AN OVERVIEW OF THE USE OF WOOD REFUSE FOR FUEL IN THE PULP AND PAPER INDUSTRY IN THE USA

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Since the turn of the century, the pulp and paper industry has been cogenerating. This has been brought about because of the volume of self-generated fuels produced in fully integrated kraft mills. Black liquor is the result of the kraft pulping process, hogged bark is the result of bark removal from the logs prior to chipping. Both of these, when used as fuel, contribute significantly to the energy needs of a paper mill. Even through the years from 1950 to 1980, when other industries could not justify such plants, the availability of wood waste products as cheap fuels allowed this industry to cost effectively cogenerate. Figure 1 illustrates the U.S. geographical cogeneration capacity of the pulp and paper industry.

GEOGRAPHIC AREA	PULP AND PAPER
A	238
B	31
C	83
D	406
E	204
F	165
G	754
H	507
I	1028

*Data obtained for EPRI survey.

Figure 1 Cogeneration Capacity of the United States Pulp and Paper Industry

Typically, pulp and paper mills derive 20-40 percent of their fuel requirement from self-generated wood refuse, usually hogged bark. Figure 2 illustrates a typical hogged bark storage area. In recent years, most mills have installed receiving and unloading facilities for purchased wood refuse. Depending upon the size of the operation, the reclaiming function may be performed by tractor loader or by automatic reclaiming equipment.

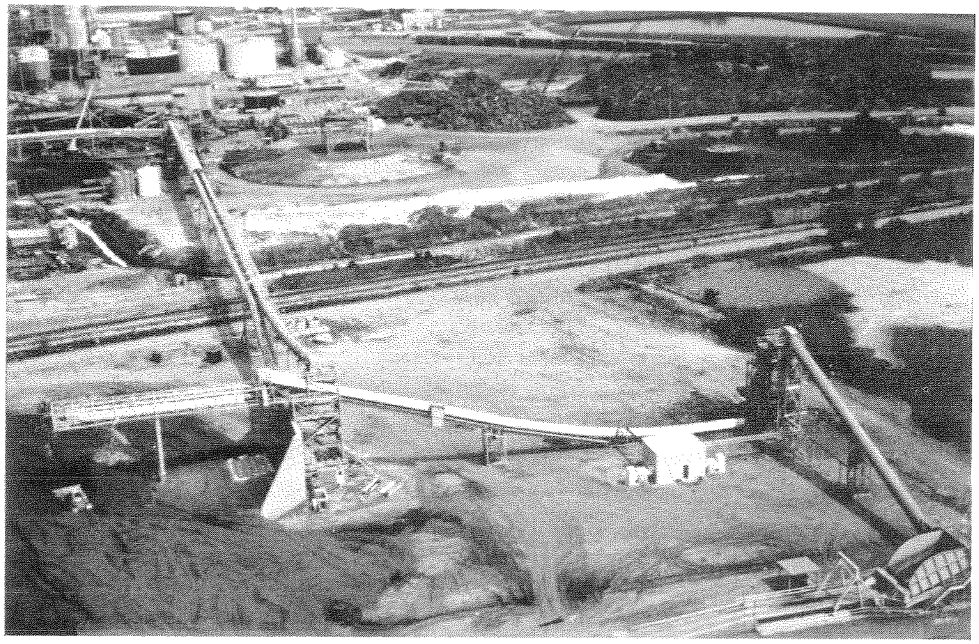

Figure 2 Typical Hogged Bark Storage Area

Normally, the storage area is remote from the power plant boiler area, and fuel is brought in by pneumatic or belt conveyors. Figure 3 illustrates a recent boiler installation in a pulp and paper mill. Note that wet scrubbers are installed to meet today's environmental standards. Figure 4 illustrates a typical pulp and paper mill. Equipment density in a mill is usually high such that the installation of a new boiler or retrofit equipment is accompanied with a degree of difficulty.

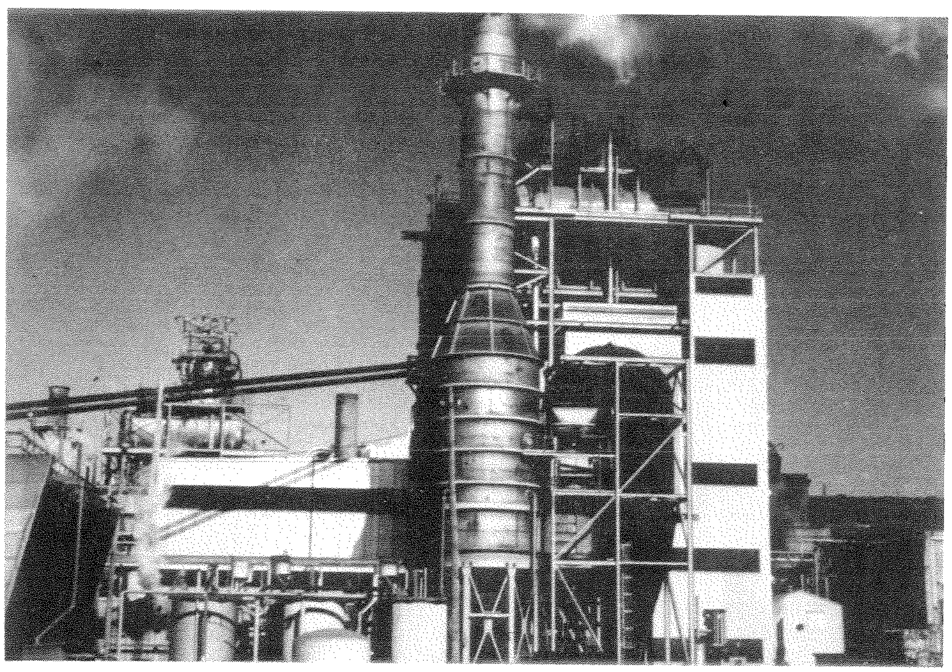

Figure 3 Recent Boiler Installation in a Pulp and Paper Mill

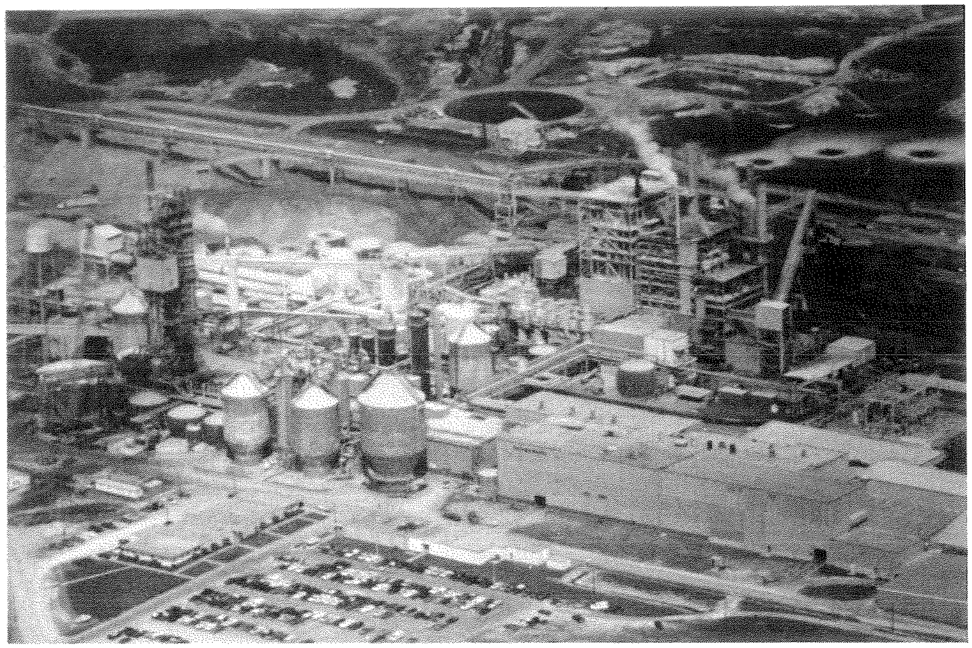

Figure 4 A Typical Pulp and Paper Mill

Boiler capacities have gradually increased with paper machine sizes and steam needs. In addition, there is a current trend to replace several small oil and gas fired steam boilers by one large solid fuel fired cogenerating boiler.

Now that conventional utility fuel prices and use prohibitions are providing widespread renewed interest in cogeneration, it makes even more economic sense for the pulp and paper industry to continue and even accelerate plans to build large cogenerating power boilers.

These higher capacity boilers fall into the utility boiler size which was typical 15 to 20 years ago, but which would be considered small by today's utility standards. Nevertheless, they often pose even greater challenges to boiler designers than most utilities due to their varied fuel design requirements.

Hogged wood fueled boilers, even of the traveling grate spreader stoker type, cannot respond to instantaneous load changes which may be the result of a paper machine shut-down. This concern, coupled with uncertainties of continuous hogged wood supplies, often result in the need to "base load" with wood firing and take load swings with pulverized coal firing. It is, therefore, not uncommon to see boilers designed for half load on hogged wood and full load on pulverized coal. Figure 5 illustrates a 500,000 PPH pulverized coal fired boiler capable of 340,000 PPH on hogged wood.

For years, stoker manufacturers limited their recommended grate heat release rates to 750,000 BTU/sq. ft./hr. in an effort to keep flyash, carbon loss and carryover under reasonable control. In so doing, grate residence time was increased while combustion temperatures were kept well below adiabatic. In recent years, however, grate heat releases in excess of 1,000,000 BTU/sq. ft./hr. have demonstrated the ability to successfully burn hogged wood at near complete combustion efficiencies. In order to control flyash carryover at such high heat release rates, several levels of overfire air nozzles in quantities approaching 50 percent have been employed. In so doing, undergrate air volume is considerably reduced and so too are through grate air velocities. This, in turn, reduces the tendency to lift the ash bed off the grate and hence reduces flyash carryover. Figure 6 illustrates such a unit design for 140,000 PPH on hogged wood.

To further illustrate this point, Figure 7 shows carryover conditions when 91 percent undergrate air is used, while Figure 8 shows the much reduced carryover quantities when only 5 percent undergrate is used.

As a result of cleaning up their effluent, paper mills are generating sizable quantities of sludge. Environmental restrictions preclude many landfill-type disposal methods for paper mill sludge. The obvious alternative is to incinerate such sludges within the boiler furnace. To successfully incinerate sludges which contain high moisture levels requires prudent application of the three T's of combustion technology (Time, Temperature and Turbulence).

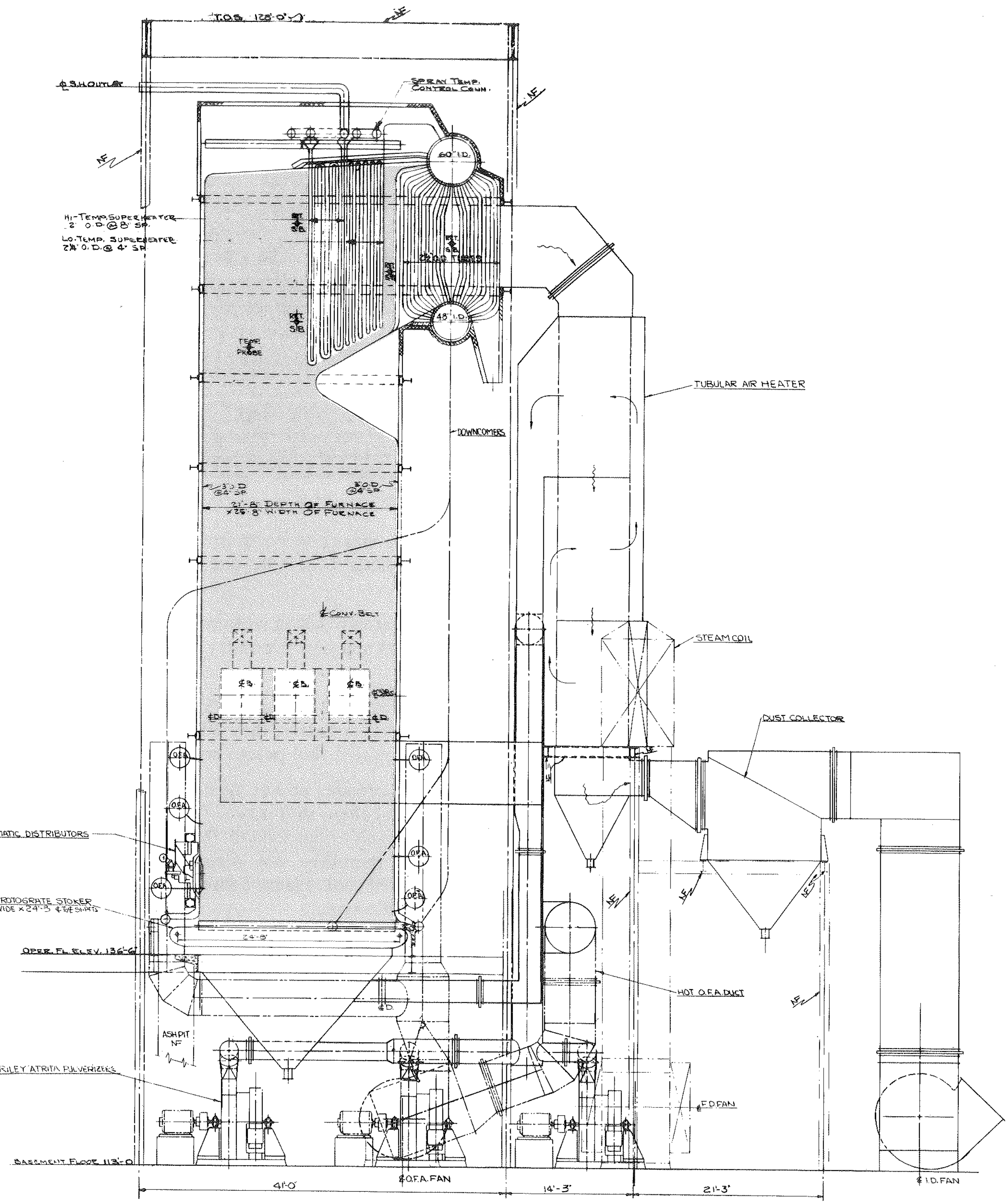

Figure 5 Boiler Designed for Pulverized Coal and Hogged Wood
500,000 pounds steam per hour at 950 psig and 900°F superheat. 340,000 pounds steam per hour firing hogged wood alone. Also designed to incinerate 22,000 pounds of paper mill sludge per hour.

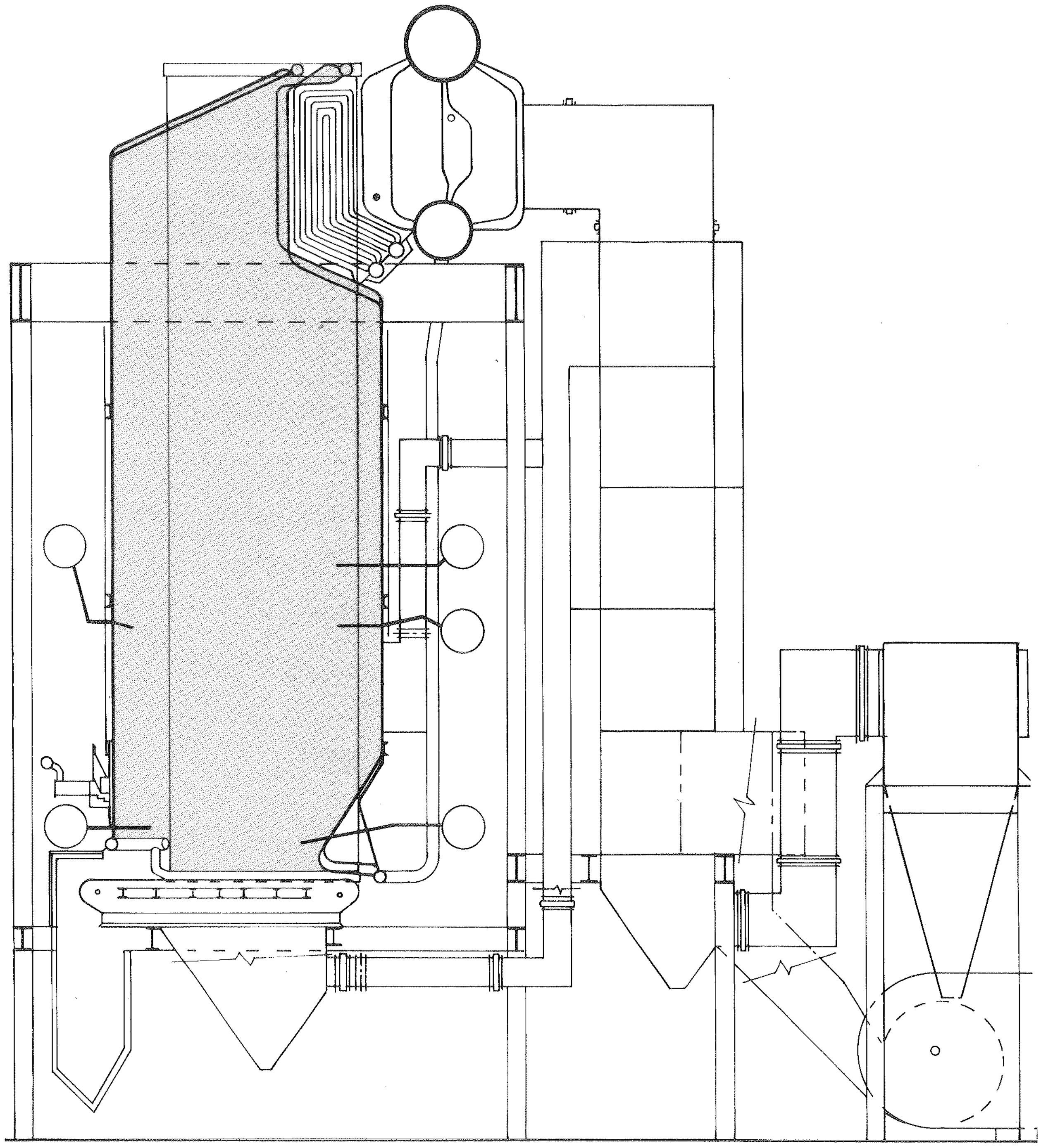

Figure 6 Boiler Fired by Hogged Wood
140,000 pounds steam per hour at 400 psig and 725°F superheat. Fired by hogged wood with #5 oil as auxiliary fuel.

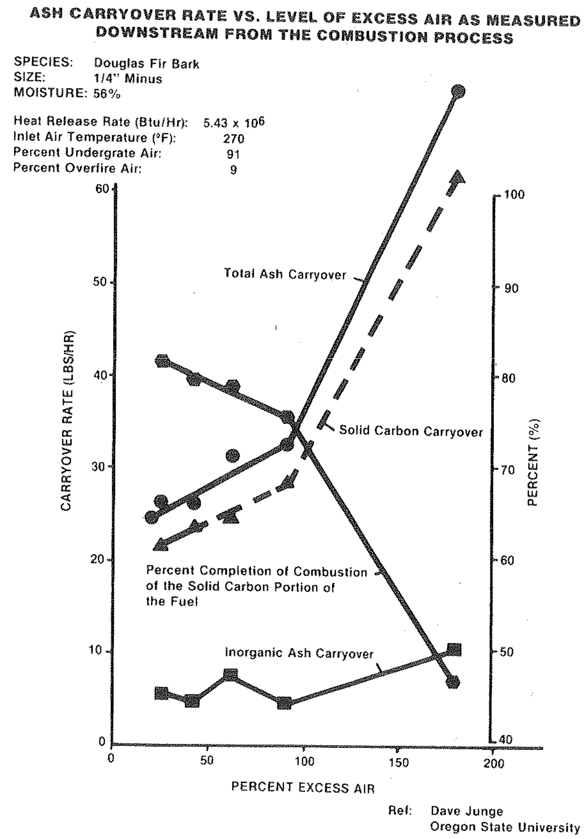

Figure 7 Carryover Conditions With 91% Undergrate Air

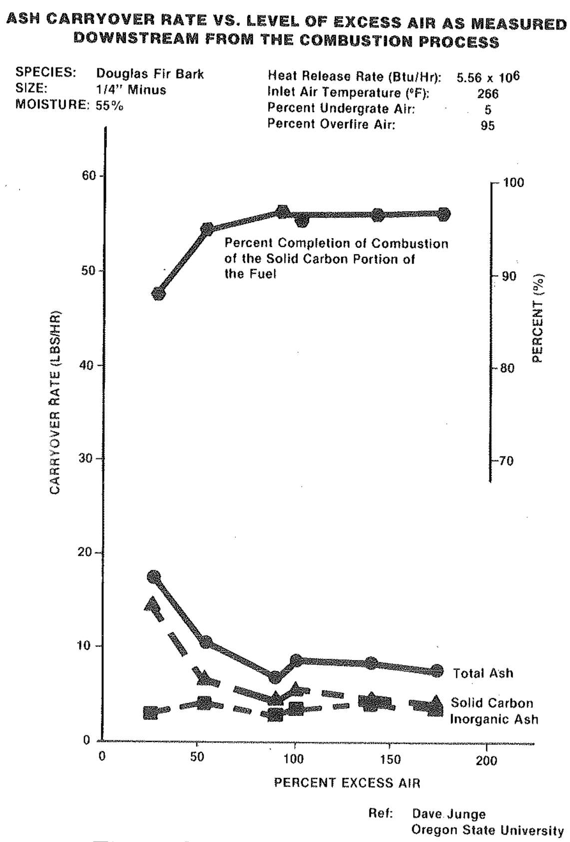

Figure 8 Carryover Conditions With 5% Undergrate Air

Most users would rather minimize the turbulence factor which inherently leads to high inorganic ash carryover. They justifiably express concern for accelerated convection tube fouling and erosion should this high ash-containing sludge exhibit such properties. They also share the belief that particulate collection systems are difficult enough to make, operate and maintain without additional loading on them.

The sludge incineration dilemma becomes obvious should high combustion intensity (temperature) be used to dry the sludge. This raises the question, would long furnace residence time be a better approach?

Proponents of the high temperature approach favor a design providing for high stoker grate heat release rates. They argue that this enables the unit to turn down further before the combustion process is adversely affected by the sludge moisture and smoking results. For example, the 1,000,000 BTU/sq. ft./hr. full load grate heat release would allow turndown of 2 and 4 to 1 based on past operating experience burning high moisture cellulose fuels such as wet pine bark, and bagasse and high moisture lignite as shown on Figures 9 and 10. To initially design for 750,000 BTU/sq. ft./hr. would limit turndown to only 1.5 to 1 on that basis for hogged wood and sludge firing.

The problem with high grate release rates is that the rates of sludge input often encountered result in rapid accumulation on the grate which quickly covers and insulates the sludge from exposure to the radiant drying effect of the furnace fire.

An alternative approach is to design for lower grate heat release rates in an effort to reduce rapid sludge piling. This requires a larger grate which, therefore, increases furnace resident time for sludge drying and then incineration.

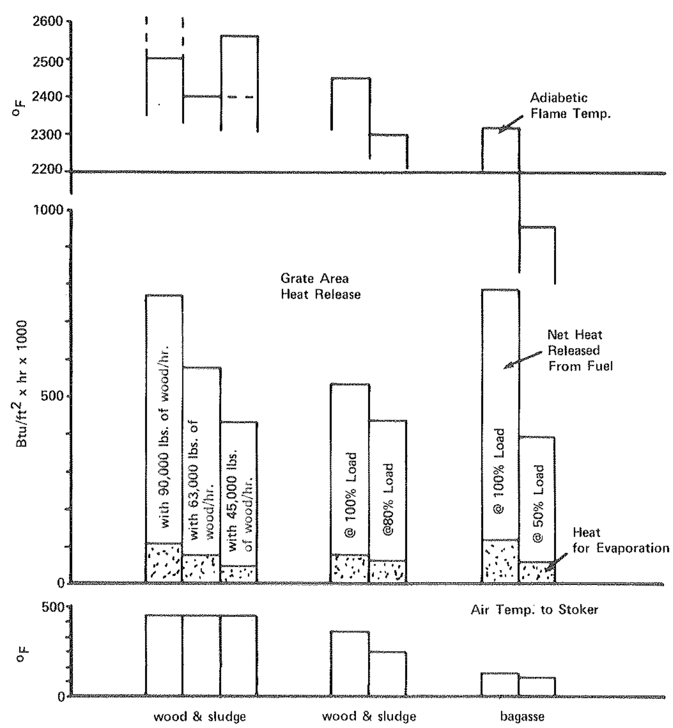

Figure 9 Comparison of Anticipated Combustion Conditions When Burning Wood and Sludge in Combination With Those Observed in Similar Installations

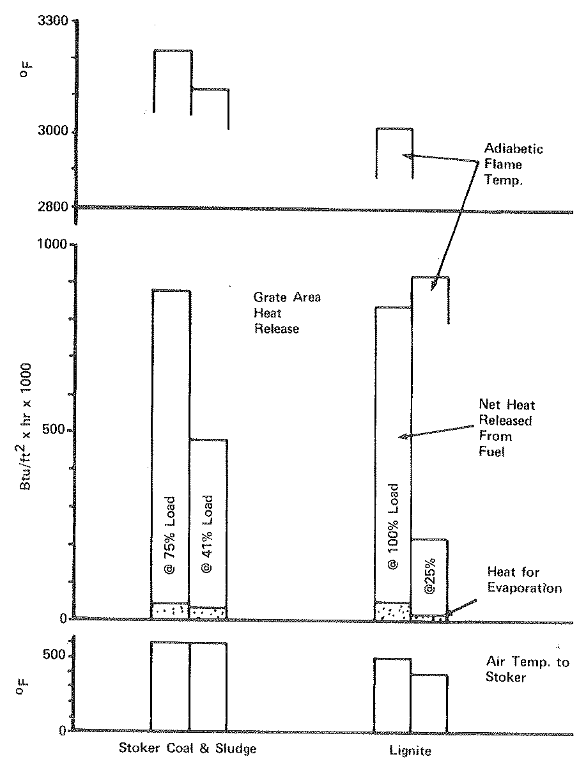

Figure 10 Comparison of Anticipated Combustion Conditions When Burning Stoker Coal and Sludge With That of Lignite Firing

Table I shows the results of laboratory testing of paper mill white water clarifier sludge and reveals the following information with respect to sludge incineration:

1. When dried, sludge will incinerate well. Dried sludge readily ignited and exhibited self-supporting flame characteristics. As received (wet basis) sludge contained 11.8 percent volatile matter (54% on dry basis) by ASTM test. It could not be ignited.
2. After drying, rewetted sludge occupied only about ½ the volume of the original sample. This implies enhanced stability, and no free swelling problem potential.
3. The ash in this particular sample exhibited ash fusion properties in excess of 2700°F. Therefore, it is not likely to cause furnace slagging or convection bank fouling, and it is likely to form an excellent insulation for stoker grate thermal protection.

SAMPLE	LB. MOISTURE / 100 LB AS REC'D SLUDGE
As received sludge	78.1
Dried (212°F) and rewetted	52.1
Dried (212°F) Pyrolized (1400°F) and rewetted	42.5
Dried (212°F), Pyrolized in Flame and rewetted	45.4

Table I Rewetted Sludge Moisture Content

A comparison of various traveling grate stoker approaches is illustrated in Figures 11 and 12. Typical spreader stoker firing of hogged wood and sludge is depicted in Figure 11.

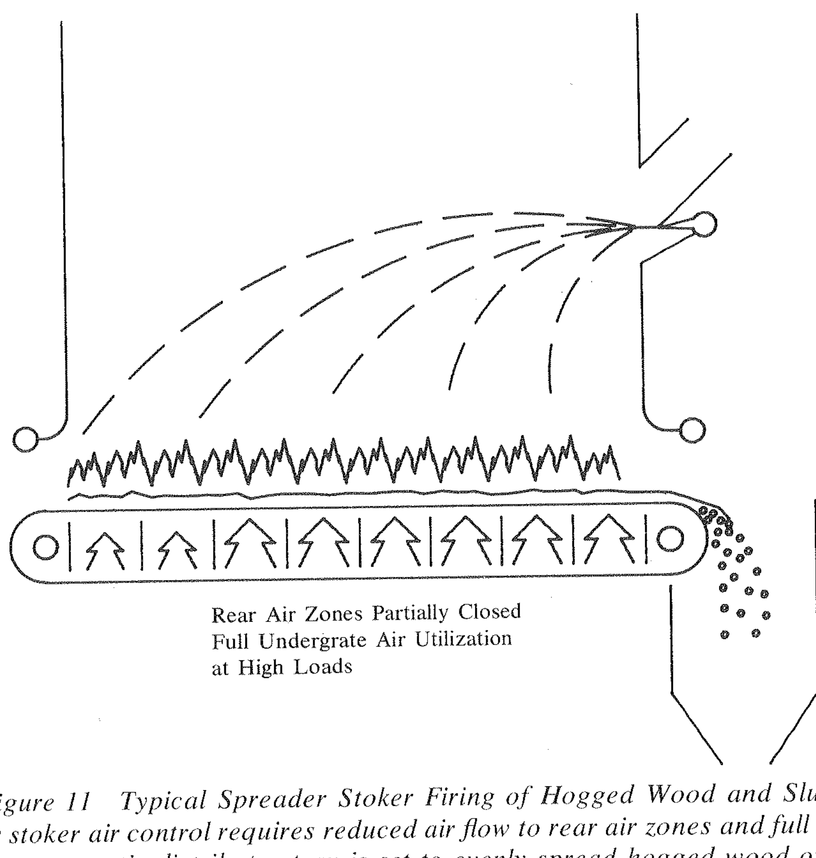

Figure 11 Typical Spreader Stoker Firing of Hogged Wood and Sludge
Normal spreader stoker air control requires reduced air flow to rear air zones and full undergrate air flow to remainder. The pneumatic distributor tray is set to evenly spread hogged wood over the entire grate surface.

To counter the apparent boiler load turndown restriction associated with designing for lower fuel load stoker grate heat release rates, designers have borrowed a page from hopper-fed coal stoker traveling grate technology. The use of lateral undergrate air zoning and variable trajectory hogged wood/sludge pneumatic distributors permits the concentration of both the fuel/sludge mixture and undergrate air. In so doing, local grate heat release rates can be increased to promote combustion and inhibit smoking and loss of ignition at low loads as shown in Figure 12.

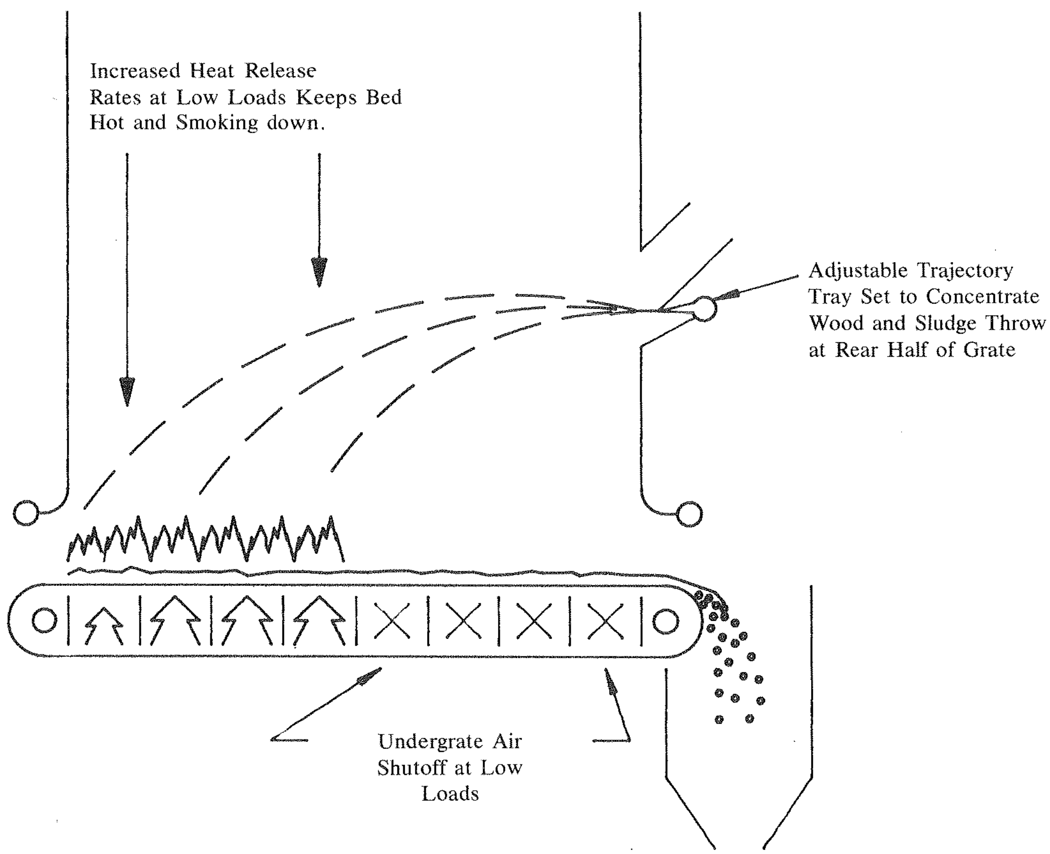

Figure 12 Spreader Stoker Firing of Hogged Wood and Sludge Using Lateral Undergrate Air Zoning and Variable Trajectory Distributors

Incorporating the outstanding air control feature of the overbed feed stoker with the adjustability of the pneumatic distributor trajectory tray allows the potential of locally increasing grate heat release rate. This promises to keep combustion rates high enough to prevent smoking while tightly controlling undergrate air flow.

Another serious consideration when designing for the high temperature steam requirements of cogeneration is the adverse effects of slag falls on mechanical stoker grates. Pendant radiant superheaters are prone to slag accumulations when firing any solid fuel with slag forming inorganic impurities. Serious damage to the grate can be done by large slag falls. To overcome this potential, Figure 13 shows how a waterwall furnace hopper can be formed to totally protect the stoker grate from both slag fall mechanical damage and overheating from direct furnace radiation.

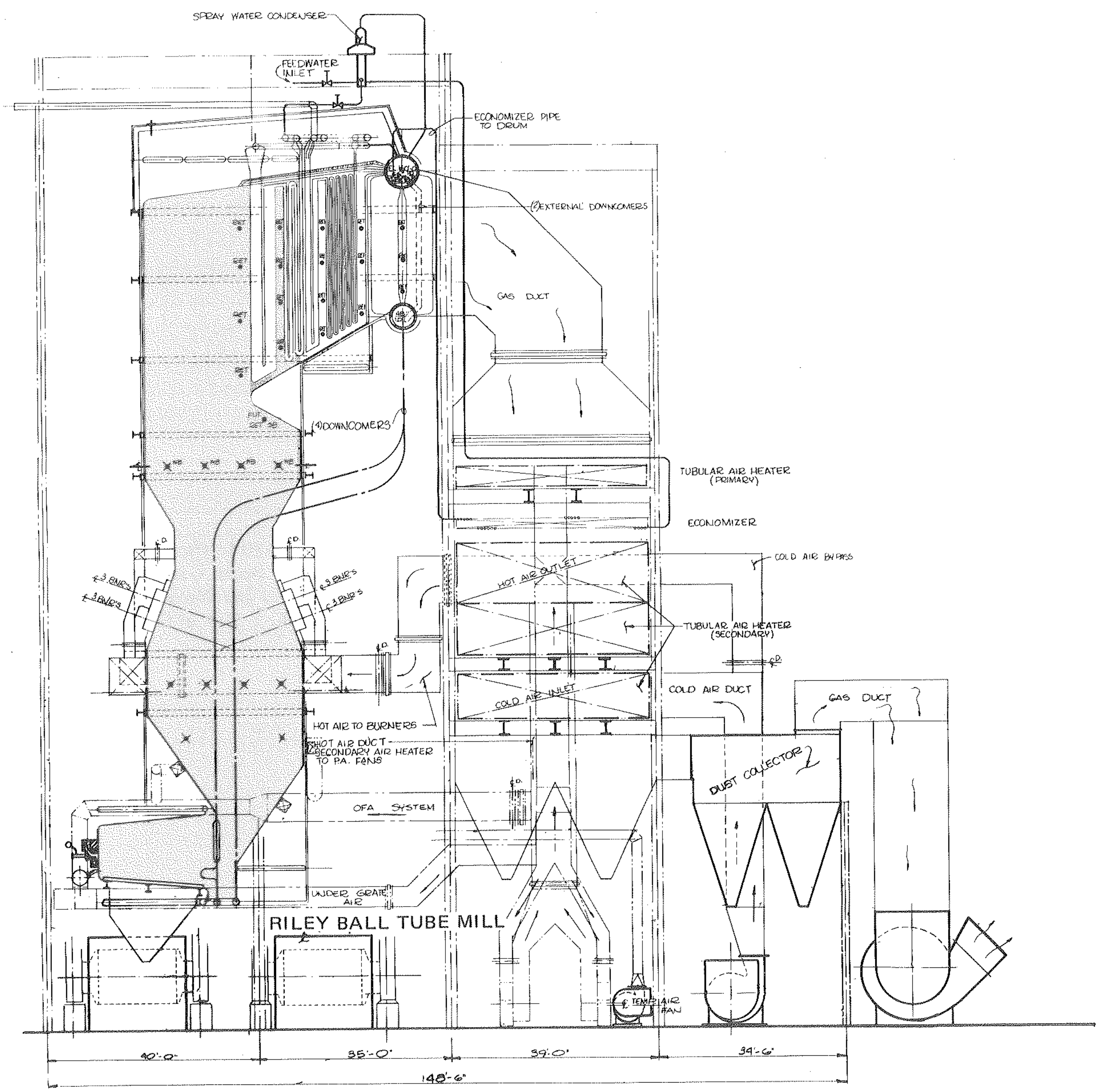

Figure 13 Cogeneration Design Boiler Fired by Pulverized Coal and Hogged Wood 600,000 pounds steam per hour at 1300 psig and 950°F superheat. Note that the waterwall wood firing chamber is isolated from slag falls and upper furnace radiation.

Paper mills normally have several boilers providing steam simultaneously to maintain operations. Usually the total of self-generated fuels is only 60-70 percent of the requirement of the mills, so the remainder is purchased fuel. For economic analysis, any increment of change in utilization efficiency is based upon purchased fuel price. It is therefore necessary to install and maintain good instrumentation to ensure safe, efficient operation. The trend in today's world is bringing in the microprocessor and direct digital control (DDC). Many companies are installing an energy management computer to supervise existing instrumentation. In one mill, instrumentation was completely replaced on three old boilers and joined with two new turbine-generators and a new pulverized coal/wood refuse fired boiler. Figure 14 illustrates another recent installation (note the computer in the foreground).

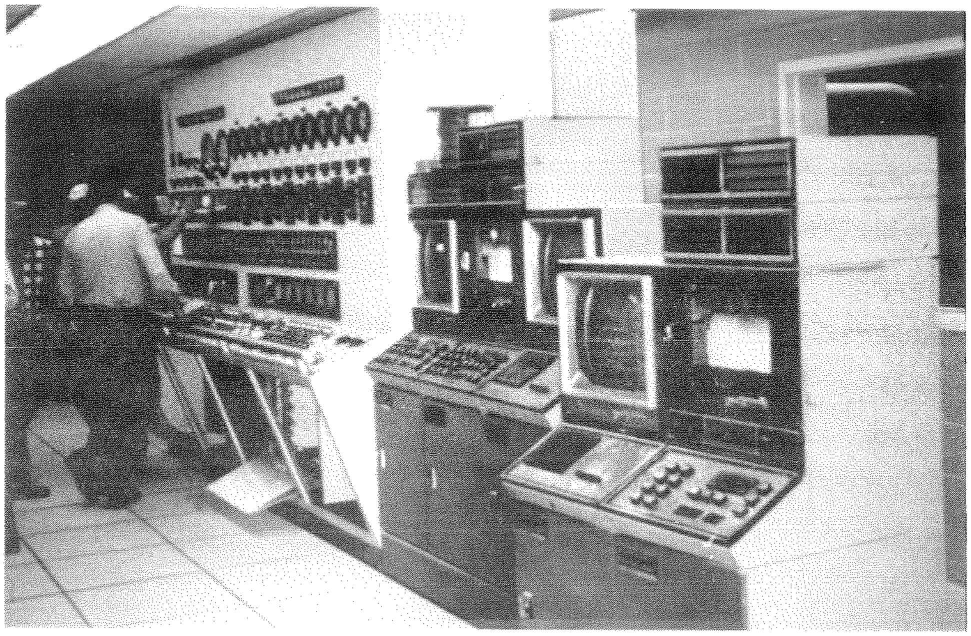

Figure 14 Recent Control Room Installation in a Paper Mill

Large cogenerating boilers for the pulp and paper industry represent a large capital investment. Boiler reliability and availability have never before been demanded so earnestly by this industry. Prudent users are understandably giving such novel approaches as those presented above very serious consideration in their efforts to protect their cogeneration investments and assure the highest levels of equipment flexibility, reliability and economy.