is essential.
Although other potential uses for the pith are constantly being con-
sidered and some small amounts of pith are being used for cattle food
roughage and for other purposes, these uses so far have been minor.
Therefore, in most cases, either all or a major portion of the pith must
be burned and it is essential that the maximum fuel value be realized
from it.

Information is given on the developments which have taken place
toward more efficient burning of bagasse pith at the leading bagasse
pulp and paper mills all over the world and/or at the sugar mills who
supply the bagasse to these pulp and paper mills. Comments are included
on the present status of pith burning technology, the fuel value of the
pith, the problems encountered in burning it, and the steps which have
been taken by various mills to enable them to burn the pith satisfactorily
and efficiently. Information is included on efforts to burn pith alone
and/or in combination with whole bagasse, fuel oil, natural gas and coal.
The various types of boilers which can be considered for pith burning
are also described briefly.

There appears to be no doubt that pith can be burned successfully
in combination with whole bagasse or fossil fuels, if the boilers are
designed and operated properly.

INTRODUCTION

Starting with the Eleventh Congress of the ISSCT in Mauritius in 1962, the
author has had the pleasure of presenting papers before this distinguished group at
each conference held since that time (Atchison 1, 2, 3, 4, 5, 6, 7). All of these papers were related to the utilization of bagasse for the manufacture of pulp, paper, paperboard and composition panelboard.

The utilization of bagasse for manufacture of these products has continued to grow rapidly during the last 20 years. Capacity for producing bagasse pulp of all types is now in excess of 2,000,000 tons annually and the rate of increase in its use exceeds that of any other fibrous raw material, including wood. When considering all types of pulp being produced from bagasse, the average requirement amounts to 3 BD/MT of bagasse off the sugar mill convey or BD/MT of pulp. Therefore, some 6,000,000 BD/MT of bagasse are being used annually for pulp and related products. For production of top quality products from bagasse, good depithing is required. Therefore, some 2,000,000 BD/MT of this material goes into the pith fraction annually.

As the bagasse pulping industry has expanded the efficient methods of depithing have been developed, it has become more and more necessary to develop efficient methods of handling and burning the pith fraction. Although other potential uses for pith are constantly being considered and small amounts of pith are used for cattle food roughage and for other purposes, these uses so far have been minor. Therefore, in most cases, either all or a major portion of the pith must be burned.

At first, some mills burned it merely to burn it efficiently. However, with the tremendous increase in the price of fossil fuels in recent years, more concentrated efforts are now being made to obtain the maximum fuel value from the pith which is separated from bagasse.

Both the sugar mills and the bagasse based pulp and paper mills have been showing increased interest in the problems of burning pith and the boiler manufacturers are likewise now showing a greater interest in it.

In this paper, the author describes the progress which has been made toward successful and efficient pith burning and what new techniques might be available for consideration.

DISCUSSION

General comments on the evolution of bagasse pith burning

The burning of bagasse pith as a primary fuel has developed gradually and naturally along with the development of the modern bagasse based pulp and paper industry. Sugar mills traditionally burned all of their bagasse both to provide the steam and power required for cane processing and as a means of disposing of any surplus above their fuel requirements.

After the bagasse pulping industry started in 1939, the sugar mills initially furnished only their surplus bagasse to the pulp mill. The pith resulting from depithing the surplus bagasse could easily be returned to the sugar mill boiler, blended with the whole bagasse, and burned without any changes in the operation.
As the bagasse pulp and paper mills expanded, surplus bagasse alone was not adequate to meet the requirements, so it became necessary to replace part of the whole bagasse with fossil fuel of some type. At the same time, as quality requirements for bagasse paper became higher, it became necessary to carry out more efficient depithing operations which resulted in higher and higher proportions of pith being returned to the sugar and boilers.

So long as the ratio of pith to whole bagasse was no more than about 3 to 1, there was no difficulty in burning the pith along with the whole bagasse in the conventional bagasse burning boilers, with only minor changes. These changes involved an increase in the amount of air and the position in which the pith-whole bagasse mixture entered the boiler. However, these minor changes resulted in excellent performance of the boilers whereby the full fuel value of the pith was obtained.

As the production of bagasse pulp and paper mills continued to increase, a higher and higher proportion of the whole bagasse was diverted from the sugar mill boilers and the percentage of pith going to the sugar mill boilers, in some instances, increased to 100%, with no whole bagasse being available, and with pith being burned alone or in combination with fuel oil, natural gas or coal.

In the case of second stage wet depithing, which was introduced by Atchison in the early 1960s, the wet pith initially was, in some cases, returned to the cane irrigation system for its fertilizing value or, alternately, was dewatered and hauled to a disposal area. Subsequently, in at least one case, at the El Palmar Sugar Mill in Venezuela, the wet pith was dewatered, pressed and mixed with moist pith and whole bagasse and burned.

In cases where the bagasse based pulp and paper mills were located some distance from the sugar mills who supplied the bagasse, the moist depithing operations were carried out at the sugar mills, with the pith being returned to the sugar mill boilers. The wet depithing was carried out at the pulp mills, where there was no readily available means of disposing of this wet pith. In some cases, therefore, the wet pith was dewatered and burned, along with auxiliary fuel, in a dual-fired boiler at the pulp mill.

In still other cases, where the sugar mills refused to install depithing installations on their property, the pulp mills have installed both moist and wet depithing systems at the pulp mill. Therefore, in some cases, these pulp mills have been forced to install pith burning boilers to burn both moist pith and dewatered wet pith, along with auxiliary fuel. This required further modifications of the boiler design, but basically the bagasse burning type boilers have always been used and usually modified by the mills themselves to obtain the best results.

In the case of most older sugar mills, when they began supplying bagasse to pulp mills, their fuel requirements were generally in balance with their bagasse production so as to eliminate any disposal problem. Therefore, when they started to supply their bagasse to pulp mills, supplementary fuel was required to replace the bagasse which was removed from the sugar mill. Usually this auxiliary fuel was burned in the same boiler along with the pith being returned from the moist depithing...
system and whatever whole bagasse was still available to the sugar mill.

Likewise in cases where the bagasse pulp and paper mill has been located some distance from the sugar mills, the boilers have been sized for total mill steam requirements, which required dual firing of pith and some fossil fuel in the same furnace to meet the load.

At the present time, bagasse pith is being burned successfully, either alone or in combination with various fuels under various conditions, as mentioned in subsequent sections of this paper.

**PROGRESS IN BURNING PITH ALONE OR IN COMBINATION WITH OTHER FUELS**

*General statement*

In a few cases, bagasse pith is being burned alone with fuel oil being used only as a pilot fuel for start-up and to keep the furnace sufficiently hot to assure complete combustion of the pith. However, in most cases, pith is burned in combination with other fuels, such as whole bagasse, fuel oil, natural gas or coal.

*Burning pith with whole bagasse*

In general, the sugar mills, which are burning moist pith (at about 50% moisture content) with whole bagasse, have no particular difficulty in getting the full fuel value from this pith when using the various types of bagasse burning boilers. This is the usual procedure when the sugar mill does not furnish all of its bagasse to a pulp mill, but merely a part of it. When the pith is burned in this manner, very little change is required in the furnace and boiler operations so long as the ratio of pith to whole fuel oil or natural gas is always used for purposes of start-up and to maintain the temperature of the bagasse-pith fuel bed sufficiently high so as to assure complete combustion of the pith-bagasse mixture.

There are a few cases where, in the moist depithing at the sugar mill, very large perforations are used in the depithers so that 40% to 45% or more of the whole bagasse weight goes into the pith fraction. In this case, there is such a high proportion of fiber in the pith fraction being returned to the sugar mill boilers that the normal bagasse burning boiler can handle it along with only 10% to 15% whole bagasse, with very little modification except possibly increased air supply.

Mills which burn pith very successfully along with the whole bagasse include Ledesma in Argentina, El Palmar in Venezuela, several sugar mills in Mexico, several sugar mills in South Africa, Central Trinidad, the sugar mill which supplies bagasse to Papelera Pulpa in Cuba, Edfu in Egypt and others. In almost all cases, supplementary fossil fuel is also used to replace the bagasse which is furnished to the pulp mills. In the case of Ledesma and El Palmar, the supplementary fuel is natural gas. In Mexico, Cuba and Egypt, it is fuel oil, and in South Africa, it is coal. All of these installations operate extremely well when burning pith in combination with whole bagasse and with or without a supplementary fossil fuel. In all cases, engineers
have been available who were familiar with bagasse burning problems, so that the necessary modifications could be made to achieve optimum results.

In the case of Papelera Pulpa Cuba, they purchased package boilers for burning the supplementary fuel oil and converted their existing bagasse burning boilers for burning pith in combination with about 20% whole bagasse.

The Papelera Pulpa Cuba bagasse pulp and paper mill in Trinidad, Cuba started operations in 1959 and the sugar mill which supplies bagasse to it was one of the first plants to burn a high proportion of pith along with some whole bagasse. The moist depithing operation was carried out at the sugar mill and all of the pith was returned to two sugar mill boilers.

The old sugar mill boilers which were converted to pith burning were the old Babcock & Wilcox straight tube boilers with standard horseshoe type bagasse burning furnaces including air inlets all around. These were three pass boilers.

The pith was fed into the boilers through inclined chutes, at the bottom of which connections were provided for injecting air into the boiler so as to deflect the pith and disperse it horizontally into the furnace. By means of minor modifications, it was found possible to burn the pith in suspension and to accomplish very good combustion. Pith burning in this way was complete and was accomplished above the floor of the furnace.

On the side of each boiler a small oil burner was installed. This burner was necessary for starting up and is also necessary in case the sugar mill shuts down and the pith feed is interrupted for a few minutes. If this happens, the oil burners must be immediately started so as to maintain the temperature in the furnace. Otherwise, when the pith is fed again, it will not burn.

During normal operations it was not necessary to keep the burner in operation; however, the operators usually liked to keep it on with a very small atomizer plate since it helped considerably to keep the pith burning, especially if there was variation in the moisture content.

**Burning pith with coal**

Several sugar mills in South Africa, Taiwan and The Peoples Republic of China burn coal as a replacement fuel for bagasse being used for pulp, paper and panelboard. In most cases these sugar mills also burn very substantial amounts of whole bagasse along with the pith so that only minor modifications are required to burn the pith.

At the Gledhow sugar factory in South Africa, however, which furnishes bagasse to the new Stanger Pulp and Paper Company, it has been reported that a part of the pith is burned with coal without the use of whole bagasse. Part of the pith is also burned in combination with whole bagasse in a Dutch Oven furnace with pith representing as much as 50% of the total bagasse fed to the furnace.

They burn the remainder of the pith in combination with coal in a Spreader...
Stoker dump gate International Combustion boiler. They indicate that from 0.2 to 0.3 MT of coal are fed per BDMT of pith. Since one ton of coal is equivalent to about 2 BD tons of pith, this means that in terms of fuel value the ratio is about 1 part pith to 0.6 parts coal for this boiler. With this combination, they do not seem to have any difficulty.

The Propal mill in Colombia has two Foster Wheeler combination coal-pith burning boilers of 60,000 pounds/hour steam capacity each. These are equipped with spreader stokers and traveling grates. The coal spreaders are installed just about the grates and the pith spreaders are located at a higher level. The pith and coal are metered and fed separately, by the pneumatic spreaders, into the furnaces. Suspension burning of the small particles is achieved, with complete combustion of the larger particles taking place on the traveling grate.

Reportedly, the results with these modern coal-pith burning boilers have been excellent. Even when pith was being used to supply up to 50% of the total fuel, excellent combustion of pith has resulted with good fuel value from the pith.

Spreader stokers with dump grates can be used for burning the coal-pith combination, with the coal entering near the grate by means of coal spreaders and with pith spreaders being located above the coal spreaders.

Based on the experiences of engineers who have burned pith with coal, it is believed that it is possible to burn up to 75% to 80% pith along with 20% to 25% coal with either a traveling grate or dump grate, so long as a thin bed of coal is burned on the grate.

Burning pith with fuel oil

In general, where pith burning has been in the hands of sugar mill engineers, with extensive experience in bagasse burning, the operations have been very successful in burning pith in combination with fuel oil in almost any proportion. In some cases, the proportion of pith has been almost 100%, with the fuel oil burners merely serving as pilot burners for start-up and to maintain the temperature in the furnace when pith entered at high moisture content. However, in other cases, where engineers without sugar mill experience have handled the design and operations, serious difficulties have resulted and the installations have been claimed to be unsatisfactory. Examples of very successful operations, in which pith has been burned with fuel oil, include Paramonga and Cartavio in Peru, Papeleira Pulpa Cuba in Cuba and Taiwan Sugar Corporation in Taiwan.

The large Foster Wheeler boiler at Paramonga was designed to burn up to 100% pith in four Detrick Dennis cells. The Detrick Dennis cell is a refractory furnace shaped something like a milk bottle. The cells at Paramonga are installed under an oil-fired boiler. The boiler was originally designed to burn whole bagasse. With only minor modifications, pith has been burned very successfully. Because of the high steam load requirements at Paramonga, combination firing is required. However, the W. R. Grace engineers, who installed this system, claim that in the Detrick cells 100% pith can be burned without oil being fired in the upper furnace.
However, in all cases, they recommend the addition of oil or gas pilot burners due to the generally higher moisture content of the pith.

At Cartavio, also in Peru two of the boilers were originally designed to burn whole bagasse only, are now burning pith along with fuel oil. The primary furnace where pith burning occurs is a typical Dutch oven type with dumping grates. Pith is introduced into the furnace by the same spreader stokers that were originally used for whole bagasse. The spreaders are of the rotary vane type instead of the pneumatic type. When the pith burning was started, in some instances when the moisture content of the pith ran up to the 55% level, they had problems in maintaining ignition. Therefore, they installed oil-fired pilot burners to maintain ignition at all times.

The W. R. Grace engineers, who were successful in burning pith in both Paramonga and Cartavio, have emphasized strongly their view that a hot refractory furnace is needed when burning pith with its generally higher moisture content than whole bagasse. However, in all cases, a pilot fuel oil or gas-fired burner has been used to maintain the temperature in this type unit. In the case of existing water-cooled furnaces, they suggest raising the boiler setting to accommodate a refractory furnace section for the pith burning, or to cover the lower part of the water walls with refractory. Other sugar mill engineers, however, have expressed their feeling that the spreader stoker type boiler with either dump grate or traveling grate can be used effectively if designed properly. In fact, with coal-fired boilers, pith is already being burned with the coal in both dump grate and traveling grate furnaces, and pith is being burned very successfully in Taiwan in a highly modern fuel oil pith burning boiler with water tube bottom.

Perhaps the most modern pith burning boiler which is now operating is the large Kawasaki pith-fuel oil boiler installed at the 300 ton/day bleached bagasse pulp mill at Taiwan Sugar Corporation. This is very large modern boiler which operates extremely well with the pith being blown in from the four corners of the boiler so that it burns in suspension, with the ash passing down through water tubes in the bottom to a collecting hopper. Oil burners are located about one meter above and below each pith entrance and the pith is burned completely.

Overall, it has been found that when pith has been burned with supplementary fuel, so long as the ratio of pith to supplementary fuel was no greater than about 4 to 1, in terms of fuel value, the results have been satisfactory in most cases, where engineers who were familiar with bagasse burning problems have been available to make the necessary modifications to obtain optimum results.

FUEL VALUE OF BAGASSE PITH VERSUS FUEL VALUE OF WHOLE BAGASSE

At the 16th ISSCT Conference in Brazil in 1977, Atchison compared the fuel values of bagasse and other fibrous raw materials to the fuel value of fossil fuels. However, based on the experience of Joseph E. Atchison Consultants, Inc., going back to the Papelera Pulpa Cuba bagasse pulp and paper mill in 1959, it has been found that the bagasse pith has a somewhat lower fuel value than whole bagasse.
This is due to two basic reasons:

1. In the first place, by means of a good moist depithing or wet depithing system, a major portion of the dirt and high ash content material goes into the pith fraction. This results in the fuel value of the pith, as tested in a bomb calorimeter, being lower than the fuel value of the whole bagasse on a moisture free basis. Tests over the years have indicated the fuel value of the pith [on a bone dry basis] to have a fuel value of only 6,800 to 8,000 BTUs/pound, depending upon the dirt content of the pith, as contrasted to whole bagasse which normally has a BTU value ranging from 8,000 to 8,400 BTUs/pound on a BD basis, depending on the ash content, when tested in a bomb calorimeter.

2. Secondly, the pith has a much higher surface area than the fiber and therefore it selectively absorbs the moisture. Therefore, when the pith is separated in a moist depthing operation, the moisture content of the pith fraction is almost always at least 2% to 3% higher than the moisture content of the whole bagasse. This results in slightly lower overall efficiency when burning pith due to this higher moisture content. Based on the higher moisture content alone, even if the ash content of pith and whole bagasse were the same, it would be expected that the efficiency of the boiler when burning pith at 53% moisture content might be 2% to 3% lower than when burning whole bagasse at 50% moisture content.

In cases where the cane is still hand cut and very clean, and neither the whole bagasse nor the pith has a high ash content, the BTU value of the BD pith as tested in a bomb calorimeter is approximately the same as the BTU value of the BD whole bagasse, tested in the same manner. Therefore, some mills, where clean bagasse is being used, have reported BTU values for the pith as being approximately the same as for the whole bagasse. In these cases, the only difference observed when burning the pith, as compared to burning the whole bagasse, resulted from the higher moisture content of the moist pith. Even this problem can be overcome if the pith is transported to the boiler in a hot air stream such as flue gas. Under the best conditions, the amount of steam generated per ton of pith (BD basis) might be as high as when burning the same amount of whole bagasse.

On the other hand, when the cane is harvested mechanically, it is very dirty and has a high ash content. A major portion of the ash goes into the pith fraction and the resulting heating value as tested by the bomb calorimeter may be as low as 6,800 BTUs/BD pound, or even lower.

When combining these two factors, when using dirty bagasse, the steam generated per MT of pith (BD basis), direct from the moist depething operation, may be as much as 10% to 15% less than when burning the same amount of whole bagasse. Therefore, both the ash content and the moisture content of the pith are important when estimating the amount of steam which might be generated by pith burning.

When burning wet pith, it is, of course, necessary to dewater this pith and press it to as close to 50% moisture content as possible. During the process of dewatering the wet pith, a considerable amount of the dirt is washed out, thus decreasing the ash content of this pith. Therefore, if the wet pith is well washed and
dewatered to 50% moisture content, it will tend to have a higher fuel value, as determined by the bomb calorimeter, than the moist pith from the same bagasse, and in some cases a higher fuel value than the dirty whole bagasse itself.

As a result of work carried out jointly by Atchison and Improved Machinery Company some years ago, it was determined that the two drum press, which IMPICO manufactures, has the capability of pressing pith from 3% to 4% consistency to 50% consistency. Based on Atchison recommendations, one of these units was installed at Siam Kraft Paper Mill in Thailand some years ago, and it was proved in mill operations that it could achieve 50% consistency when dewatering wet pith. Other heavy duty presses, such as the French press, can undoubtedly also be used for this purpose.

**COMMENTS ON DRYING BAGASSE AND/OR PITH WITH FLUE GASES BEFORE BURNING**

In view of the rapidly rising cost of fossil fuels in recent years, the sugar mills in Louisiana and Florida have been making every effort to improve the efficiency of their bagasse burning boilers in order to reduce to an absolute minimum the amount of supplemental fuel used to process the cane. These steps have included the use of air heaters on the boilers and more recently the use of flue gases to dry the bagasse below the traditional 50% moisture content before it goes to the boilers.

In some cases, rather dramatic results have been obtained by installation of driers which utilize the flue gases to dry the bagasse. Even when drying the bagasse from 53% moisture down to 48% moisture content in such driers, in some cases has resulted in drastic decreases in the amount of supplemental fuel oil or natural gas required to support the sugar factory. Based on the results obtained thus far, it appears that for burning either whole bagasse or pith, this procedure of using flue gases to dry the material before burning, combined with the use of air heaters, should prove to be very attractive from an economic standpoint.

**TYPES OF BOILERS WHICH CAN BE CONSIDERED FOR PITH BURNING**

**General comments**

A steam generating unit is the colloquially called a boiler. Actually, it consists of the boiler where hot gases convert water to steam, and a furnace where fuel is burned to produce the hot gases. The selection of the proper boiler is determined by the quantity of steam to be produced, the pressure and temperature of that steam, the temperature of the gases entering and leaving the boiler, as well as many other physical and economic factors.

Furnaces for burning pith are basically of four types:

(a) Pile burning and inclined hearth  
(b) Spreader stoker firing  
(c) Suspension burning  
(d) Fluid bed burning
There are variations and combinations of all these types being used to burn pith and bagasse today. These are described briefly in subsequent parts of this section of this paper.

**PILE BURNING OR CELL TYPE FURNACES**

*The Dutch oven or horseshoe furnace*

Pile burning of bagasse or pith is accomplished in a refractory lined chamber or cell. Fuel is admitted through the roof and air is admitted through the sides and across the top via small ducts called tuyeres, which are built into the refractory walls. It is a hearth burning furnace with the refractory cells shaped in the form of a horseshoe and is called a Dutch oven.

The advantage of the horseshoe shape is that it permits the refractory walls to closely encircle the fuel cone. The gases pass from the cell over a bridge wall into the secondary furnace. Complete combustion occurs in the secondary furnace. There are many variations for combustion chambers of this type which are used in the sugar industry.

With this type furnace, of course, only the outer layer of bagasse or pith burns in the pile, getting smaller as one “outer layer” burns away to expose another “outer layer.” However, by use of a pilot fuel oil or gas fired burner to maintain the temperature, this type unit has been used to burn pith successfully at the Papelera Pulpa Cuba installation.

*The inclined or sloping grate furnace*

A variation of the horseshoe furnace involves the use of an inclined grate or hearth. Here, the bagasse enters the upper drying hearth and is spread across the hearth which is inclined at an angle which allows the fuel to slide slowly down the sloping grate while burning, with the ash ending up on a small dump grate at the bottom. At the top of the grate, the fuel is dried by the flue gas and reflected heat from the refractory walls, then the volatile matter is driven off. Combustion then takes place and is complete when the fuel reaches the bottom of the grate. The inclined grate is usually installed below the boiler. This type unit has been very satisfactory for obtaining complete combustion when burning whole bagasse. However, at Pars Paper Company in Iran, where it is being used for burning pith in combination with fuel oil, it has thus far shown rather poor results.

*The Ward cell and the Detrick Dennis cell*

The Ward cell and the Detrick Dennis cell furnaces represent an advance over the older Dutch oven type furnace. The Ward cell type furnace is a refractory cell similar to the horseshoe cell. Bagasse is gravity fed to the cell, where it burns from the surface of the pile, the combustion air being injected through tuyeres around the cell walls. There is incomplete combustion, but enough heat is released to dry the moist bagasse entering. This drying is also aided by heat reflected from the sloping arch above the cell and from the cell walls. Complete combustion occurs in
I

the upper furnace above the arch.

The Detrick Dennis cell is somewhat similar to the Ward cell. It is a refractory furnace shaped something like a milk bottle. It was originally designed to burn whole bagasse which was gravity fed by chute into the top of the cell. Primary air is introduced radially through small ports in the refractory wall around the pile. Secondly, air is introduced just above the pile through the tangential tuyeres which set up turbulence, mixing the air and volatiles which make up as much as 80% of the combustible. An additional set of tangential tuyeres are located in the throat, causing turbulence which lifts the fines into the secondary furnace where flash drying and burning takes place.

It is claimed that these cells result in high burning rates and complete combustion. The controlled whirlwind action causes flotation and combustion of the fine particles of pith in the combustion chamber above the cells. The heavier particles dry in suspension and burn in the cells. These cell installations can be designed for fully automatic operation and any type boiler which can accept wet fuel firing can be placed over the cells. Ash falls back into the cells for cleanout, and power activated dumping hearths can be installed for automatic ash disposal. It has been reported that the Detrick Dennis cells are operating extremely well at Paramonga in Peru, for burning pith along with fuel oil. The only modification made was to lower the feed chute so that the pith is introduced into the furnace below the throat of the cell.

**SPREADER STOKER FIRING WITH DUMP GRATES OR TRAVELING GRATES**

The previously described furnaces employ a gravity fed system for the fuel. Fuel may also be introduced into the furnace by a spreader stoker. In this case it can fall on a horizontal grate as the burning "outer layer" is replaced by another "outer layer" from above rather than below, as in pile burning. The ash which is the solid residue from combustion builds up on the grate and various designs are employed to remove this ash. These include dump grates, vibrating grates and traveling grates.

Most of the boiler manufacturers have developed meters for feeding bagasse to the spreader stokers at a uniform rate, which are also applicable to pith. The fuel is metered ahead of the spreader stoker and from the outlet of the meter it falls by gravity into the distributor tray. The angle of the tray can be adjusted to insert the fuel at the proper level for the depth of the furnace. The feeders or spreaders can be either of the pneumatic type or the mechanical type, and they direct the fuel across the width of the furnace so as to provide complete coverage of the grate. In ideal operation, this results in a thin fuel bed distributed over the grate, which may be a dump grate or a traveling grate.

At the Propal mill in Colombia and at several sugar mills in South Africa some distributions feed coal while others located above the coal feed bagasse pith. This system includes a pith conveyor, bagasse meters for regulating the flow, pneumatic distributors, a traveling grate furnace or dump grate and ash pit. The pith distributors are located above the coal distributors, so that the fine pith particles
BY-PRODUCTS

I will burn in suspension over the hot coal fire, while heavier particles will fall to the traveling grate or dump grate and will be burned with the coal. This system works extremely well when burning a combination of pith and coal with either the traveling grate of the dump rate.

SUSPENSION BURNING OF PITH

Fuel may also be introduced into the furnace by means of distributors and burned completely in suspension. Pith, as well as pulverized wood, can be burned with fuel oil or natural gas in this type of unit if it is properly designed. Unfortunately, several units of this type have been installed for burning pith with fuel oil which have proved unsatisfactory because of improper design. In one case, the pith tends to fall to the grate and builds up in a pile where it smolders without complete combustion, when any appreciable amount of pith is fed with the fuel oil. However, in this case, no special provisions were made for metering or feeding the pith and there is no hot furnace under the pith as it is introduced. This results in incomplete combustion and poor fuel value being obtained.

By contrast, the new pith burning boiler at Taiwan Sugar Corporation, which was designed specifically for burning a combination of pith in suspension, along with fuel oil, operates extremely well and results in complete combustion of the pith. In this case, the pith is metered uniformly to the blowers which blow it in at the four corners of the furnace so that it remains in suspension while burning, with oil burners located both above the below each pith entrance. The ash then falls down through the boiler tubes in the bottom and is collected in a hopper from which it is removed pneumatically.

FLUIDIZED BED BURNING OF PITH FOR STEAM GENERATION

A modern concept, which is not presently being used for burning either bagasse or pith, involves the fluidized bed burning system, which has been used very successfully in chemical recovery. This concept appears to offer great promise for burning pith because it can be used to burn pith with as much as 65% moisture content, and indications are that with as low as 50% moisture content, high efficiencies can be obtained with this type unit. Large scale experimental units are already in operation for burning coal and designs are under development for burning wet solids such as pith at moisture contents from 50% to 65%.

This type of furnace consists of a bed of inert material which is heated to a fluid state by an auxiliary fuel source. After the furnace has attained design temperature, pith is introduced through a chute with a proper feeder above the fluidized bed. It is drawn across the bed by an induced draft fan. The pith burns in suspension with the heavier particles and ash dropping into the bed. The combustion of the pith maintains the temperature of the furnace, thus permitting the auxiliary fuel source to be extinguished. The heavier particles burn in the bed and the ash is removed during periodic cleaning.

The flue gases produced are drawn out of the furnace by an induced draft fan through a multi-cyclone separator, for particulate removal and to the boiler.
unit for generation of steam. By careful design of the installation, the hot gases could be passed over the tubes of an existing boiler.

The potential capital cost of a fluidized bed installation of this type would be only a fraction of the capital cost of a multi-fuel fired bagasse or coal fired type boiler which is presently the standard in the sugar industry.

SUMMARY OF OBSERVATIONS RELATIVE TO PROGRESS IN PITH BURNING

General comments

There appears to be no question that bagasse pith, at approximately 50% moisture content, can be burned in bagasse type furnaces of various types by proper modifications of these furnaces. In all cases, some supplementary fuel is used which may consist of whole bagasse, fuel oil, natural gas or coal. A review of the information available on mills which are burning bagasse pith is summarized in the following sections of this paper. It is assumed that the mills all used modern combustion controls and maintenance and constant uniform feed of fuels with proper furnace conditions for optimum performance. The conditions considered in the following sections of the paper are related to furnace design and methods of feeding the fuels. The summary observations are classified according to the supplementary fuel used with the pith and the type furnace used.

Mills which burn fuel oil with pith

A number of mills are burning pith in combination with fuel oil, and those installations which have been designed or modified specifically for burning pith have given excellent results.

Paramonga and Cartavio sugar companies in Peru, Papelera Pulpa in Cuba, and a number of sugar mills in Mexico are burning pith in Dutch oven type or cell type primary furnaces, while burning fuel oil in secondary furnaces located over the Dutch oven. This system has proved to be highly satisfactory.

At the new Pingtung Pulp Factory, operated by Taiwan Sugar Corporation, pith is being burned in suspension very successfully in a large highly modern boiler with fuel oil nozzles both above and below the four pith entrances at each corner of the boiler.

In other cases, where suspension burning of pith with fuel oil is being practiced, the boilers have not been properly designed relative to location of pith entrance and fuel oil nozzles, and when the pith is not metered uniformly to the boiler, the operations have not been satisfactory, with piles of pith collecting on the grate.

In other cases, where the inclined grate type furnace has been used, the results have not been satisfactory, possibly due to improper design features.
Mills which burn coal with pith

Taiwan Pulp and Paper Co. in Taiwan, reports satisfactory results in burning pith in complete suspension over a coal stoker boiler furnace. The pith is fed pneumatically into the combustion chamber over the stoker grate which is fed coal by mechanical means.

Propal in Colombia, feeds both the pith and the coal to the boiler pneumatically through separate metering feeders. The coal is introduced just above the grate where it is partially burned in suspension and then falls to the traveling grate where it forms a bed and is completely burned. The pith is introduced above the coal spreaders where it can be burned alone in suspension, or as it falls, in suspension with coal or finally on the traveling grate in the coal bed.

Pith is also burned in South Africa very successfully in a number of sugar mills from which moist depithed bagasse is delivered to pulp mills and/or composition panelboard mills. In South Africa, however, a certain amount of whole bagasse is usually burned along with the pith with the bagasse-pith mixture being metered into the boiler above the entrance of the coal distributors.

Mills which burn pith with whole bagasse

In some of their sugar mills, Taiwan Sugar Corporation burns pith in complete suspension over a bagasse fed inclined grate. The bagasse is gravity fed through a feeder to the inclined grate while pith is introduced into the throat between the ignition chamber and combustion chambers. This has proven to be satisfactory.

Central Trinidad, which provides bagasse to Papelera Pulpa Cuba in Cuba, introduces the pith above the Dutch oven by a gravity chute. The pith is dispersed above the oven by a horizontal air jet which provides the oxygen required for combustion and accomplishes complete burning of the pith in suspension, with a fuel fired burner being used merely for start-up and to keep the temperature sufficiently high during periods when the moisture content of the pith is high.

Many other sugar mills, including five sugar mills which supply bagasse to the Kimberly Clark mill in Orizaba, Mexico, also burn pith in combination with whole bagasse (sometimes as low as 10% to 15% whole bagasse) with a pilot fuel oil or gas burner to keep the temperature sufficiently high.

CONCLUSIONS

Based on the information presented in this paper, it can be seen that the most successful pith burning installations are those which burn pith in suspension over a hot bed of coal or whole bagasse, or between fuel oil nozzles. Pith can be burned in bagasse fired boilers in combination with whole bagasse, in Dutch ovens or cell type primary furnaces with fuel oil or gas in the secondary furnaces, or in modern boilers in suspension with either coal or fuel oil, if the boilers are specifically designed for burning pith along with these fuels.

At the present time, the only mills which utilize wet pith as a fuel, first dewater this wet pith as much as possible, then mix it with the moist or dry pith
before feeding it to the furnace.

In almost all cases where pith is being burned successfully, it has been the sugar mill engineers who have designed the modifications on the furnaces required for these successful operations rather than the boiler manufacturer's or the pulp and paper mill engineers. In cases where sugar mill engineers were not involved and it was left up to the pulp and paper mill engineers without experience in burning bagasse, the operations have proved to be unsatisfactory.

One of the most promising developments for burning pith without supplementary fuel except for start-up, appears to be the fluidized bed steam generator which is being proposed by a number of companies for burning wet solids of a moisture content up to 65%. However, naturally, much higher fuel value will be realized if the moisture content can be brought down to 50% or below.

If a substantial reduction in consumption of fuel oil or natural gas is required when burning pith, consideration should be given to drying the pith by means of flue gases to somewhat below 50% moisture, followed by using the fluidized bed furnace, with the hot gases going to a waste heat boiler or to the boiler section of existing package boilers. This system, including cyclone separators to clean the gases before entering the boilers, would appear to result in minimum investment and maximum saving of the fuel oil or natural gas.

If it is desired to use coal or lignite as a fuel, then the pre-dried pith should be pneumatically fed over the hot bed of coals in a boiler specifically designed for this usage.

For mills where two stages of wet depithing are used, it will be necessary to dewater the pith to about 50% moisture content, possibly followed by some additional drying with the gases to a moisture content below 50%, followed by the use of either a coal fired boiler, fuel oil or natural gas fired boilers or a fluidized bed furnace with a waste heat boiler. However, as mentioned in this report, it is possible to burn pith in the fluidized bed at a moisture content as high as 65%. Naturally, a much higher fuel value is realized if the moisture content can be brought below 50%.

There appears to be no doubt that pith can be burned successfully in combination with whole bagasse, or fossil fuels, if the boilers are designed and operated properly.

As a guide to determining the equivalent fuel value of bagasse pith, bagasse and other fibrous raw materials at various moisture contents, as compared to fossil fuels (Table 1 and Fig. 1).
### TABLE 1. Equivalent fuel value of bagasse and other fibrous raw materials as compared to fossil fuels

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Higher Heat Values</th>
<th>Modern Boiler Heat Efficiency (%)</th>
<th>Moisture Content of Fuel as Fired (%)</th>
<th>Boiler Heat Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>6,665 kcal/kg as is</td>
<td>85%</td>
<td>0</td>
<td>78</td>
</tr>
<tr>
<td>Oil (Bunker C)</td>
<td>9,997 kcal/kg as is</td>
<td>85%</td>
<td>10</td>
<td>76</td>
</tr>
<tr>
<td>Gas *</td>
<td>9,380 kcal/m³ std.</td>
<td>85%</td>
<td>20</td>
<td>74</td>
</tr>
<tr>
<td>Bark</td>
<td></td>
<td></td>
<td>30</td>
<td>72</td>
</tr>
<tr>
<td>Hardwood</td>
<td>4,220-4,890 kcal/kg bone dry (4,355 av.)</td>
<td>Depends on moisture content of bark</td>
<td>45</td>
<td>66</td>
</tr>
<tr>
<td>Softwood</td>
<td>4,720-5,330 kcal/kg bone dry (5,025 av.)</td>
<td>Depends on moisture content of bark</td>
<td>50</td>
<td>64</td>
</tr>
<tr>
<td>Wood</td>
<td></td>
<td></td>
<td>65</td>
<td>61</td>
</tr>
<tr>
<td>Hardwood</td>
<td>4,555-5,045 kcal/kg bone dry (4,830 av.)</td>
<td>Depends on moisture content of wood</td>
<td>60</td>
<td>57</td>
</tr>
<tr>
<td>Softwood</td>
<td>4,665-5,500 kcal/kg bone dry (5,025 av.)</td>
<td>Depends on moisture content of wood</td>
<td>65</td>
<td>52</td>
</tr>
<tr>
<td>Bagasse</td>
<td>4,445-5,465 kcal/kg bone dry (4,555 av.)</td>
<td>Depends on moisture content of bagasse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cereal straw</td>
<td>4,445 kcal/kg bone dry</td>
<td>Depends on moisture content of straw</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Method of Preparation**

<table>
<thead>
<tr>
<th>Moisture in Bark and Wood Residues</th>
<th>Moisture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Klin dried</td>
<td>8-12</td>
</tr>
<tr>
<td>Air dried</td>
<td>15-25</td>
</tr>
<tr>
<td>Drum barked, dry handled</td>
<td>35-50</td>
</tr>
<tr>
<td>Drum barked, wet handled</td>
<td>45-66</td>
</tr>
<tr>
<td>Hydraulic barked</td>
<td>60-75</td>
</tr>
</tbody>
</table>

*Note: Fuels should not be equated for cost on the Higher Heating Value only. In the case of the refuse fuels, the boiler heat efficiency at the moisture content of the fuel also enters into the conversion of monetary value of one fuel to that of another. Then from the related monetary values the physical equivalences of the fuels can be calculated for any given situation.

*In the metric system the calorific value of gas is expressed at 0°C and 760 mm of Hg., whereas in the U.S. system, the value is expressed at 60°F and 30" of Hg.*
FIGURE 1. Equivalent fuel value of bagasse and other fibrous raw materials as compared to fossil fuels.
EL VALOR DE COMBUSTIBLE DEL MEOLLO DE BAGAZO Y DESARROLLOS DE MEOLLO A FUEGO EN MOLINOS DE PULPA DE BAGAZO Y MOLINEROS DE PAPEL Y/O DE AZUCAR

Joseph E. Atchison

RESUMEN

En vista del rapido acrecentimiento en el uso de bagazo para la manufactura de pulpa, papel, papel acatulinado, tabla de laminas compuestas (boards) en los años recientes, combinadas con la necesidad de demedular completamente el bagazo para la produccion de productos de alta calidad, grandes cantidades de este meollo se han hecho disponibles para ciertos usos esenciales. A unque otros usos posibles para el meollo son constamente desarrollados y algunas cantidades pequeñas se usan para el forrage o alimento aspero de vaculos y para otros propósitos, estas, hasta la fecha han sido en cantidades minimas.

Asi es que en la mayoria de los casos, o todo o la mayor parte del meollo tiene que quemarse y es esencial que el mismo valor de combustible sea realizado de ello.

Se presenta informacion sobre el desarrollo que ha tomado lugar hacia la manera mas eficaz para quemar el bagazo de meollo en las principales plantas de pulpa y papel por todo el mundo y/o en las centrales azucareras que suplen el bagazo a estas plantas de pulpa y papel. Aquí tambien se incluyen comentarios sobre el estado actual de la tecnica de quemar meollo, el valor de combustible del meollo, los problemas que surgieron en quemarlo, y los pasos que varias centrales han tomado para que puedan quemar el meollo satisfactoriamente y eficazmente. Informacion tambien se da sobre los esfuerzos de quemar medula sola y/o en combinacion con bagazo entero, aceite combustible, gas natural y carbon. Los varios tipos de calderas que se puedan considerar para quemar medula tambien se describen brevemente.

No parece haber ninguna duda de que la medula se puede quemar con exito en combinacion con bagazo entero y combustibles fósiliferos (fossil fuels) si las calderas se disenan y se operan debidamente.