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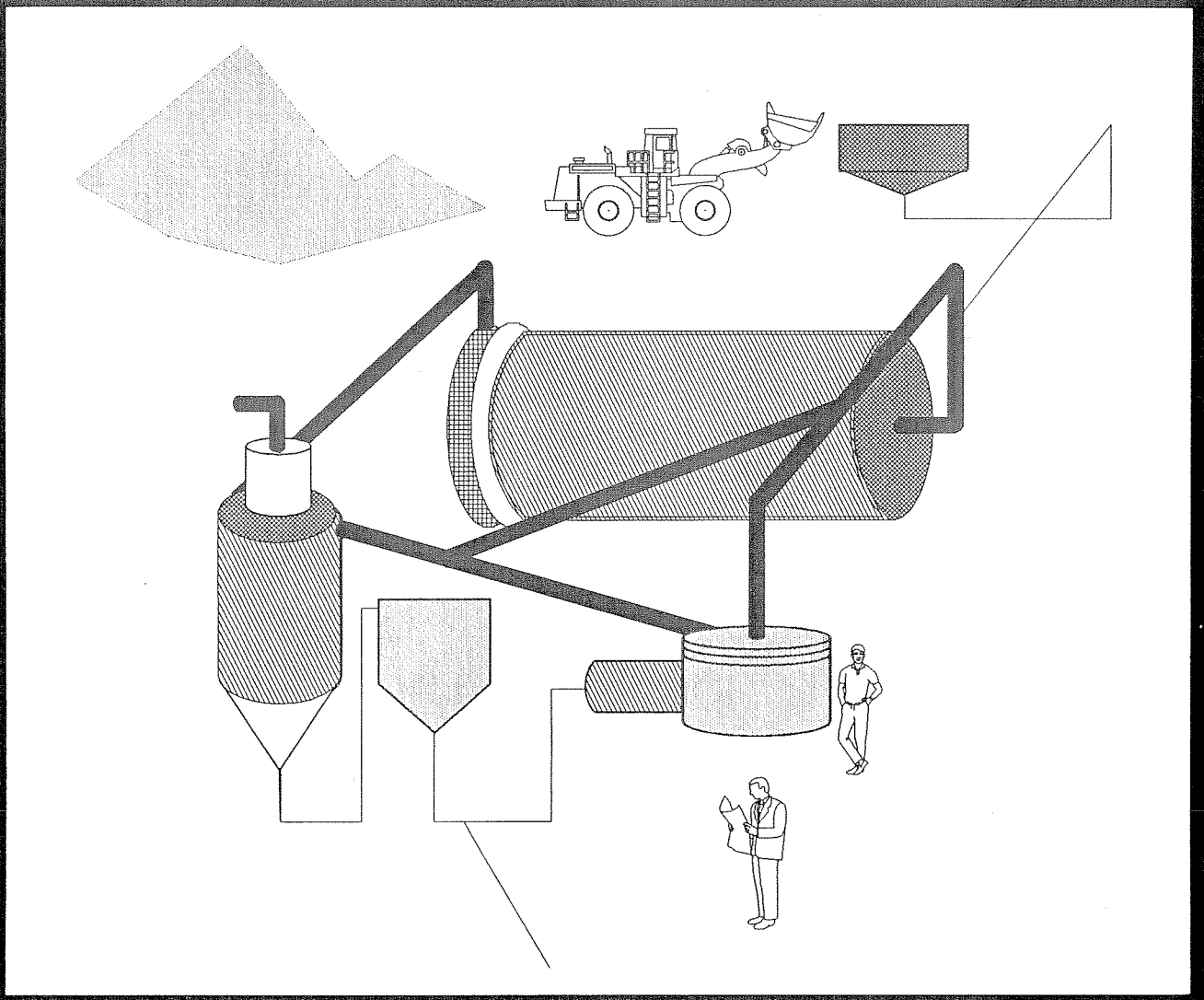
Wood Pellet Feedstock Drying System Demonstration Project



Idaho Department of Water Resources

Energy Division

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WOOD PELLET FEEDSTOCK DRYING SYSTEM

DEMONSTRATION PROJECT

Final Project Report To

IDAHO DEPARTMENT OF WATER RESOURCES
ENERGY DIVISION
BOISE, IDAHO

In Fulfillment of

Contract # DWR-89-03-81-103/03-25-108-66

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For

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ACKNOWLEDGMENTS

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The staff and management of Jensen Lumber Company wish to thank the Idaho Department of Water Resources, Energy Division, for the support and encouragement that made this project possible.

DISCLAIMER

Any opinions, findings, conclusions or recommendations including the mention of brand names of equipment expressed herein are those of the author and do not necessarily reflect the views or endorsement of USDOE, BPA, or IDWR.

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EXECUTIVE SUMMARY

The production of densified biomass pellets as a fuel source is not a new development in itself (Farnsworth, 1977). However, the popularity of pellet fuel has surged in recent years with the development of highly efficient appliances designed to burn this fuel. Much of this resurgence has come about as a result of increased awareness of air quality and particulate emissions produced by conventional wood and coal burning appliances.

Conversion of biomass residue, which is the byproduct of forest products manufacturing, into a valuable energy resource is particularly desirable for several reasons. It provides for environmentally efficient utilization of a by-product, thus eliminating the need for landfill disposal or waste burning.

The conversion process requires capital investment and the employment of a labor force which stimulate local economies.

Successful pellet production does, however, require feedstock which is low in moisture content.

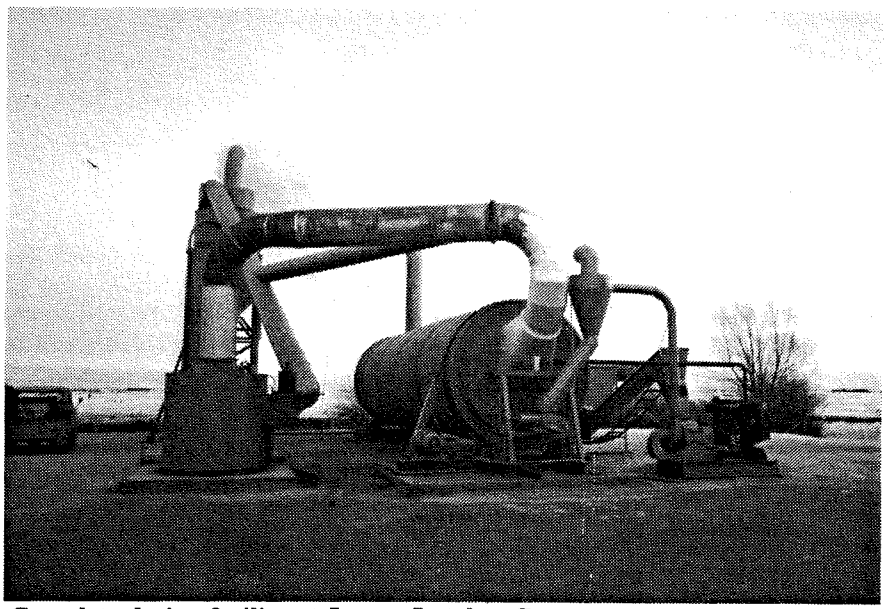
Normal sawmill operation produces biomass residue at a relatively high moisture content which is much higher than that suited for successful pellet production. It is desirable to have a system capable of drying sawmill residue to a uniform moisture content prior to densification of the product into fuel pellets.

It is also necessary to match the size of the drying system closely to the production capability of the existing pellet production facility in order to be as fuel efficient and otherwise economical as possible.

Air quality considerations, primarily fugitive emissions of particulate material from the process must also be a consideration.

The size and economic prerequisites of this proposal presented a somewhat "non-traditional" or unique challenge to achieving the end result.

It was apparent at the onset that commercially available technology could be utilized, but some creativity would be required to meet the size and production requirements for the Jensen Lumber Company project.



Complete drying facility at Jensen Lumber Company.

With the foregoing information, the project was formulated to demonstrate the use of drying technology in a configuration that would allow recovery of useable biomass energy resources by small and medium size forest products manufacturing firms.

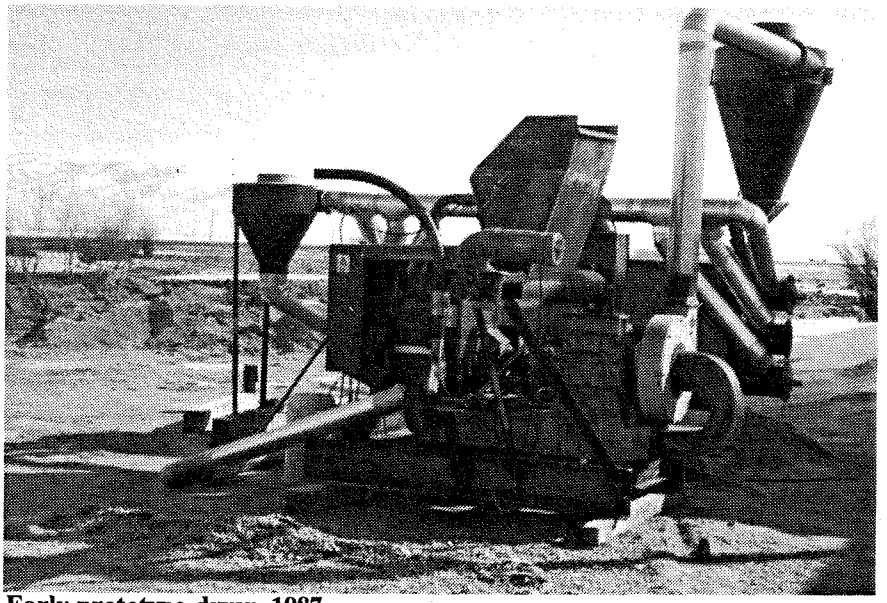
BACKGROUND

The need for feedstock drying capability became apparent soon after Jensen Lumber Company entered its densified fuel production venture in 1984. Early development of densified wood fuel at the Ovid site utilized Potlatch Presto-Log (TM) extruding machines in conjunction with the manufacture of the "Bear Lake" stove which was produced by Jensen Lumber between 1985 and 1986. Over 75 of these stoves were produced, and extruded pellet production continued until the introduction of the present generation pellet heating appliances, which utilize smaller diameter pellets.

During this development period, two prototype drying systems were tested by Jensen Lumber. The first was a wood-fired triple pass system in which the feedstock was passed through heated tubes by a series of screw augers. Following this effort, the system was enhanced by incorporating a hammer hog driven by a diesel engine. The engine exhaust was vented into the hog to add heat. Hogged material was then routed to the triple pass tubes which were heated with propane burners.

Both prototype dryers produced a product suitable for pellet manufacture, but at rather modest rates of production. It was becoming apparent that the increasing demand for pellets would allow production levels that far exceeded the economic capability of the drying systems projected by the prototype design.

This combination of increased demand for dry feedstock and the search for a highly energy efficient system prompted the decision to utilize a conventional single pass rotary drum dryer.



Early prototype dryer, 1987.

Jensen Lumber Company is a family owned small business and has successfully operated a sawmill at Ovid, Idaho since 1972 (Figure 1). The sawmill was designed to produce rough cut lumber and timbers. Later, in an attempt to better utilize the volume of small diameter timber being harvested from the nearby Caribou

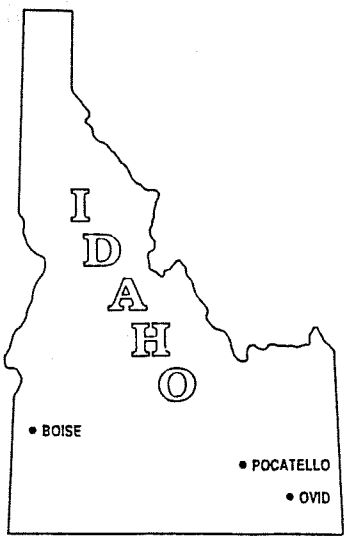


Figure 1. VICINITY MAP

National Forest, a small log break down facility was added. The intent of the break down side was to rip small logs into two inch cants, air dry the cants and subsequently re-saw the cants into studs (2x4 and 2x6). The re-saw process yields residue which is suitably dried for pellet production. Later, Jensen Lumber added planer equipment to produce surfaced studs, which resulted in additional air dried feedstock for production of the firm's Red-E-Fuel (TM) pellets.

However, the market for fuel pellets increased dramatically during the 1987-1988 heating season. Pellet production capability and market demand exceeded the limited dry feedstock supply, even when supplemented by the purchase of dry products from nearby wood processing facilities.

In the Fall of 1988, serious consideration was undertaken to locate a drying system that could provide the dry feedstock requirements for the Ovid pellet mill. It was apparent that the margin for drying cost in the total unit cost of the final product could not support newly manufactured drying equipment. Likewise, because of the dry wood residue associated with pellet production, a wood fueled drying system was preferred over conventional fossil fueled systems due to the readily available and lower cost wood supply at the sawmill. This resulted in a search for previously operated dryer components that could be moved to Ovid and assembled on the site.

Contact was made with Mr. A.B. Baardson, President of Red Crown Engineering & Manufacturing, Inc., Sisters, Oregon.

Red Crown had successfully designed and manufactured medium size wood fired suspension burners and dryers. Mr. Baardson is currently involved in the sale of previously used equipment. At the time, he was able to locate a Red Crown burner, a Mill Conversion Contractors Inc. (MCCI) dryer tube, and most of the peripheral equipment needed for the proposed project.

In February, 1989, Jensen Lumber entered into a purchase agreement with Red Crown to acquire the available equipment to begin developing the project.

During the development of the densified biomass fuel program at Jensen Lumber, considerable company capital was invested in product development. In 1987, a $100,000 loan was obtained through the Idaho Department of Water Resources Energy Conservation Loan Program. This loan assisted in the purchase of processing equipment for pellet production.

In 1988, when the dryer project was beginning to unfold, Jensen Lumber responded to the Idaho Department of Water Resources Energy Division solicitation for bioenergy demonstration projects (Galinato, 1988). Subsequently, a $30,000 grant was awarded to Jensen Lumber to demonstrate the ability to dry sawmill residue for pellet production using equipment which uses very little fossil fuel and is in the price range affordable by small to medium scale forest products firms. The grant money was combined with $102,000 of company capital to finance the project.

During the several year period that the "pellet production" idea was taking shape, Jensen Lumber received continuous encouragement and support from state and local commerce and economic development agencies. This support, the current and projected demand for wood pellets, and the very active sale of heating appliances, has provided the confidence that production of a biomass energy product in the form of densified pellet fuel is a viable venture.

DRYER OPERATION

The thermal drying principle utilized by the Jensen Lumber system involves moving wood products which have been sized to uniform dimension, through a rotating drum with hot gases. Lower air pressure at the discharge end of the drum facilitates movement of the hot gases and wood products (Livingston, 1976).

Temperature sensors at both inlet and discharge ends of the dryer provide feedback for control of energy input and product flow into the system.

The burner is made up of two distinct parts. The first part is a suspension combustor, or primary burner, where a portion of the dry wood coming from the dryer is injected under high pressure air into a preheated refractory lined chamber. The second part is a second stage burner, which consumes unburned particulate matter being recycled from the dryer by a cyclone separator.

Exit gas temperature from the burner is reduced below the exhaust temperature of the primary burner by blending recycled air in the second stage burner.

This feature recycles large volumes of process gases (approximately 60%), which contain quantities of particulate. The particulate material is given an opportunity to burn out and the remaining ash is separated by cyclonic effect in the second stage burner.

Air blending allows lowering of temperature where it is desirable to have process air temperature less than combustion gas temperature.

This principle results in clean burning at controlled temperatures without fossil fuel, and produces large quantities of heated air.

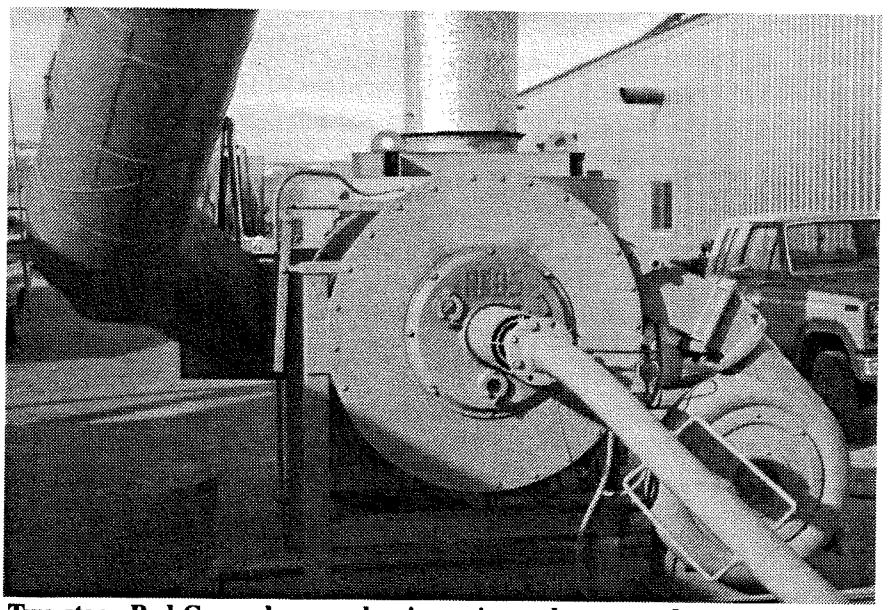
Burning at lower controlled temperatures also extends service life of combustion and burning equipment by reducing the effect of excessive temperatures.

Propane fuel is used during startup to preheat the primary burner. This sequential operation involves gas, gas with wood, and finally total wood. During the short time that the dryer has been in operation, there has not been a situation in which the system has returned to gas after burner operating temperature has been reached. This may be, in part, due to the moisture characteristics of the fuel, which is below 10% moisture content (W.B.). The sequential startup phase requires about 30 minutes to attain burner operating temperature.

DRYER SYSTEM

The dryer equipment components were delivered to Ovid, Idaho, by truck from Portales, New Mexico, and Vicksburg, Mississippi. The equipment began arriving in early February 1989 and was unloaded and stored at the plant site until warmer weather allowed proceeding with construction.

Following ground thawing, concrete footings and foundation structures were constructed and placement of the large equipment components was completed by the end of May.

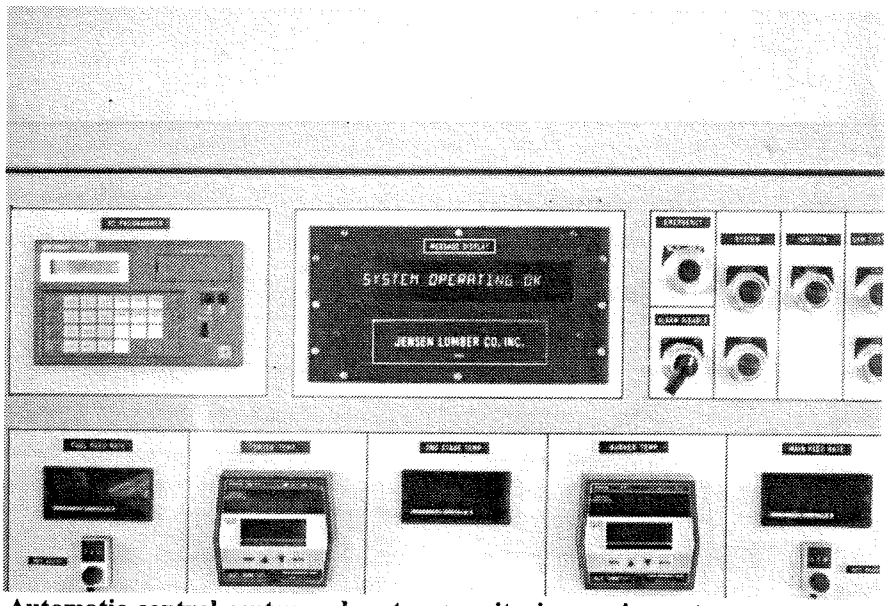


Two stage Red Crown burner showing primary burner and waste air return to secondary burn chamber.

The two stage wood-fired suspension burner, provided by Red Crown Engineering is unique in that it is designed to recycle and refire emissions returned from the dryer and transfer this heat back to the dryer or to a waste heat boiler if desired. This burner is rated at eight million Btus per hour. The primary stage of the burner is initially fired with propane and automatically switches to wood when desired temperature is reached.

Erection of some peripheral equipment was slowed due to severe damage to one of the fuel storage bins, which occurred in transit, as well as the discovery of unacceptable wear and deterioration in several electric motors and associated moving parts. This resulted in the need to fabricate and install new storage bins, and to repair or replace motors and bearings.

The electric control system originally supplied by the vendor was found to be unserviceable due to prolonged weather exposure. A decision was made to upgrade the entire control system with new state-of-the-art automatic equipment. These materials were designed and installed by JAB-CO Electrical of Weston, Idaho. This technical upgrade constituted a major capital investment that had not been included in original budget estimates.



Automatic control center and system monitoring equipment

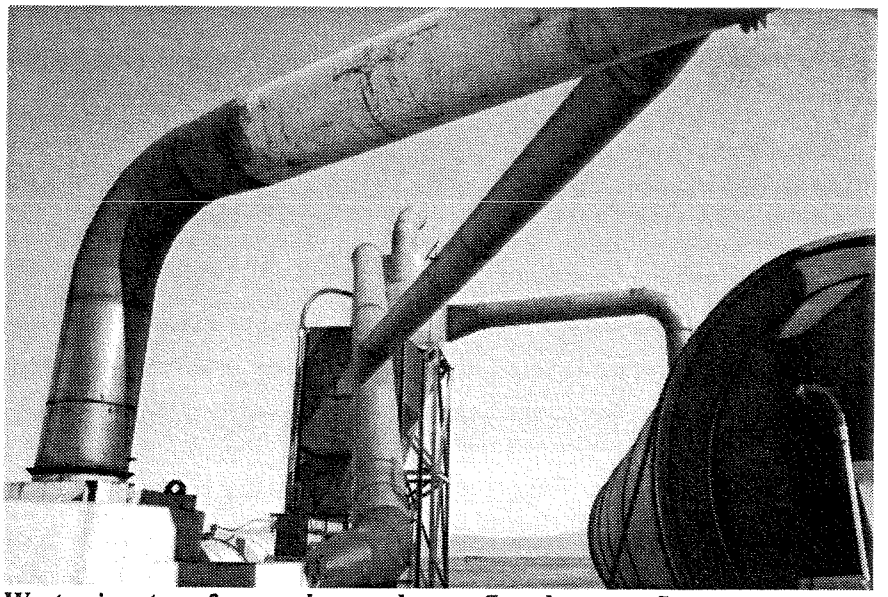
The air system and product flow duct work was installed by FAB-TECH, Incorporated of Salt Lake City, Utah. When the automatic control system was upgraded, the design included the installation of a series of air operated valves to control distribution of the dry feedstock. Control of these product distribution valves is programmed through the control center to automatically maintain product levels in the pellet mill and burner fuel storage bins. The balance of the dry material is routed to a dry product storage area. This system is also equipped with an automatic abort feature allowing direct discharge of all materials leaving the dryer in the event of malfunction or fire.

Initial test operation of the dryer began in early September, 1989, and continued throughout the month to correct operational difficulties, calibrate controls and tune the burner air system.

A significant retrofit in the hot air flow system was required at this time when it was discovered that proper air balance between the burner, dryer and secondary burner could not be maintained. A cross flow duct and damper system between the hot air duct and waste air return was installed and has resulted in improved burning characteristics and temperature balance throughout the system.

By late September, the dryer began operating for extended periods on a semi-production basis while the plant staff continued to fine tune the system. Some difficulty has been experienced with "bridging" of undried material within the primary storage bin during subfreezing weather. It is planned to eventually replace the existing bin with a larger "live bottom" bin and replace the existing diesel powered hammerhog with electric power.

Upon leaving the dryer tube, dried material and waste steam flow through a cyclone separator. Steam is discharged to the air and the dry feedstock is separated and routed to a storage bin. At this point, unburned particulate material is also separated in the cyclone and returned to the secondary burner, where it is refired. This action removes airborne particulates and provides additional heat to the entire process.



Waste air return from cyclone and cross flow duct retrofit.

The dry material flows to the storage bin, through a "rotary" valve into the pneumatic product distribution system. From this point, it is routed to the burner fuel storage bin, directly to the pellet mill, or to a dry storage area for later use (Figure 2).

The rotary valve supplied by the vendor proved to be a bottleneck in the system, and frequently plugged with dry material. This problem was corrected by replacement with a larger capacity valve.

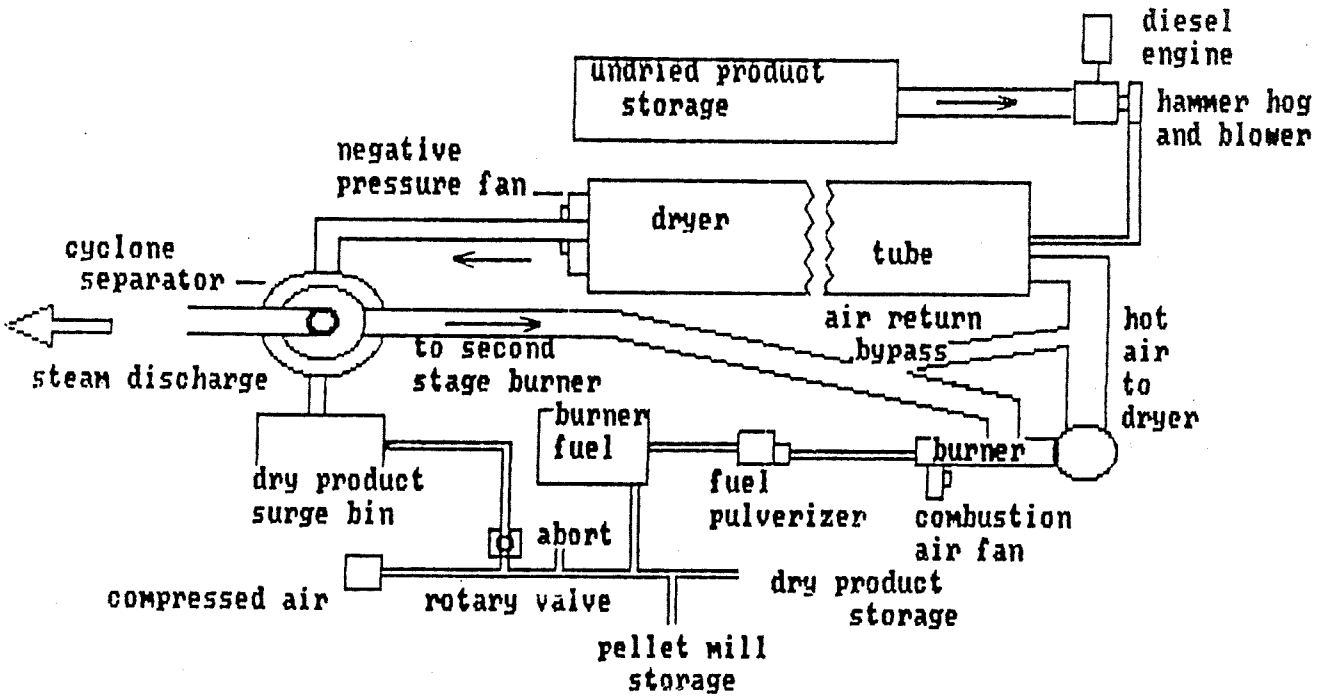


Figure 2. PRODUCT FLOW DIAGRAM

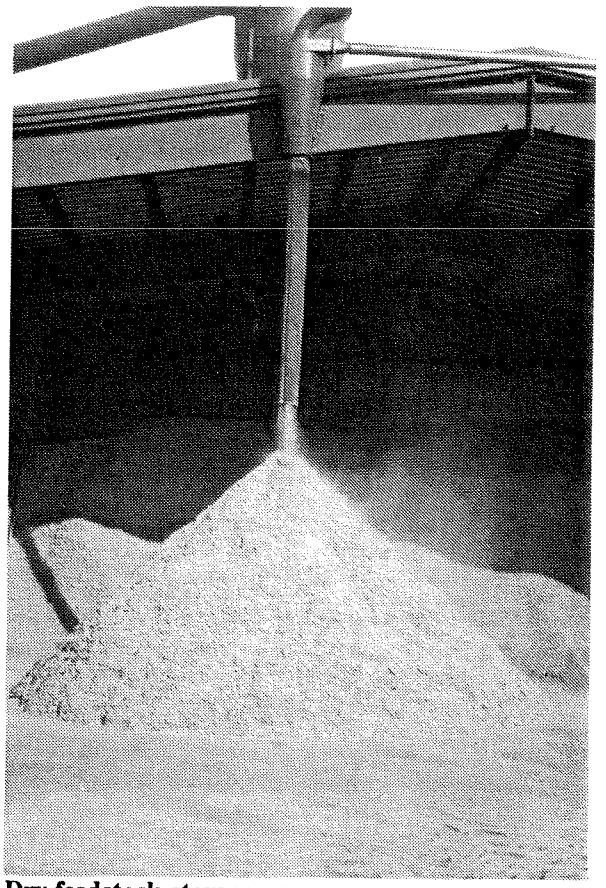
All dryer functions are monitored at the control center, which is designed for either automatic operation through a programmable micro-processor, or manually by an operator in attendance.

The system is equipped with audible alarms to alert plant personnel when preset conditions change. Unless corrections are made, the system will automatically initiate a shut down sequence to avoid equipment damage or excessive temperatures.

Sensors on the various storage bins relay information to the control center to maintain operating levels at all times. Excess feedstock is routed to the dry storage area.

Preliminary performance characteristics of the system are shown on Table 1.

This medium size dryer is expected to meet all the drying needs of a pellet plant producing 40 to 50 tons per day, at operating costs well within acceptable limits.



Dry feedstock storage area

Table 1. DRYER PERFORMANCE CHARACTERISTICS[1]

Initial product moisture content - undried material[2]	46 percent
Final product moisture[2]	6 percent
Burner temperature	1900 degrees F
Air temperature into dryer	580 degrees F
Air temperature at dryer exit	180 degrees F
Burner fuel consumption per hour (wood)	350-400 pounds
Net product dried per hour	3600-3800 pounds

[1] Based on five month production period.

[2] Wet Base (WB) moisture content in percent.

$$\frac{\text{Original Weight - Ovendry Weight}}{\text{Original Weight}} \times 100$$

CONSTRUCTION COST

For purposes of illustration the original project cost estimate is displayed in Table 2, with the final cost figures shown in the same format. Unusual variations are explained with footnotes.

Table 2. CONSTRUCTION COST

	ESTIMATED COST	ACTUAL COST
Machinery Purchase	$79,435	$47.756[1]
Site Preparation	2,000	5,143
Machinery Transport	7,000	7,643
Labor and Fringe Benefits	17,206	12,762
Misc. Material(iron, welding, parts, paint, etc.)	4,800	17,001[2]
Heavy lift Equip. (rental)	3,000	2,629
Electrical Wiring	5,634	[4]
Electronic Control Center	[3]	37,291
Air System Duct Work	[3]	12,563
Technology Transfer, Evaluation and Reports	5,000	3,540
Travel (in state)	500	----
Contingency	7,765	----
TOTAL	$132,340	$146,328

[1] Adjustment in original purchase agreement due to damaged and unserviceable equipment delivered by vendor.

[2] Additional cost associated with fabrication of new storage bins.

[3] Not included as an individual cost item in original proposal.

[4] Substitute electrical control center.

DRYER OPERATING COST

During the first five months of production drying, operating cost has been analyzed and is displayed in Table 3. The author hesitates to quantify cost of operation in great detail, due to the limited experience to date.

Several factors contribute to this "cautious" approach.

1. Frequent startup and shutdown to perform adjustments on automatic controls and other mechanical components.

2. Metering of propane fuel and electric energy is not isolated to just the dryer.

3. Operation of the equipment during warm summer conditions is just beginning.

Table 3. ANTICIPATED OPERATING COST OF BIOMASS DRYER

		Monthly Cost
Electric power		$1225
Propane fuel		630
Diesel fuel		209
Plant labor[1]		587
System maintenance[2]		400
	Total	$3051
Monthly production - 400 Tons[3]		
	Cost per ton	$7.63

[1] Dryer is operated by pellet plant staff, therefore cost is based on actual increment of time required (3 hrs. per shift).

[2] Normal periodic maintenance, parts replacement and burner service.

[3] Net dry material to pellet production.

DEMONSTRATION DAY

In mid February 1990 a public demonstration of the dryer and pellet production facility was held at the Ovid operation. Approximately 50 people attended. Those present included state and local officials, as well as wood products people interested in the pellet feedstock drying technology developed by Jensen Lumber Company.

During the demonstration, background information regarding the pellet operation was explained, including the financial support provided by the Idaho Department of Water Resources, Energy Division, through the grant for this project and a prior $100,000 low-interest loan to Jensen Lumber, which supported development of the densified biomass fuel production facility.

A detailed discussion of the control system was provided by JAB CO. staff. Many detailed questions were addressed by the Jensen Lumber employees during the complete "walk-through" of this integrated wood processing facility.

Several questions regarding the economics of biomass drying were raised by the visitors, including the cost to duplicate this type of drying system. Mr. Jensen reported that his original budget estimate of $132,000 was expected to be exceeded somewhat, due to the unplanned cost of the automated control system. Also the normal cost of installing previously used equipment was somewhat more than planned. However, at this time the total cost of the dryer will be well below the cost of a new manufactured drying system.

CONCLUSIONS AND RECOMMENDATIONS

The medium size biomass dryer described in the foregoing report is expected to meet the drying needs of a pellet plant producing 40-50 tons per day. Capital investment and cost of operation appear to be within the acceptable range of total manufacturing cost at the Jensen Lumber Company Red-E-Fuel(TM) pellet facility.

At this time, it is safe to say that the equipment components of a new drying facility of the type described in this report could exceed $300,000 if purchased from the manufacturer. The decision to gamble on used equipment appears to have been justified. After some redesign and retrofit, the dryer performance and total project cost is well within the expectations of both the vendor and Jensen Lumber.

The installation of a similar wood fired facility in areas with sensitive air quality requirements should receive careful consideration. If additional pollution control measures are required, cost will increase accordingly.

This contract was administered by the Idaho Department of Water Resources Energy Division. The completion date of the contract requires a project report soon after the dryer became operational. In the subject project, this requirement prevented development of reliable statistical performance and operating cost data, which comes with experience and time.

For further information, including a 10 minute video tape and 35mm slide presentation describing the construction and operation of this biomass dryer, contact the Idaho Department of Water Resources Energy Division, Statehouse Mail, Boise, Idaho 83720.

LITERATURE CITED

Farnsworth, Ellen. "The Technology For Manufacturing Densified Fuels Has Been Around A Long Time." Wood and Wood Products, November 1977.

Galinato, G.D. Financing Small To Medium-Sized Bioenergy Projects In Idaho. Paper presented at 5th Inland Empire Forest Products Marketing and Management Conference. Moscow, Idaho, July 1988.

Livingston, A.O. "Convey Products Pneumatically With Low Pressure Air Systems." Forest Products Research Society, Proceedings Number P-76-14, Atlanta, Georgia, November 1976.