THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

OZONATION PROCESS ANALYSIS

Project 2697-3

Report Three

A Progress Report

to the

FOURDRINIER KRAFT BOARD GROUP

OF THE

AMERICAN PAPER INSTITUTE

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SUMMARY

Results of previous research on this project have indicated that ozonation treatment of old corrugated (OCC) significantly increases most strength properties of OCC without any major reduction in freeness. Ozone treatments tend to produce microfibrillation and pitting of the fiber surface. This promotes better fiber-to-fiber bonding in the sheet.

An engineering cost assessment of the ozone process has been carried out at the Institute in cooperation with IMPCO, a Division of Ingersoll Rand. For a plant treating 100 TPD (o.d. basis) the operating costs were estimated to range from $15.9 to $17.6 per ton. Capital costs were estim ated to be $13.9 per ton amortized over 10 years. Some reduction in the capital costs per ton would be expected for a larger plant size.

The total costs for ozone treatment of OCC are estimated to be $28.8 - $31.5 per o.d. ton. Thus the process appears to be relatively expensive, in part because of the relatively large amounts of power required.

INTRODUCTION

A research project to maximize recycled fiber use in linerboard is being carried out at the Institute in cooperation with the Fourdrinier Kraft Board Group of the American Paper Institute. Increased use of recycled fiber will assist the industry to reduce needs for new capital investment, keep pollution abatement costs down and conserve resources.

One approach to improving the bonding potentials of recycled fibers is to utilize chemical treatments which will mildly increase delignification, swelling, or fibrillation of the fibers. The effects of various conventional chemical agents such as caustic soda, and green and white liquor were compared in Project 2697-3, Report Two (1). In general the treatments studied produced only modest changes in most properties of OCC.

In another major phase of the work, the effects of ozonation treatments on recycled fiber properties were studied. This research was carried out under Institute funding. The initial work (2) indicated that ozonation significantly increases most strength properties of repulped OCC without any major reduction in freeness. For example the burst and tensile properties of hand sheets made from OCC increased 35 and 26% repectively, after the fiber had consumed 2.3% ozone. Ozone treatments also tended to increase ring compression strength. Scanning electron micrographs show that ozonation of fibers produces microfibrillation of their surfaces. This promotes better fiber-to-fiber bonding in the sheet.

Additional research has been carried out on various ozonation process and fiber variables (3). Among other things these results indicated that

1. Ozonation treatments are not affected by the residual contaminants remaining in commercially cleaned OCC or by utilization of the asphalt dispersion process.

2. The long and short fiber fractions of OCC were ozonated separately and found to respond equally well to ozonation. Thus cost savings could be achieved if only one fraction requires treatment.

3. Prerefined OCC responds to ozonation in a similar manner to unrefined stock. Thus refining in combination with ozonation may achieve strength levels above those recorded by either process alone within reasonable operating parameters.

4. Limited trials suggest that blending ozonated OCC with prerefined virgin kraft may be more attractive than post-refining of ozonated OCC/virgin kraft blends.

All planned experimental ozonation research is complete.

Cost estimates in the ozonation process were made as part of the initial study (2). For a 300 ton/day plant using 2.5% O_3 on an o.d. basis, the operating costs were estimated to range from $12-14 per ton. Capital costs were estimated to be about $4.50-$5.00 per ton of treated fiber based on a 10-year amortization period.

To update the above, we carried out an engineering analysis of the ozonation process for the FKBG. Estimates of capital and operating costs for a 100 TPD treatment plant applying 2.5% O_3 (both on an o.d. basis) were made based on the process analyses.

Arrangements were made with IMPCO, a Division of Ingersoll Rand, to carry out the process analyses. Their letter reports are included as the Appendix to this report. The process flow sheet and cost estimates are summarized herein.

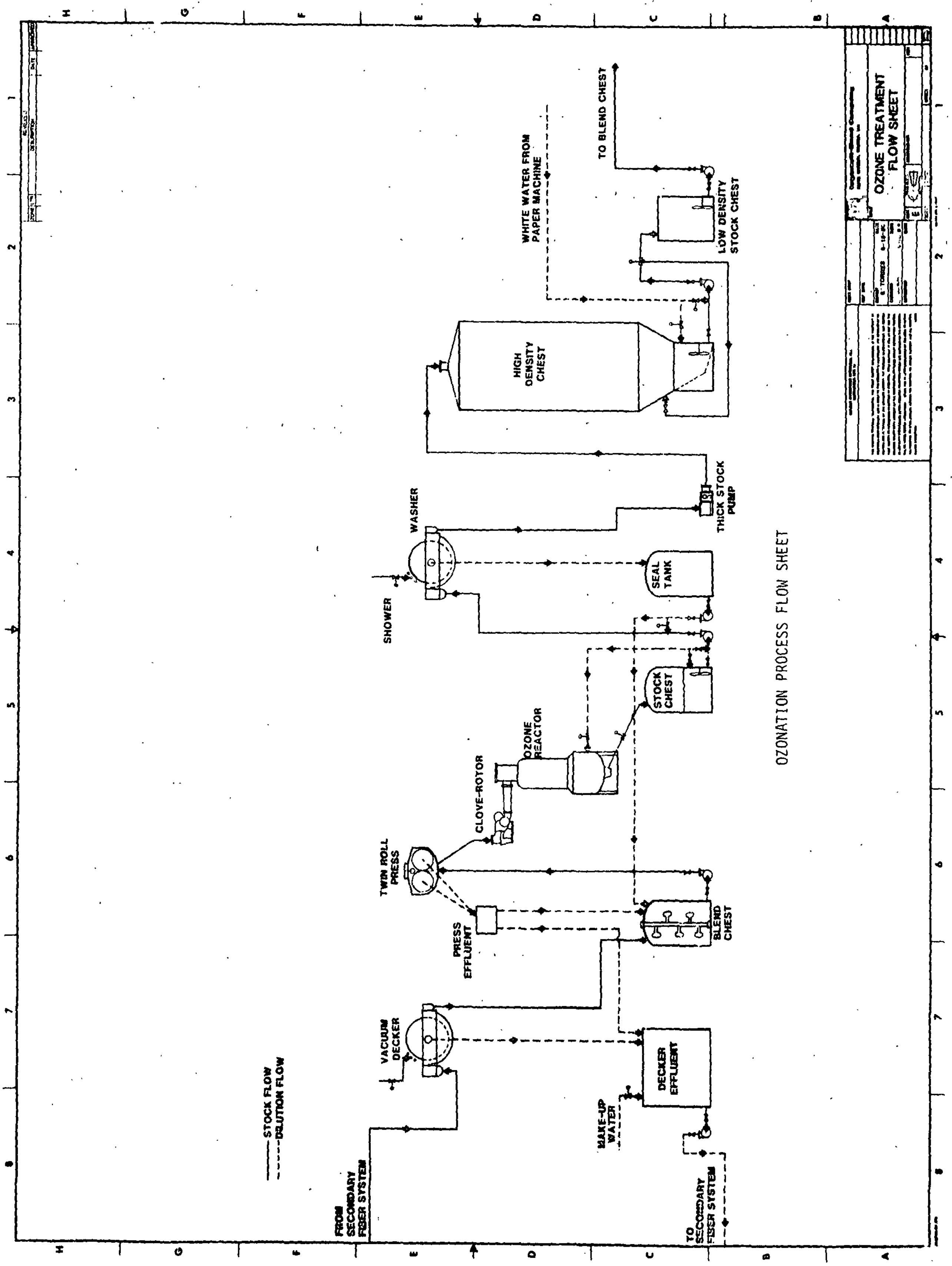
OZONATION TREATMENT SYSTEM

The flow sheet for the ozonation treatment system is shown in Fig. 1. The following process description was supplied by IMPCO.

The pulp leaving the thickener at the end of the Secondary Fiber System is diluted to 4-5% and stored in an agitated tank with about 10-20 minute capacity. From this chest the pulp is pumped to an IMPCO type TRC 600 x 1.5 Twin Roll Press for dewatering. The press will be provided with an automatic control system to deliver a measured, constant flow of pulp at 35-38% consistency to the ozone reactor. An IMPCO type 600 Clove-Rotor pump feeds the high consistency pulp to the inlet of an IMPCO fluffer located at the top of the ozone reactor.

The high consistency feed system is designed so that a very tight plug of pulp is formed between the Clove-Rotor pump and the fluffer. This assures that ozone gas cannot leak from the reactor back into the feed chute. The fluffer breaks the compacted pulp into small fiber aggregates, which are then contacted with an ozone-oxygen gas mixture in the reactor. The Clove-Rotor pump and fluffer combination has been in commercial operation for several years in oxygen bleaching systems for up to 600 TPD.

The IMPCO ozone reactor was developed specifically to handle a large flow of gas through a bed of fluffed pulp. A pilot reactor for 12 TPD has been in experimental operation since 1973 for ozone bleaching of chemical pulp. The principle of operation has been demonstrated at a 300 TPD scale. The pulp is first contacted with the ozone at the top of the reactor where the fluffed pulp at high turbulence falls down to the top of the column of pulp. This column moves slowly and continuously downward while the gas is flowing through and the ozone then leaves the reactor and is recycled for purification and ozone generation.



OZONATION PROCESS FLOW SHEET

At the bottom of the reactor the pulp is diluted to 3-4% and agitated before it is discharged to a pump chest. The zone of dilute pulp at the bottom of the reactor seals against the atmosphere and prevents ozone from escaping with the pulp. The reactor is operated at ambient temperature and a few PSI above atmospheric pressure.

In the reaction between ozone and pulp, some of the lignin will be oxidized to organic acids and the pH will be around 4. The environment is not very corrosive and regular stainless steel, Type 316 or Type 317, has proven adequate. Because of the acidic condition of the pulp, we have suggested a washing stage prior to sending the pulp to the paper machine. The washer will discharge the pulp at 12%, suitable for high density storage, if so desired. However, further studies should be made to see if the washing stage can be omitted, thereby reducing the system cost.

Generation of ozone for this system can be done by any of several commercially proven systems available on the market. Because of the relatively large quantity of ozone required, about 2.5% on pulp, it is less expensive to produce ozone from pure oxygen than from air. A normal system will produce 3% ozone by weight in oxygen gas, and the oxygen will be reused after the contact with the pulp. Organic components, moisture and other impurities present in the oxygen gas after the contact with the pulp must be removed before the oxygen reenters the ozone generator.

CAPITAL AND OPERATING COSTS

Cost estimates to obtain a 35% burst improvement using 2.5% O_3 are shown in Table I. The capital costs are based on treatment of 100 o.d. ton/day of OCC and were supplied by IMPCO. Their capital cost estimate for a 100 TPD system was 5 million dollars. This includes 1.1 million dollars for the pulp-handling equipment, 2.4 million dollars for the O_3 generators and O_2 recycle system, and 1.5 million dollars to cover installation, piping, engineering, etc.

IMPCO commented that the costs for the total system escalate very little with system capacity. Consequently the costs per ton will be much higher for a 100 TPD system as compared to a larger system. For example based on conversations with IMPCO it was estimated that the capital cost for a 200 TPD system would only be 6.5-7.5 million dollars.

The operating cost estimates range from \$15.9-17.6 per ton depending on variations in oxygen and labor costs. The operating costs will also vary directly with the cost of power which was estimated at 4 cents/kw-hr.

Considering both capital and operating costs the total costs per ton of treated fiber are estimated at \$28.8-31.5. This estimate does not consider possible savings in refining energy. Because the ozonated fibers may require little refining, it appears that savings in refining energy could amount to several dollars per ton.

In 1978 the estimated total costs were \$16.50-\$19.50 per ton. Considering inflation, the 1978 estimates compare quite well with the current estimate.

Considering the total cost, it appears that the ozonation process for treating OCC is too expensive for practical use in most commercial applications.

TABLE I

OZONATION COST ESTIMATES

BASIS

35% Burst Improvement, 2.5% O_3 Applied/o.d. ton
100 o.d. tons/day OCC treated
O_3 Required: 2.5 tons
Power Cost: 4¢/kw-hr
O_3 Concentration: 2% in O_2
O_2 Recycling Rate: 95% +
O_2 Required: 2.5 tons or less
Power, O_3 generation, O_2 recycle, pulp handling: 1250 kw

CAPITAL COSTS: (Million $)

	100 Ton/Day	200 Ton/Day
Ozone Treatment System		
Pulp Handling Equipment	1.1	-
O_3 Generators and O_2 Recycle System	2.4	-
Installation, Piping, Electrical, Building & Engineering	1.5	-
Total	5.0	6.5 - 7.5

OZONATION

Operating Costs, $/Ton	
Electrical (at 4¢/kw-hr):	12.00
Oxygen:	1.0 - 2.0
Labor and Maintenance:	2.9 - 3.6
Total	15.9 - 17.6
Costs/Ton of O_3 Treated Fiber, $	
Operation:	15.9 - 17.6
Capital (10-year amortization)	13.9
Total	28.8 - 31.5

NOTE: Capital costs for a 200 ton/day plant are estimated at 9.0 - 10.4 dollars/ton

The process requires considerable amounts of energy and this is a drawback in an era of rapidly increasing power costs. Under special circumstances--e.g., available on-site excess O_2/O_3 generating facilities or treatment of only the short hardwood fraction of OCC--the costs might become more realistic.

LITERATURE CITED

1. Effect of chemical treatments on OCC properties. Project 2697-3, Report 2, to the FKBG of the American Paper Institute, May 19, 1980.

2. Effect of ozonation on recycled fiber properties. Project 2697-53, Report 1, to Members of The Institute of Paper Chemistry, Sept. 24, 1978.

3. Ozonation of recycled fiber: Process and fiber variables. Project 2697-53, Report 2, to Members of The Institute of Paper Chemistry, June 15, 1980.

THE INSTITUTE OF PAPER CHEMISTRY

Wm C Krueger

William C. Krueger
Group Leader
Special Processes Group
Engineering Materials & Special
Processes Section
Engineering Division

W J Whitsitt

William J. Whitsitt
Research Associate
Paper Materials & Systems Division

APPROVED BY:

Clyde H. Sprague

Clyde H. Sprague
Director
Paper Materials & Systems Division

APPENDIX

IMPCO CORRESPONDENCE

Ingersoll-Rand
Pulp Machinery

IMPCO

May 6, 1980

Dr. W. J. Whitsitt
Research Associate
The Institute of Paper Chemistry
Appleton, Wisconsin 54911

Dear Dr. Whitsitt

I am sending you our description of a complete system for post-consumer corrugated reclaim, cleaning and ozone treatment. In a few days, I will also send you a large flowsheet for display and a set of slides for your presentation to the FKBG next month.

The process description follows the flowsheet and you may want to follow this in your presentation. The equipment cost is based on our current selling price and estimates of auxiliary equipment not manufactured by IMPCO. Installation, electrical, piping and controls, building and engineering costs were estimated using factors for typical average mill systems. This may vary substantially in individual cases depending on local conditions.

We also want to point out that the estimate is made for a 100 TPD system, whereas many of the components in the system are capable of higher capacities because it is the smallest standard size available. Many of the additional costs for the total system escalate very little with the system capacity; therefore, the capital cost per ton of pulp will be much higher for a 100 TPD system than for, say, a 300 TPD system.

I included only a short description of the ozone generation. For further details of this system, I am sending you one original and two copies of literature on ozone generation, available from Emery Industries, Inc.

I hope this will fulfill your needs for your presentation, but we will be very happy to furnish more information or answer any questions that you may have. It has been a great pleasure to be working with you and we appreciate the opportunity to be of assistance to you.

Very truly yours,

Rudi W. Schleinkofer

Rudi W. Schleinkofer
Manager of Process Development

RWS/cza

Enclosures

150 Burke Street, Nashua, N.H. 03061 Phone 603 882 2711

Ingersoll-Rand
150 Burke St., Nashua, N.H. 03061

POST-CONSUMER CORRUGATED RECLAIM SYSTEM WITH OZONE TREATMENT FOR STRENGTH DEVELOPMENT

Description and Cost Estimate for a 100 TPD System

by

J. K. Perkins

B. D. Hartel

R. W. Schleinkofer

INGERSOLL-RAND COMPANY
IMPCO DIVISION
NASHUA, NEW HAMPSHIRE

SECONDARY FIBER SYSTEM

The following is a description of the equipment layout for a Secondary Fiber System to produce 100 TPD of clean secondary fiber furnish for use in kraft sheet as a supplemental furnish.

You will note that we have not included an Asphalt Dispersion System for as far as we can tell by talking to mill personnel relatively recently, they do not feel that asphalt contamination is a real problem. Hot melts and some waxes are, but if they pulp at a relatively cold temperature (around 120°F), plastics, hot melts, waxes, and so forth are not broken down so small that they cannot be removed from the paper stock by means of screens and/or reverse flow cleaners.

We feed a continuous pulper by means of a slat-type conveyor which will hold whole bales of waste paper. The pulper is equipped with a junk tower. There is a clamshell and hoist mounted on a monorail over the pulper so that junk can be extracted from not only the junk tower but also the tub of the pulper itself. It is important to keep in mind that the extraction plate will normally have 5/8" diameter or 3/4" diameter extraction holes. We call this "Macro Pulping". This is done to keep contaminants in as large a size as possible to make them easier to remove. Many mills do not have a surge chest following the continuous pulper but rather go directly to cleaning equipment. We feel it is better to have a surge chest to let consistencies and flows level out.

This would be an agitated chest since the system is based on pulping at 4% consistency and storing at 4% consistency or a little less. We would pump directly from the agitated dump chest to an IMPCO/Escher Wyss Fibersorter. This Fibersorter is a Fiberizer having 0.1" extraction holes in the extraction plate with accepts discharging into an intermediate chest. The light reject bleed as well as the outlet for the normal heavy reject bleed would both go to a rejects tank from where it would be pump through high density cleaners and through another Fibersorter with the accepts from this Fibersorter going to the intermediate chest also. Both Fibersorters have 0.1" extraction holes.

There would be a junk trap with isolation and dump valves on this second Fibersorter. The light rejects bleed would go continuously to a vibratory tailing screen with the accepts from this tailing screen going to a tower on the intermediate chest. The reason for the tower is to prevent these accepts from the vibratory tailing screen, which are at a lower consistency than that of the stock in the chest, from diluting the stock in the chest.

Control valves on the discharge side of the Fibersorters are remotely controlled by "power packs" on each Fibersorter main drive motor. As contraries tend to collect in the housings of the Fibersorters, they will require more power from main drive motors. This will send a signal to the appropriate control valve. The valve will be throttled and thus cause more rejects to be flushed from the Fibersorter. As the power load drops, the valve will reposition itself.

A pump at the intermediate chest would take stock and transfer it to the suction side of a pump on the "backwater" chest, where it is diluted and pump through pressure screens having perforations as well as the secondary pressure screens having slots. Rejects from these screens would go to a drainer for thickening to 3.5 to 4% consistency and then into a small screen rejects tank.

From this screen rejects tank they would pump through a Deflaker to a vibratory tailing screen for recovery of fibers that will be in the rejects from the pressure screens. Accepted stock from the slotted screen would go to the cleaner feed chest, which again is agitated. This chest would also have a tower on it so that "recleaner" accepts and rejects could be joined and piped to the tower on the suction side of the pump taking stock from the cleaner feed chest. That pump takes stock and pumps it directly to the primary stage of a three-stage low density cleaning arrangement. Accepts from this primary stage would go to the disc thickener, where the stock would be thickened from approximately .7% consistency up to about 8-10% and then diluted down to about 4-5% consistency.

The rejects from the primary stage of the centrifugal cleaners would go through a secondary stage, with the rejects from the secondary stage going through a tertiary stage. Rejects from the tertiary stage would be sewered, but accepts from the tertiary stage would be fed back through the secondary stage and the accepts from the secondary stage would be fed back to the primary stage by piping them back to a tower on the cleaner feed chest.

The primary stage of the centrifugal cleaner banks would have core bleed for removal of light particles that are in the stock furnish. This core bleed would go to a small tank and from there it would be pumped through "recleaners", where the highly concentrated light rejects from these "recleaners" would be piped to a drainer so that the water could be reclaimed and the rejects dewatered. Normal accepted stock from the "recleaners", as well as the normal rejects from the "recleaners", would be piped back to the tower on the cleaner feed chest for recycling through the system again.

OZONE TREATMENT SYSTEM

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At the bottom of the reactor the pulp is diluted to 3-4% and agitated before it is discharged to a pump chest. The zone of dilute pulp at the bottom of the reactor seals against the atmosphere and prevents ozone from escaping with the pulp. The reactor is operated at ambient temperature and a few PSI above atmospheric pressure.

In the reaction between ozone and pulp, some of the lignin will be oxidized to organic acids and the pH will be around 4. The environment is not very corrosive and regular stainless steel, Type 316 or Type 317, has proven adequate. Because of the acidic condition of the pulp, we have suggested a washing stage prior to sending the pulp to the paper machine. The washer will discharge the pulp at 12%, suitable for high density storage, if so desired. However, further studies should be made to see if the washing stage can be omitted, thereby reducing the system cost.

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May 1980

CAPITAL COST AND POWER REQUIREMENT

Secondary Fiber System

Process Equipment	$1,385,300
Installation, Electrical, Piping, Building and Engineering	$2,100,000
	$3,485,300

Motors for equipment require 1200 HP installed. Estimated operating power is 750 kw.

Ozone Treatment System

Equipment for Pulp Handling	$1,090,500
Ozone Generators and Oxygen Recycle System	$2,380,000
Installation, Electrical, Piping, Building and Engineering	$1,500,000
	$4,970,500

Motors for pulp equipment require 400 HP installed. Estimated operating power is 250 kw.
Power required for ozone generation and oxygen recycle is 1000 kw.

Total cost for complete system:	$8,455,800
Total power consumption:	1,750 kw

May 1980