

SAUDER WOODWORKING COMPANY: A WASTE WOOD ELECTRIC GENERATING FACILITY

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ABSTRACT

Sauder Woodworking Company (SWC) generates waste wood as a byproduct of its manufacturing operation. Studies suggested that energy costs could be reduced by utilizing the waste wood to generate steam and electricity. Since the wood is dry, it is possible to utilize suspension burner technology. Two (2) 45,000 lb/hr boilers produce steam at 625 psig and 750°F. Each boiler is equipped with an economizer, mechanical dust collector, selective catalytic reduction, and an electrostatic precipitator. Electricity is produced from two (2) 3500 kW turbine generators operating full condensing and capable of future steam extraction which could be used for plant heating or cooling. The major features of the cogeneration studies, permitting, and design will be reviewed.

BACKGROUND DISCUSSION

SWC was founded in 1934. In the early years, the company primarily built church pews and furniture. In 1951, SWC introduced Ready To Assemble (RTA) furniture. SWC has maintained a path of continual growth from that time to the present. SWC operates 3.2 million square feet of facilities in Archbold, Ohio and is presently constructing an additional 500,000 square foot production facility scheduled to be completed in June, 1994. Because of the company's growth, the quantities of waste wood has continually increased. This has created increasing wood waste disposal problems. A small portion of the waste is used for heating in a small boiler, but the majority has been disposed of off site. The quantity of wood waste disposed of in 1993 was about 175 tons per day. Having what is es-

entially a free fuel is one of the elements leading to the creation of a cogeneration facility.

The second element leading to the initial cogeneration study was a high electrical energy cost. The electricity requirements for SWC increased with the companies expansion. The peak electrical usage in 1993 was about 11,000 kW. Archbold, Ohio is in a region of high electrical rates. Prior to the initial cogeneration study, the average electrical rate from Toledo Edison Company (TECO) was approximately 7.0 cents/kWh. The combination of waste fuel and high electric energy costs justified the study of cogeneration and SWC contracted with SFT, Inc. to undertake the project.

COGENERATION STUDIES

The initial cogeneration study was performed by SFT in 1987. The high electric rates made such a study most worthwhile. The waste wood fuel was very low cost even though disposal costs were not an issue since SWC sold the wood waste for agricultural purposes. SWC also used a small amount of the wood waste in a heating boiler. The study indicated that compared to the cost of electricity from TECO, a cogeneration facility looked attractive. However, in the negotiations with TECO, in order to forestall the installation of a cogeneration facility, TECO made a five year incentive offer of lower electric rates. The rate offered was low enough that SFT recommended to SWC that they could not justify the capital costs to build a cogeneration plant.

In 1990, SFT was again retained by SWC to provide an update to the cogeneration study based on the termi-

nation of the incentive electrical rate in 1992. SWC had continued to grow, and the 1990 study indicated enough wood waste to produce 7000 kW of electricity. Also, the amount of wood waste was continuing to increase with the expansion of the SWC operation and disposal was becoming a cost item. The results of the study indicated that electricity could be produced at a cost of 5.5 cents/kWh. The negotiation with the TECO concluded with an agreement for SWC to sell all of the cogenerating facilities output to the utility who, in turn, would sell power to SWC from plant start up for a period of fifteen (15) years. The rate SWC would pay for the period of the agreement is a sliding scale based on a percentage of the nonfuel portion of the published tariff. In return, TECO would pay to SWC the avoided cost at the time of electrical generation by SWC. Presently, this rate is approximately 1.5 to 2.0 cents/kWh. The financial analysis indicated that the SWC out of pocket costs for labor and operations would break even with the avoided costs. In addition, there was a credit for the disposal of the wood waste. Finally, in 1999, a capacity payment from TECO to SWC will begin. The resulting conclusion was a recommendation for SWC to construct the cogeneration facility.

The final design called for two (2) 45,000 lb/hr boilers operating at 625 psig and 750°F. Each boiler is fired by wood or natural gas and is equipped with one (1) wood fines burner, an economizer, a selective catalytic reduction system, and an electrostatic precipitator. An air heater was not required because of the dry nature of the wood waste fuel. The economizer lowered the exit gas temperatures to the desired level (450°F). Each boiler supplies steam to one (1) steam turbine generator rated at 3500 kW. Each turbine is full condensing with provisions for future extraction at 165 and 15 psig. Condenser water is cooled utilizing a cooling tower. See Table 1 for a list of major pieces of equipment and suppliers.

PERMITTING

The State of Ohio codes require that an owner obtain a permit to install from the Ohio EPA. The proposed SWC cogeneration facility was subject to Federal New Source Performance Standards (NSPS) and Prevention of Significant Deterioration (PSD) permitting. The two (2) boilers were subject to Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units, 40 Code of Federal Regulations part 60 subpart Dc. These standards apply to boilers having an input less than 100 MBtu/Hr. For a wood fired boiler in this size range, the only pollutant regulated is particulate and the limit is 0.1 Lbs/MBtu. Natural gas is not regulated.

PSD applies to all areas that are in attainment with National Ambient Air Quality Standards (NAAQS). PSD is applied on a pollutant by pollutant basis and considers what impact the new source will have upon air quality.

TABLE 1 MAJOR EQUIPMENT SUPPLIERS

System Component	Component Supplier
Boiler-Economizer	Tampella Power
Suspension Burner System	Coen Company
Electrostatic Precipitator	Environmental Elements
Selective Catalytic Recovery	Norton Chemical Process Products
Control System	Bailey Controls
Steam Turbine Generator	Dresser-Rand
Condensers	Graham Manufacturing
Cooling Towers	Marley Cooling Tower
Water Treatment	Illinois Water Treatment
Deaerator	Cochrane
Feedwater Heater	Hydrotyne
Continuous Emission Monitoring System	Servomex

TABLE 2 WASTE WOOD ANALYSIS

Proximate Analysis	Sauder - As Received	Typical Pine As Received
Moisture	7.6	45.0
Ash	1.3	1.5
Volatile	74.9	40.2
Fixed Carbon	18.2	13.3
Ultimate Analysis		
Moisture	7.6	45.0
Carbon	46.6	30.0
Hydrogen	5.5	3.0
Nitrogen	2.6	0.2
Chlorine	0.2	N/A
Sulphur	0.1	0.1
Ash	1.3	1.5
Oxygen	38.1	20.2
Heating Value Btu/lb	7800	5000

Each pollutant has a maximum annual emission rate which must not be exceeded to avoid PSD permitting. To avoid PSD, SWC would have had to limit the hours of operation on an annual basis which would not have been acceptable. The choice was then to either lower emissions below the PSD trigger quantities or proceed with PSD permitting.

The pollutants for which PSD applied are Particulates including PM10, Nitrogen Oxide (NOx), Carbon Dioxide (CO), and Volatile Organic Compounds (VOC). Wood from the forests generally is low in nitrogen. However, the wood waste at SWC is high in nitrogen content due to the addition of resins necessary in the manufacture of particle board. Table 2 is an analysis of the SWC wood waste compared to natural wood.

After the initial Permit Application, which met the NSPS requirements for particulate, an electrostatic precipitator was added to reduce particulate emissions. The reduction was enough to lower both particulates and PM10 below the PSD annual limits. Table 3 shows the timetable

TABLE 3 PERMIT APPLICATION SCHEDULE

Event	Initial Permit Application	Submission of Revised Permit Application	Issuance of Permit to Install
Date	March 1991	November 1991	June 1992
Particulate Limit Controls	0.1 lb/MBtu Wet Scrubber	0.025 lb/MBtu ESP	0.025 lb/MBtu ESP
NOx Limit Controls	1.0 lb/MBtu Proper Combustion	0.7 lb/MBtu Staged Combustion	0.2 lb/MBtu SCR
CO Limit Controls	0.45 lb/MBtu Proper Combustion	0.45 lb/MBtu Proper Combustion	0.45 lb/MBtu Proper Combustion
VOC Limit Controls	0.17 lb/MBtu Uncontrolled	0.15 lb/MBtu Proper Combustion	0.15 lb/MBtu Proper Combustion

for the permitting process and the values of emissions permitted.

As required by PSD, dispersion modeling of the proposed facility was performed using expected performance data. This modeling showed that the proposed facility would be in compliance with NAAQS and below the de minimis value for preconstruction monitoring. Based on these results, the facility was granted an exemption from preconstruction monitoring.

PSD required that Best Available Control Technology (BACT) be determined for NOx, VOC, and CO. Proper combustion control was the only technology given serious consideration as BACT for CO and VOC. Ohio EPA concurred with the selection of proper combustion control as BACT for CO and VOC.

Six technologies were considered for NOx control:

- Pelletizing
- Staged Combustion
- Low NOx Burners
- Flue Gas Recirculation (FGR)
- Selective Non Catalytic Reduction (SNCR)
- Selective Catalytic Reduction (SCR)

The Ohio EPA requested an investigation of pelletizing the wood waste with combustion on a stoker grate as a means of NOx control. Since the pelletizing process did not reduce the nitrogen content in the wood fuel, there would be little reduction in the formation of fuel NOx. There was also a significant increase in capital and operating costs. Therefore, this technology was eliminated from further consideration.

Three factors were considered in proposing BACT to Ohio EPA. These were: the reduction expected, the cost impact, and the level of experience of the technology. Based on an analysis using these factors, staged combustion was proposed as BACT for NOx control. Ohio EPA advised that the application was complete. However, Ohio EPA disagreed with the proposed selection of staged combustion as BACT for NOx control. SCR was investigated

and vendors were queried as to their willingness to guarantee an SCR system at SWC. The cost impact of an SCR system on the project economics was reviewed. The result of this analysis indicated that project economics were still acceptable and that vendors were willing to make appropriate guarantees. Based on this, SWC accepted Ohio EPA's request that the boilers use SCR technology for NOx control.

FUEL HANDLING

The waste wood preparation, storage, and conveying system to the fuel metering bins at the boiler were designed and furnished by SWC in consultation with SFT. The system consists of waste wood pulverizers and storage silos located some distance from the boilers. The waste wood is fed from the silos using screw feeders which discharge into the pressure duct of a low pressure conveying pipe line. The waste wood is blown to a bag filter located on top of the metering bin. The metering bin has a low and high level switch which starts and stops the waste wood screw feeder at the storage silo. A variable speed drive on the storage silo screw feeder allows adjustments to the screw feeder speed to minimize the number of off and on cycles of the screw feeder drive.

SUSPENSION BURNER SYSTEM

The suspension burner system starts with the waste wood metering bin and terminates with the burner shown in Photo 1. A single live bottom bin is utilized for both boilers. The metering bin has a volume of 400 cubic feet. The outlet of the bin is divided into two sections by a splitter plate. Each section has four (4) metering screws driven by a variable speed drive. The variable speed drive receives a 4 to 20 milliamp signal from the combustion control system to vary the fuel feed and the output from each boiler. Each screw feeder has a variable pitch increasing by 50 percent along the screw length.

The metering screw feeders discharge into a transition section which delivers the waste wood to a vibrating pan feeder. The pan feeder is expected to level out any uneven discharge from the metering screws. The pan feeder discharges the waste wood into a suction pipe leading to the inlet of a material handling fan. The material handling fan then blows the fuel to the single burner. There is one metering screw system, vibrating pan feeder, and material handling blower for each boiler.

The burner is a combination natural gas and suspension fired waste wood system. As stated above, the original BACT permit application was for a burner with staged combustion. A low NOx burner was not available for the combination firing. Staged combustion would have required a longer furnace than normally furnished with a

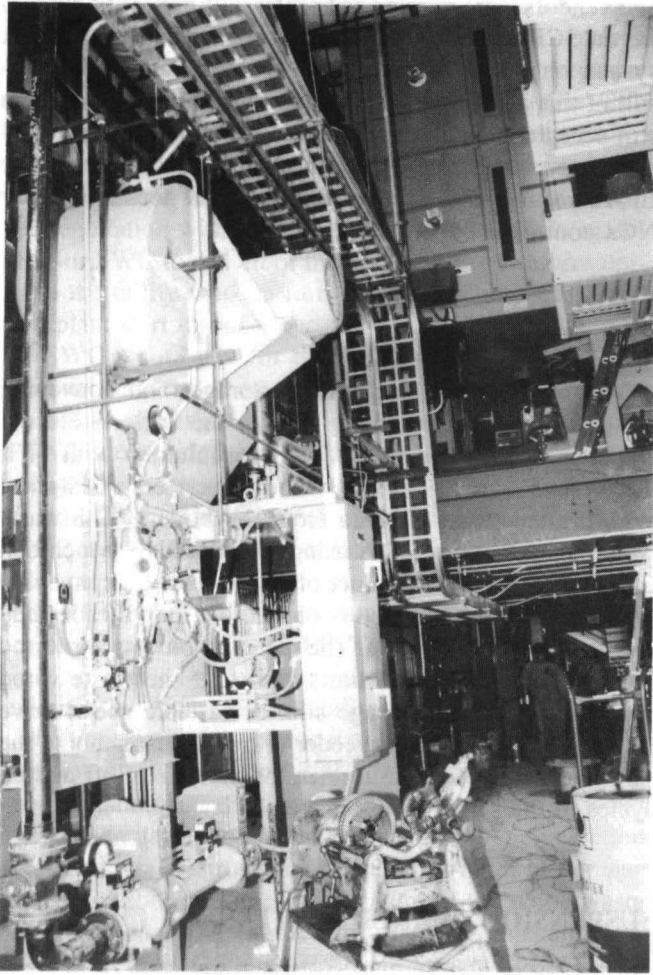


FIG. 1

boiler of this size. Since the Ohio EPA insisted on the use of SCR, staged combustion with the longer furnace was not furnished. The design of the combustion system allows full load on either natural gas or waste wood. A combination of the two fuels can be burned.

BOILER TO STACK — ARRANGEMENT AND DESCRIPTION

Photo 2. The boiler is located alongside the electrostatic precipitator and is dwarfed by the size of the precipitator. The combustion gases pass from the boiler through a mechanical dust collector on the way to the precipitator. The mechanical dust collector, having a draft loss of approximately 2.5 inches of water, will collect any large particles of flyash which might be still glowing. The efficiency of the mechanical dust collector is 85 percent. This will minimize the possibility of fires in the electrostatic precipitator. From the precipitator, the flue gas passes through a SCR, economizer, and then to an 80 foot stack. A platform is lo-

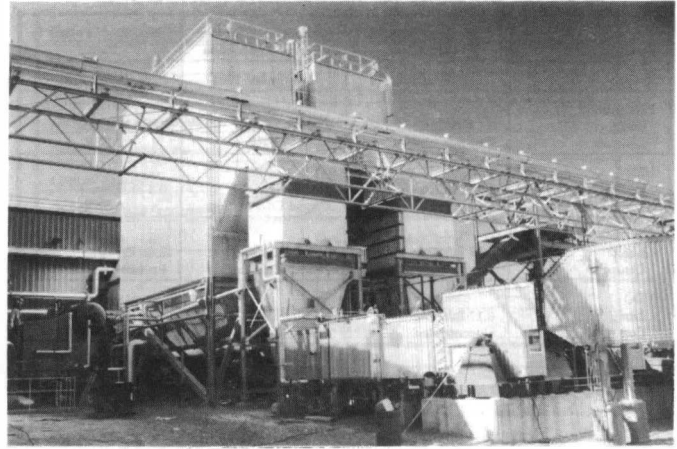


FIG. 2

cated on the stack for the continuous emission monitoring system.

Steam Generation System

The choice of a suspension fired combustion system allowed the use of a "D" type packaged boiler rather than a field erected boiler. This choice substantially lowered the capital costs of the boiler. The final size of the waste wood required for the suspension burner and the low quantities of ash will result in low abrasive properties of the material passing through the boiler with the products of combustion. The choice of steam conditions was appropriate for the size of the turbine generator and facility size.

The feedwater temperature to the economizer is 360°F. The economizer is a fin tube type. The exit flue gas temperature from the economizer to the stack is 400°F. Facility water treatment consists of a dual bed demineralizer and carbon filters. The water treatment equipment is located in the turbine building on the same elevation as the condensers.

Combustion controls are a distributive control system. The computer controls all of the functions of the facility: combustion, steam, and electrical. The suspension burner system has its own controls and burner management, and the turbine generator has a control system. However, these functions are duplicated in the distributive control system and the plant will be controlled from the central computer.

Emission Control System

The collection of particulate is with a mechanical dust collector having an efficiency of 85 percent followed by an electrostatic precipitator. From Table 3, it can be seen that the precipitator must lower the particulate discharge from the stack to 0.025 lbs/MBtu. The electrostatic precipitator is equipped with three fields.

The flyash collected in the mechanical dust collectors is discharged through rotary seal feeders onto a screw conveyor system from which the flyash is transferred to an ash collection chain conveyor which discharges into a surge bin. The flyash collected in the precipitator is conveyed with screw conveyors discharging through rotary seal feeders onto the ash collection chain conveyor. The surge bin unloads into trucks through a mixer-unloader.

Previously, it was stated that the control of CO and VOC was with proper combustion control. The emission control systems are for the control of particulates and NOx. The choice of an electrostatic precipitator was from the requirements to satisfy the Ohio EPA and then to avoid PSD permitting requirements for particulates.

The SCR is located at the precipitator flue gas discharge, upstream of the economizer. This was to locate the SCR in a temperature range for maximum NOx removal. The temperature into the SCR is 650°F. It has been reported that an SCR can operate with good NOx removal efficiencies at temperatures from 550°F to 850°F. The expected efficiency of the SCR is 80 percent. The reagent for the SCR system is anhydrous ammonia. The reagent is stored as a liquid in a tank. A vaporizing system converts the liquid to a gas under pressure for delivery to the SCR nozzles.

A continuous emission monitoring system (CEM) is installed in the stack. NOx, O₂, and opacity are monitored providing the desired averaging reporting.

STEAM TURBINE GENERATORS

Each turbine generator is rated at approximately 4300 KVA, and a gross output of 3656 kW. The total output from the two turbine generators is then 7312 kW. The facility power requirements are approximately 750 kW for a net total output of 6562 kW. Electricity is generated at

4160 volts and is then stepped up to 12,470 volts for tie in to the TECO system. The 15 psig steam extraction is for facility use in the deaerators. The 165 psig extraction is presently used for a high pressure heater and, in the future, will be for manufacturing plant heating and for process steam. At the present time, steam lines are being run to supply extraction steam to the manufacturing facilities.

The condensers are located near the turbine generators on the same elevation. The size of the turbines and the surface required for the condensers made an arrangement without a basement possible. Cooling water for the condensers is pumped to a dual cooling tower arrangement. The design temperatures into and out of the condenser are respectively 84°F and 99°F.

PROJECT START UP AND CONCLUSIONS

The boilers were fired on natural gas in October, 1993. After steam blows, both turbine generators were rolled and synchronized. The waste wood preparation and handling system were completed in early November, 1993. When this paper is delivered in June, 1994, operating data will be available.

There were three driving forces which made a cogeneration facility possible at SWC. These were high electric rates, a low cost fuel, and waste wood disposal problems. At another facility, other factors might be primary. A low cost fuel is one factor. A facility that has year around high steam usage is also a candidate for a cogeneration study. Another possibility for a facility with high energy usage and costs is to look for a third party developer that might be interested in building a cogeneration facility close to or on the property. Facilities that have high electric rates should look at all of the avenues which might lower energy costs.