PNFI Technical Reports

Petawawa National Forestry Institute, Chalk River, Ontario K0J 1J0, Canada

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An 800 kW Wood Fuelled Energy Recovery Plant

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Introduction

An 800 kW/h wood fuelled, low pressure heating plant was installed at the headquarters site of the Petawawa National Forestry Institute (PNFI) in December 1989 (see Figure 1) by Sylva Energy Systems of Thunder Bay, Ontario for a cost of approximately 400 000 dollars. The plant provides heat to approximately 3700 m^2 of office space, consuming 800 tonnes of wood residue annually from the Petawawa Research Forest (PRF). Figure 2 graphically illustrates the process of heat generation.

The wood is furnished in the form of wood chips produced from a knife chipper. Fuel is produced primarily from thinnings, slash, and unmerchantable material taken from the 100 km^2 PRF.

The decision to install a wood fuelled heating plant was based on the anticipated energy savings and benefits to forest management. Recent world events have emphasized the vulnerability of low world oil prices. Post-harvest treatments and stand tending costs can be reduced if slash and unmerchantable material can be economically used. Wood energy has market value, but is subject to costs of energy production.

Discussion

A. Fuel Handling

The plant produces over 800 kw/h at 76 per cent efficiency, consuming 380 kg of fuel per hour at 50 per cent moisture content. The fuel is stored below grade in a 80 m^3 fuel bin capable of holding up to four days supply of fuel. The fuel bin is made of concrete, reinforced to withstand loads which may be applied either internally or externally. Special steel members are embedded in the floor to anchor and guide the fuel feeding rakes. These rakes are hydraulically powered, moving in an alternating fashion at very low speed. They travel about 50 cm and keep pushing the fuel forward. To prevent overfeeding of the fuel collection conveyor, sensing devices stop the action of the rakes. When the overfeeding stops the rakes resume normal operation.

Fuel from the fuel collection auger is transported by a vertical bucket elevator to the furnace fuel injection auger. Feeding of fuel to the primary cell is controlled by the demand placed on the heat exchanger. This procedure is fully modulated by a microprocessor. The operation of all components of the fuel handling segment are thermally as well as mechanically protected against overload. Alarm circuits are activated if any problem develops resulting from foreign objects in the fuel delivery or a mechanical breakdown. Pieces of angle iron and shaft and channel, miscellaneous objects of steel, and boulders have been known to travel through augers.

B. Combustion

The combustion of fuel is accomplished within two chambers in three distinct stages: moisture evaporation, distillation, and burning of the fixed carbons.

The ignition or primary chamber is where the first phase of combustion occurs. The fuel received at the injection auger terminal is fed into the chamber on top of the grate surface with a moving grate ashing system in proportion to demand from the heat users.

The combustion air enters the ignition cell via plenum sections. The temperature of the air is raised when exposed to the passages behind the clay refractory wall, and high velocity streams of this heated air enter the cell generating high turbulence. All the moisture is evaporated out of the wood and the volatiles are distilled out. The volume of air can be regulated to control fire size. Secondary air is introduced to the hot gases as they pass the mixing chamber, to thoroughly mix the distilled volatiles. Underfire air, normally 40 per cent of the total air, is not preheated prior to entering the ignition chamber.

Ash generated in the primary cell is removed automatically by a moving grate system into ash augers

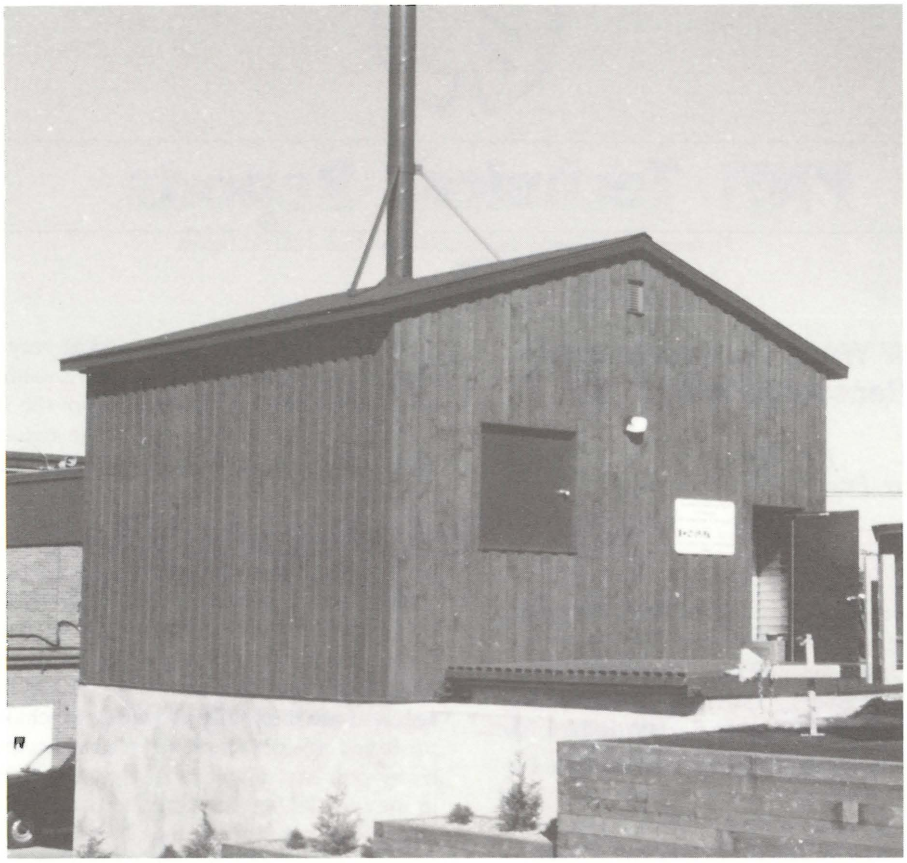

Figure 1. External view of the wood fuelled energy recovery plant at PNFI (Photo: S. Handke).

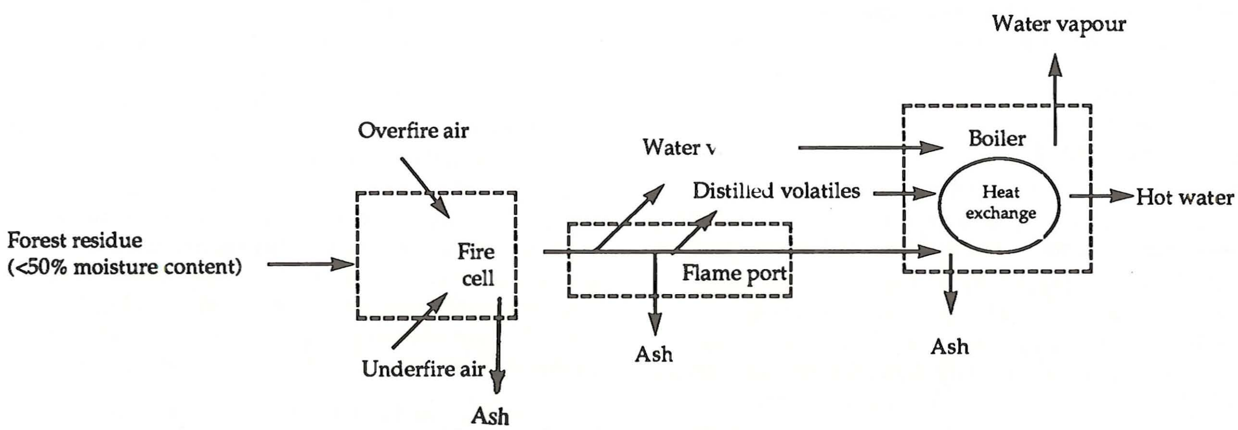

Figure 2. Overview of energy flow.

underneath. This arrangement removes the ash to transport augers which, in turn, move the ash to containers inside the boiler room.

The products of combustion leaving the ignition cell pass into the final combustion chamber. Retention time to this point is between .5 to .8 seconds, depending on fuel characteristics. Maximum fire temperatures are reached in the mixing and combustion zones and all volatiles are burnt out in these secondary phases of combustion. During travel, gases are bent both laterally and vertically to achieve thorough mixing.

When combusting fuels with high levels of moisture it is necessary to utilize clay refractory materials to stabilize firing. All hot faces of the cell, the flameport, and mixing chambers as well as the heat exchanger settings are so lined. Only the heat transfer surfaces are metal. Insulation, special refractory materials, wall supports, and air flow all play a role in cell design.

C. Ash Handling

The removal of ash from the combustion cell is automatic. Ash build-up on the burning surface greatly lowers cell output because air must flow up through the furnace grates. Dump doors or dump grate sections allow the ash to be cleared from the cell. Ash augers carry the collected ash out of the fire cell to containers in the boiler room. Other components of the system located in the gas stream after the boiler require periodic inspection, and this is facilitated by ash inspection and cleaning access doors. Some components are cleaned automatically, while others need manual cleaning. The boiler must be inspected and cleaned on a regular basis and operating experience will establish a cleaning policy.

The fly ash collector filters ash particles from the flue gas, passing the particles through a rotary valve to the ash augers. This operation is performed automatically, with the frequency or cycle time determined by the plant size and the type of fuel being used in the furnace. Interlocks on ash doors and ash auger drives automatically place the system on natural draft operation. Air locks seal ash canals to maintain furnace draft conditions during system operation. Ashing normally takes five to 10 minutes and, under normal conditions, a 45 gal. barrel is filled in a 2-week period.

D. Gas Handling

An induced draft (ID) fan removes combustion products from the boiler. In doing so it creates sufficient negative pressure to establish a slight suction in the furnace. On this account, gas handling in this system is known as a "section firing" or "balanced-draft" operation. The fan has enough capacity to accommodate any infiltration caused by the negative pressure in the equipment after the furnace.

The ID fan is located downstream of the particulate separators; hence it is a relatively clean service fan. In wood fuelled plants a backward-inclined blade design is used for the fan, which minimizes dust build-up and reduces downtime for cleaning. The design is low noise.

Various sections of breaching are often needed to establish a path for the flue gases. The path may include economizers, air preheaters, and/or flue gas cleaners. The final step in discharging the unwanted products of combustion is accomplished by way of an insulated vent stack.

E. Heat Exchanger

The heat exchanger changes the heat of combustion into an usable form. Heat exchange may be air to air, air to water, or air to thermal fluid. In all cases the "air" represents the products of combustion from the furnace. Direct radiation from the furnace may be considered as an aspect of combustion and forms the most important part of heat transfer.

Air to water/steam heat exchangers are commonly referred to as "boilers". Fire-tube or water-tube boilers are representative of the types used with oil, gas, or solid fuel fired plants. Sylva Systems utilize firetube boilers in most low pressure steam or hot water plants because of lower costs and smaller heat load requirements. As the technology stands water-tubes are more appropriate for plants with large loads. Boilers in both fire-tube and water-tube configurations have "furnaces" or fireboxes within their structure. Use of the firebox as a secondary combustion chamber totally consumes combustibles. The walls of the firebox absorb the effect of direct radiation and the black gas converts its heat to the boiler tube surfaces as the gas passes the convection section of the boiler.

A clay-lined hopper, built into the setting complete with an ash auger, automatically removes ash from this area.

F. Control Systems

The plant is equipped with a microprocessor which automatically monitors and adjusts 21 key areas of operation. Operators initiate the function of the system and system logic ensures that all functions are performed in correct sequence. There is manual override, however.

Conclusions

The use of wood energy is highly dependent on the comparative cost of fuel oil, a variable that fluctuates widely based on unpredictable political events. This unpredictability, the abundance of available wood fuel from forest rehabilitation, and the environmentally friendly features of this technology makes it a cost effective alternative to fossil fuels.

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