

PROJECT ADMINISTRATION DATA SHEET

ORIGINAL
 REVISION NO. _____

Project No. A-2969

DATE: 6/26/81

Project Director: Carol A. Aton School/Lab TAL/ECD

Sponsor: Battelle; Pacific Northwest Laboratories; Richland, Washington

Type Agreement: work order #B-83675-A-L under BOA #B-82912-A-L*

Award Period: From 6/1/81 To 10/19/81 (Performance) ---- (Reports)

Sponsor Amount: \$44,708 Contracted through:

Cost Sharing: _____ GTRI/~~CRK~~

Title: Assessment of Energy Conservation in the Textile Industry.

ADMINISTRATIVE DATA

OCA CONTACT Leamon R. Scott

1) Sponsor Technical Contact: Nancy L. Moore; Battelle; Pacific Northwest Laboratories;
P.O. Box 999; Richland, Washington 99352

2) Sponsor Admin./Contractual Contact: Ms. Ellen McCoy, Subcontract Specialist;
Battelle; Pacific Northwest Laboratories; P. O. Box 999; Richland, WA 99352
phone 509-376-0230

Reports: See Deliverable Schedule Security Classification: N/A

Defense Priority Rating: N/A

RESTRICTIONS

See Attached government Supplemental Information Sheet for Additional Requirement

Travel: Foreign travel must have prior approval - Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of \$500 or 125% of approved proposal budget category.

Equipment: Title vests with none proposed

COMMENTS: * under prime contract #DE-A-AC06-76RLO-1830

COPIES TO:

Administrative Coordinator	Research Security Services	EES Research Public Relations
Research Property Management	Reports Coordinator (OCA)	Project File (OCA)
Accounting Office	Legal Services (OCA)	Other: _____
Procurement/EES Supply Services	Technical Reports	

SPONSORED PROJECT TERMINATION SHEET

28 1177 2e

Date 1/29/82

Project Title: Assessment of Energy Conservation in the Textile Industry

Project No: A-2969 (subproject is E-27-607)

Project Director: Carol A. Aton

Sponsor: Battelle; Pacific Northwest Laboratories; Richland, Washington

Effective Termination Date: 12/31/81

Clearance of Accounting Charges: _____

Grant/Contract Closeout Actions Remaining:

- Final Invoice ~~and Closing Documents~~
- Final Fiscal Report
- Final Report of Inventions
- Govt. Property Inventory & Related Certificate
- Classified Material Certificate
- Other _____

Assigned to: TAL/PD (School/Laboratory)

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 Computer Input
 Project File
 Other File E-27-607 ✓
 & School distribution

A-2969

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

July 13, 1981

Ms. Ellen McCoy
Subcontract Specialist
Battelle
Pacific Northwest Laboratories
Box 999
Richland, Washington 99352

Subject: Assessment of Energy Conservation in the Textile Industry
Program Monthly Technical and Administrative Reports for
EES/GIT Research Project A-2969 for June 1981

Dear Ms. McCoy,

This report summarizes the technical and administrative activities on Research Project A-2969 for the month of June 1981, as discussed with Nancy Moore in a meeting at Georgia Tech on July 8, 1981.

June Activities

1. Technical and Administrative Highlights:

- Formulated a list of 28 companies having implemented energy conserving technologies in all areas of the textile industry (list is attached),
- Developed a telephone survey form to record responses from plant personnel when contacted about participation in the project (form attached).
- Contacted the 28 companies by telephone to determine their willingness to participate in the project.
- Estimated the overall impact of the case study results on the textile industry. The impact was based on the percentage of the industry having the equipment or process involved in the case study. (Results recorded on the plant contact form).
- Finalized project plan and personnel assignments (project plan attached).

Ms. Ellen McCoy
July 13, 1981
Page Two

- Received responses from 16 of the 28 plants contacted by the end of June, with 6 companies agreeing to participate in the program.
 - Developed case study format (format and sample case study enclosed).
2. Comparison to Project Plan
Still require 4 plants to agree to participate in the program.
 3. Reason for Schedule Slippage
Plants have been much slower to respond than originally anticipated.
 4. Problems Encountered
Many of the plant contacts have had to receive approval from higher management, which has taken longer than originally anticipated.

July Plans

1. Continue to pursue responses from plants already contacted.
2. Contact New plants, if necessary, to obtain ten case studies.
3. Begin 3 case studies.
4. Complete 1 case study.

Respectfully submitted,

Rachel L. Moore
Assistant Project Director

Carol L. Aton
Project Director

mro

Enclosures

BATTELLE CASE STUDY CONTACTS

<u>TECHNOLOGY</u>	<u>PLANT TYPE</u>	<u>PLANT LOCATION</u>	<u>ESTIMATED IMPACT</u>	<u>RESPONSE</u>
Boiler Economizer	Upholstery	NC	70	Yes
Wood Fired Boiler	Carpet Yarn*	GA	70	No
	Carpet	GA		
Dryer Controls	Upholstery	SC	60	
	Carpet	GA		
Dryer Heat Recovery	Apparel	SC	60	No
	Carpet	GA		
Water Heat Recovery	Apparel	GA	50	No
Solar Process Heat	Gauze*	TX	50	Yes
Ion Control	Yarn	GA	50	No
	Yarn	VA		
Foam Finishing	Sheeting*	SC	30	
	Corduroy	SC		No
Bump and Run	Carpet*	GA	30	Yes
Beck Modifications	Carpet	GA	25	No
Indirect Steam Heating	Carpet	GA	25	Yes
Steamer Controls	Carpet	GA	25	
Carpet Backing	Carpet		35	
Dyebath Reuse	Hosiery*	NC	30	No
Hyperfiltration	Upholstery*	SC	30	
Machnozzle	Sheeting	SC	30	No
Combined Preparation	Towel	AL	25	No
Caustic Recovery	Sheeting	AL	25	No
Low Temperature Curing			20	
Hot Melt Slashing			20	
Water Chlorination	Carpet	GA	20	Yes
Tandem Bleach/Scour	Hosiery	AL	15	Yes
Poly/Cotton Dyeing			15	

*DOE Sponsored

TEXTILE CASE STUDY TELEPHONE SURVEY

PLANT: _____ PHONE: _____

ADDRESS: _____

CONTACT: _____ TITLE: _____

TECHNOLOGY: _____

SURVEYOR: _____ DATE: _____

SURVEYOR, REMEMBER: THE FEWER QUESTIONS YOU ASK, THE BETTER. IF THE INDIVIDUAL BEING SURVEYED VOLUNTEERS ANY INFORMATION, WHETHER IT RELATES TO THE QUESTIONS OR NOT, WRITE IT DOWN. DO NOT HAVE THE PERSON CALL YOU BACK OR PUT YOU ON HOLD. FAMILIARIZE YOURSELF WITH THE SURVEY QUESTIONS BEFORE YOU CALL.

1. INTRODUCE YOURSELF BY STATING YOUR NAME AND SAYING THAT YOU ARE WITH GEORGIA TECH.
2. TELL THE INDIVIDUAL THAT YOU ARE WORKING ON A PROJECT TO IDENTIFY ENERGY CONSERVATION OPPORTUNITIES THAT HAVE BEEN IMPLEMENTED BY THE TEXTILE INDUSTRY.
3. STATE THAT YOUR PURPOSE IS TO FIND PLANTS TO PARTICIPATE IN THIS PROJECT SO GEORGIA TECH CAN PREPARE CASE STUDIES.
4. TELL THE INDIVIDUAL THAT BY BEING A PARTICIPANT IN THIS PROGRAM, HE WILL BE ENTITLED TO A COPY OF ALL OF THE CASE STUDIES THAT ARE PUBLISHED AND WILL AID IN THE POOLING OF INFORMATION ON ENERGY CONSERVATION, THUS HELPING HIMSELF AND OTHERS.
5. SAY: "Would you be interested in participation?" Yes ___ No ___
(IF HE SAYS NO, GO TO PAGE 4) IF YES: comments:

6. SAY: "As a participant in this program, personnel from Georgia Tech would spend one day visiting your plant. They would collect pertinent energy and process data and observe the energy conserving measure that you have installed. Would this present any problems?"

Yes ___ No ___ Comments: _____

7. SAY: "As a participant in this project, it is also required that you state for public information the following items:

- Company name
- Company address
- Employee contact
- Employee's telephone number
- Description of process or technology implemented
- Description of products produced
- Energy consumption and costs in years before and after new energy efficient technologies implemented
- Energy savings resulting from the implementation of new energy efficient technologies
- Description of investment decision making process (i.e., payback, ROI, etc.)
- Description of any institutional and environmental considerations

Would this present any problems?" Yes ___ No ___

Comments: _____

8. SAY: "Based on all of these criteria, are you still interested in participating in this program?" Yes ___ No ___

Comments: _____

9. IF HE SAYS NO, ASK: "What changes would have to be made in this program before you would consider participating?" _____

"If these changes were made, could we contact you again to ask for your participation?" Yes___ No___

Comments: _____

10. IF HE SAYS YES, SAY: "Thank you very much for your time. We will contact you soon to schedule a plant visit."

11. IF HE SAYS NO INITIALLY, ASK: "Why do you not want to participate?"

12. THANK HIM FOR HIS TIME.

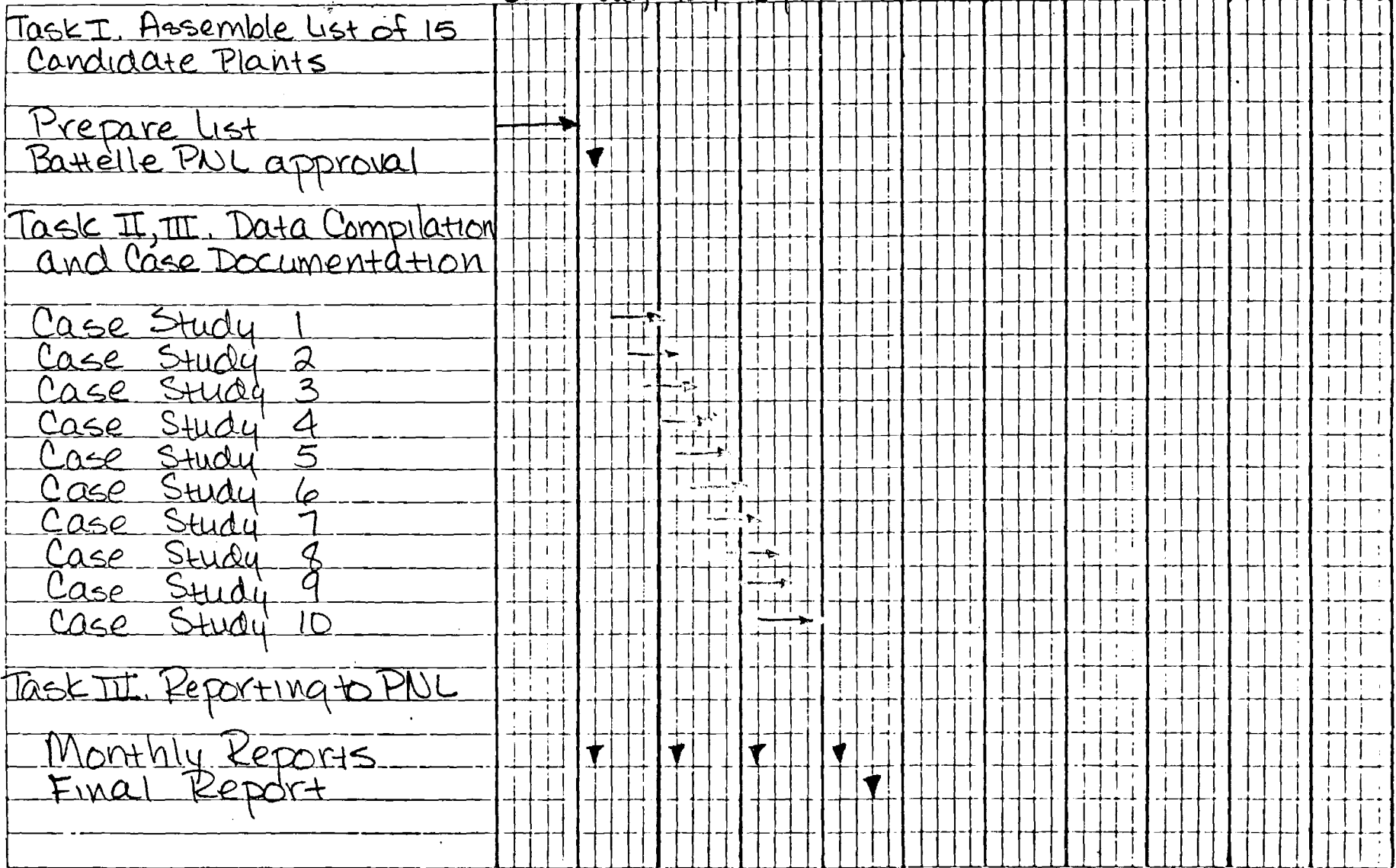
Project No. A-2969

PROJECT PLAN

Project Title Battelle Textile Case Studies

Project Director C. L. ATON

June July Aug Sept Oct



LEGEND

CASE STUDY FORMAT

- I. Introduction/Background
- II. Traditional Operation
- III. Modifications
- IV. Results/Energy Savings
- V. Summary
 - A. Investment decision criteria
 - B. Other benefits

THE INDUSTRIAL ENERGY EXTENSION SERVICE

-a joint service
GEORGIA'S OFFICE OF ENERGY RESOURCES AND
GEORGIA TECH'S ENGINEERING EXPERIMENT STATION

CASE STUDY: 22037

DIFFERENTIAL PRESSURE CONTROLLER ON A KUSTER
RANGE STEAMER

SAMPLE

Prepared by: Robin Farrow
Plant Code: 22037
Plant Type: Carpet Dyeing and Finishing
Date: 4/5/79

CASE STUDY: 22037

DIFFERENTIAL PRESSURE CONTROLLER ON
A KUSTER RANGE STEAMER

Background

The Kuster Range is a common continuous dyeing machine found in the carpet segment of the textile industry. Dyeing carpet openwidth in long production runs, this machine requires a great deal of thermal energy in the form of steam. Measurements were made on a major carpet manufacturer's Kuster Range and it was found that in this particular case the bulk of this energy was being supplied to the horizontal and vertical steamers (Figure 1). Furthermore, it was calculated that nearly half of the thermal energy supplied to this Kuster Range was ultimately lost out of the stacks of these two components (Figure 2). A very successful attempt was made, then, to reduce these stack losses.

Traditional Controls

The steaming process is necessary for fixing the dye to the carpet by subjecting it to an elevated temperature and an oxygen-free atmosphere. To assure that these conditions are met, the traditional practice has been to provide a sufficient steam flow for a maximum production run. This steam flow rate is set by the operator who opens the valve or it may be controlled by a temperature controller which adjusts the valve to maintain a desired temperature. Either method ignores changes in production rates and results in very high steam flow rates requiring exhaust stacks and sometimes fans. These are necessary to prevent the steam from discharging into the plant causing high heat and humidity.

Modifications

A possible means of controlling the steaming process is by maintaining a set pressure inside the steamer. The problem with the temperature controller

is that the steam temperature may be the same whether the steam flow rate is 3500 lb/hr or 15,000 lb/hr. A differential pressure controller, however, regulates the steam flow rate by maintaining a slight positive pressure inside the steamer. It works in conjunction with a temperature controller to maintain the desired degree of superheat. The positive internal pressure prevents air from entering the steamer and is maintained by compensating for changes in atmospheric pressure in the process room or for changes in production rate. The differential pressure controller regulates the steam flow valve to allow only the amount of steam necessary to make up for losses of heat through the steamer walls and for losses due to condensation on the fabric. This allows for a great reduction or elimination of exhaust, thereby minimizing the stack losses.

The exact type of controller installed on the steamer of this report is proprietary information and cannot be disclosed.

Operating Results

Steam flow measurements indicated that the steam flow rate to the vertical steamer is independent of carpet mass flow rate. The steam flow rates measured before and after the proprietary controller modification are recorded in the table below. As can be seen by these measurements, this modification

	STEAM RATE TO VERTICAL STEAMER
BEFORE MODIFICATION	14,330 lb/hr
AFTER MODIFICATION	7,868 lb/hr

cut the steam consumption to the vertical steamer by nearly half. The following table, based on average fuel costs and operating hours, relates the steam reduction to the dollar savings with the proprietary controller. It also gives a typical cost for a controller of the differential pressure type. The savings are so great in comparison to the cost, that the payback period is essentially negligible.

FUEL	COST	AVERAGE YEARLY OPERATING HOURS	AVERAGE FUEL COST
NATURAL GAS	\$1.45/MMBTU	4,000	\$1.70/MMBTU
#6 FUEL OIL	\$2.20/MMBTU	2,000	

BOILER EFFICIENCY	STEAM COST	STEAM SAVINGS	ANNUAL STEAM COST SAVINGS	CAPITAL COST
80%	≈ \$2.13/MMBTU	6462 LB/HR	\$82,584	\$1700

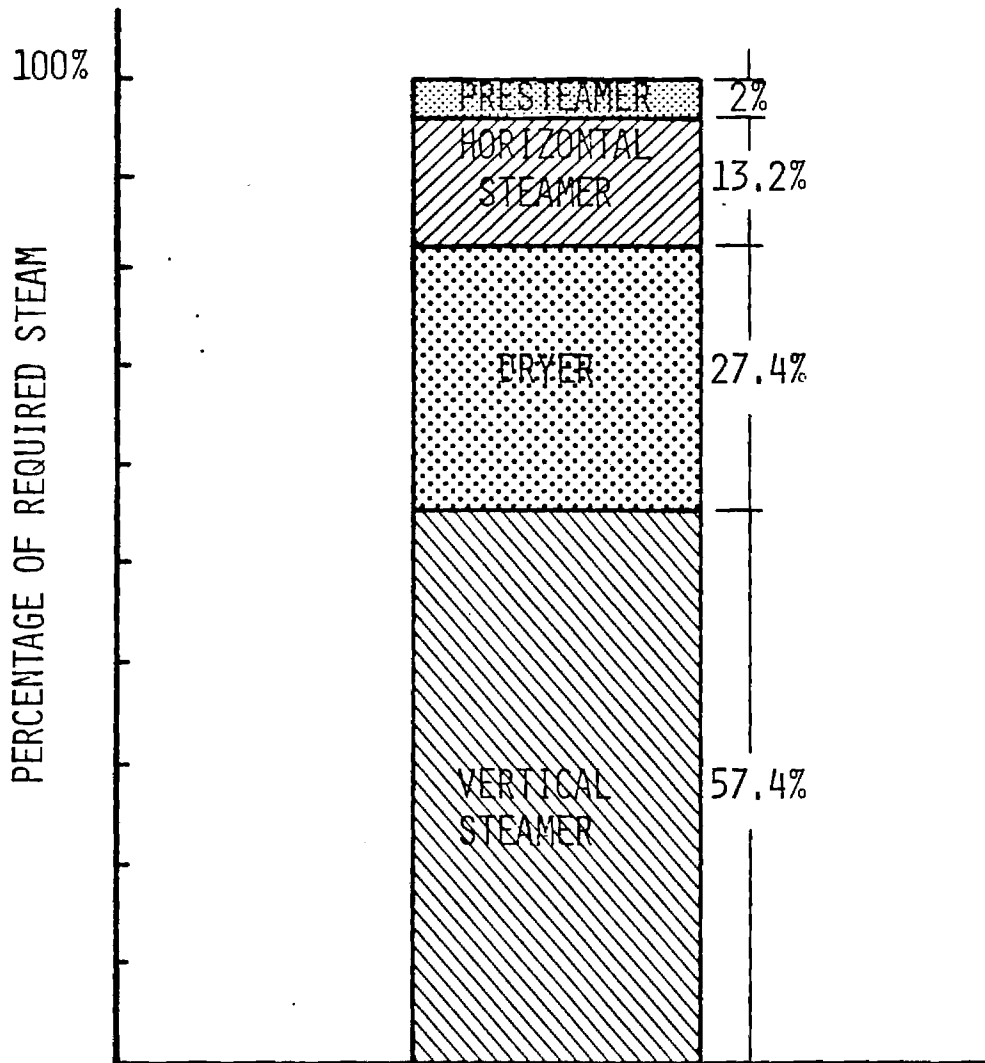


FIGURE 1. DISTRIBUTION OF STEAM TO KUSTER RANGE COMPONENTS

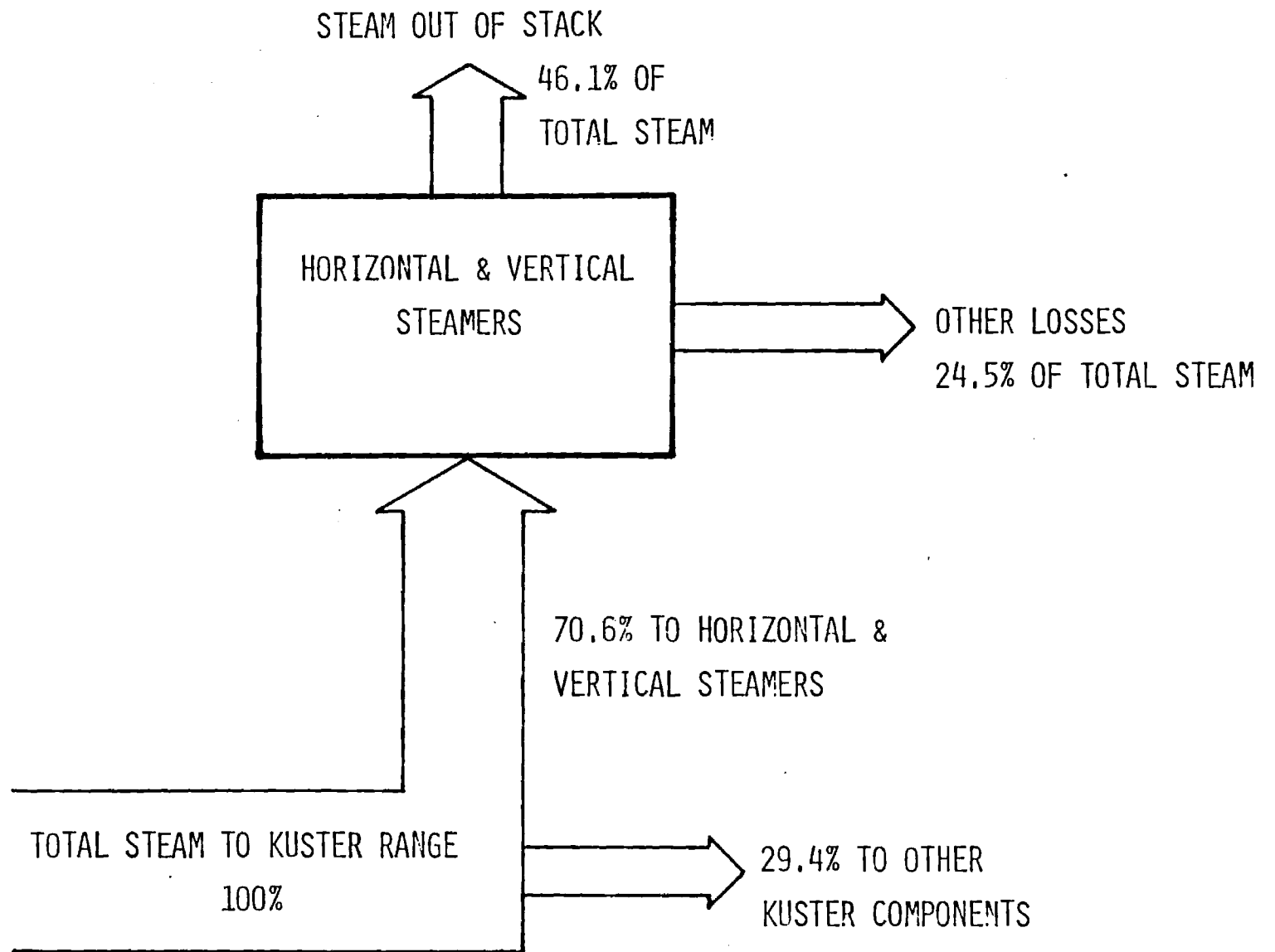


FIGURE 2. DISTRIBUTION OF STEAM TO HORIZONTAL AND VERTICAL STEAMERS



Georgia Institute of Technology

ENGINEERING EXPERIMENT STATION

ATLANTA, GEORGIA 30332

July 31, 1981

Ms. Ellen McCoy
Subcontract Specialist
Battelle
Pacific Northwest Laboratories
Box 999
Richland, Washington 99352

Subject: Assessment of Energy Conservation in the Textile Industry
Program Monthly Technical and Administrative Report for
EES/GIT Research Project A-2969 for July 1981

Dear Ms. McCoy,

This report summarizes the technical and administrative activities on
Research Project A-2969 for the month of July 1981.

July Activities

1. Technical and Administrative Highlights:

- Continued to contact plants having implemented energy conserving technologies. The results are summarized in the attached table.
- Began work on the following case studies:

Water Chlorination and Recycling
Salem Carpets
Chickamauga, Georgia

Bump and Run
Salem Carpets
Chickamauga, Georgia

Dyebath Reuse
E & B Carpets
Dalton, Georgia

Ms. Ellen McCoy
July 31, 1981
Page Two

- Doug Moore, a research engineer II, was brought in for July and is completing the water chlorination and recycling case study. Doug has been the project director for the Energy Analysis and Diagnostic Center energy audit program for the last year and has had experience in writing case studies for all industries.

2. Comparison to Project Plan

Have obtained 11 plants that will participate and are waiting to hear from 3 more. Have begun 3 case studies. One case study is in final draft form at the present time.

3. Problems Encountered

The problem of plant participation still exists. Six new plants have been contacted, of which two agreed to participate. The other four still have not responded. Of the 12 original plants that had not responded at the end of June, 3 responded positively and 9 responded negatively.

August Plans

1. Continue to pursue responses from plants already contacted.
2. Submit the remaining positive responses to Battelle for final plant selection.
3. Begin 4 case studies.
4. Complete 5 case studies.

Respectfully submitted,

Rachel L. Moore
Assistant Project Director /

Carol L. Aton
Project Director

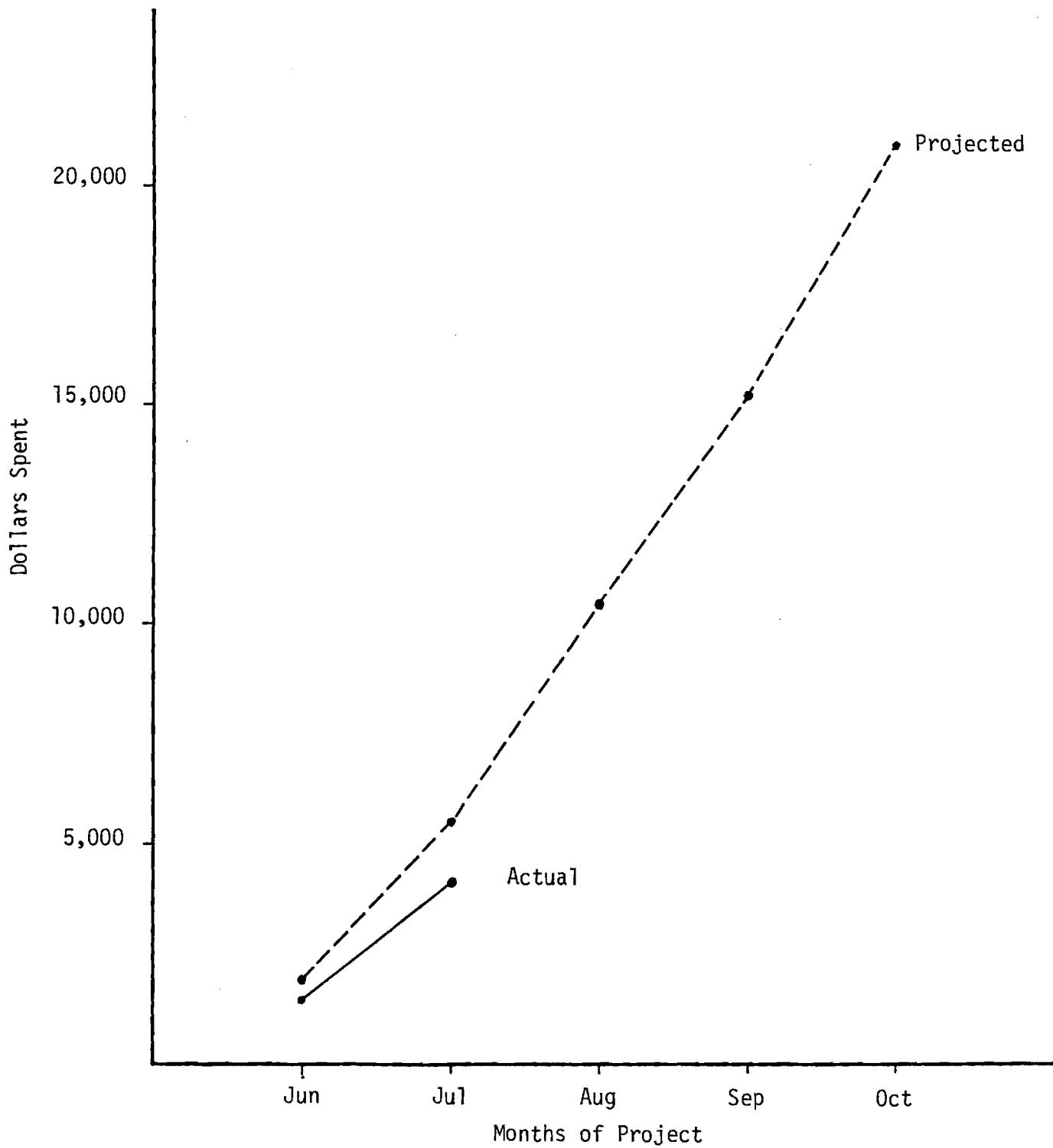
Enclosure

Battelle Case Study Contacts

<u>Technology</u>	<u>Plant Type</u>	<u>Location</u>	<u>Response</u>
Boiler Economizer	Upholstery	NC	Yes
Wood Fired Boiler*	Carpet Yarn	GA	Yes
	Carpet	GA	No
Trifuel Boiler	Apparel	NC	Yes
Dryer Controls	Upholstery	SC	Yes
	Carpet	GA	No
Dryer Heat Recovery	Apparel	SC	No
	Carpet	GA	No
Waste Fired Dryer	Towels	GA	
Water Heat Recovery	Apparel	GA	No
	Carpet	CA	
Water Recovery	Apparel	GA	
Solar Process Heat*	Gauze	TX	Yes
Ion Control	Yarn	VA	No
	Yarn	GA	No
Foam Finishing*	Sheeting	NC	Yes
	Conduroy	SC	No
Bump and Run*	Carpet	GA	Yes
Beck Modifications	Carpet	GA	No
Indirect Beck Heating	Carpet	GA	No
Steam Controls	Carpet	GA	No
Carpet Backing	Carpet	GA	No
Dyebath Reuse*	Hosiery	NC	No
	Carpet	GA	Yes
Hyperfiltration*	Uphostery	SC	Yes
Machnozzle	Sheeting	SC	No
Combined Preparation	Towels	AL	No
Low Temperature Dyeing	Carpet	CA	

<u>Technology</u>	<u>Plant Type</u>	<u>Location</u>	<u>Response</u>
Caustic Recovery	Sheeting	AL	No
Low Temperature Curing	Upholstery	GA	No
Hot Melt Slashing	Yarn	GA	No
Water Chlorination	Carpet	GA	Yes
Tandem Bleach/Scour	Hosiery	AL	Yes
Poly/Cotton Dyeing	Sheeting	GA	No

*DOE sponsored



Comparison of Personal Services Funds Spent to
Budget Projection for Project A-2969

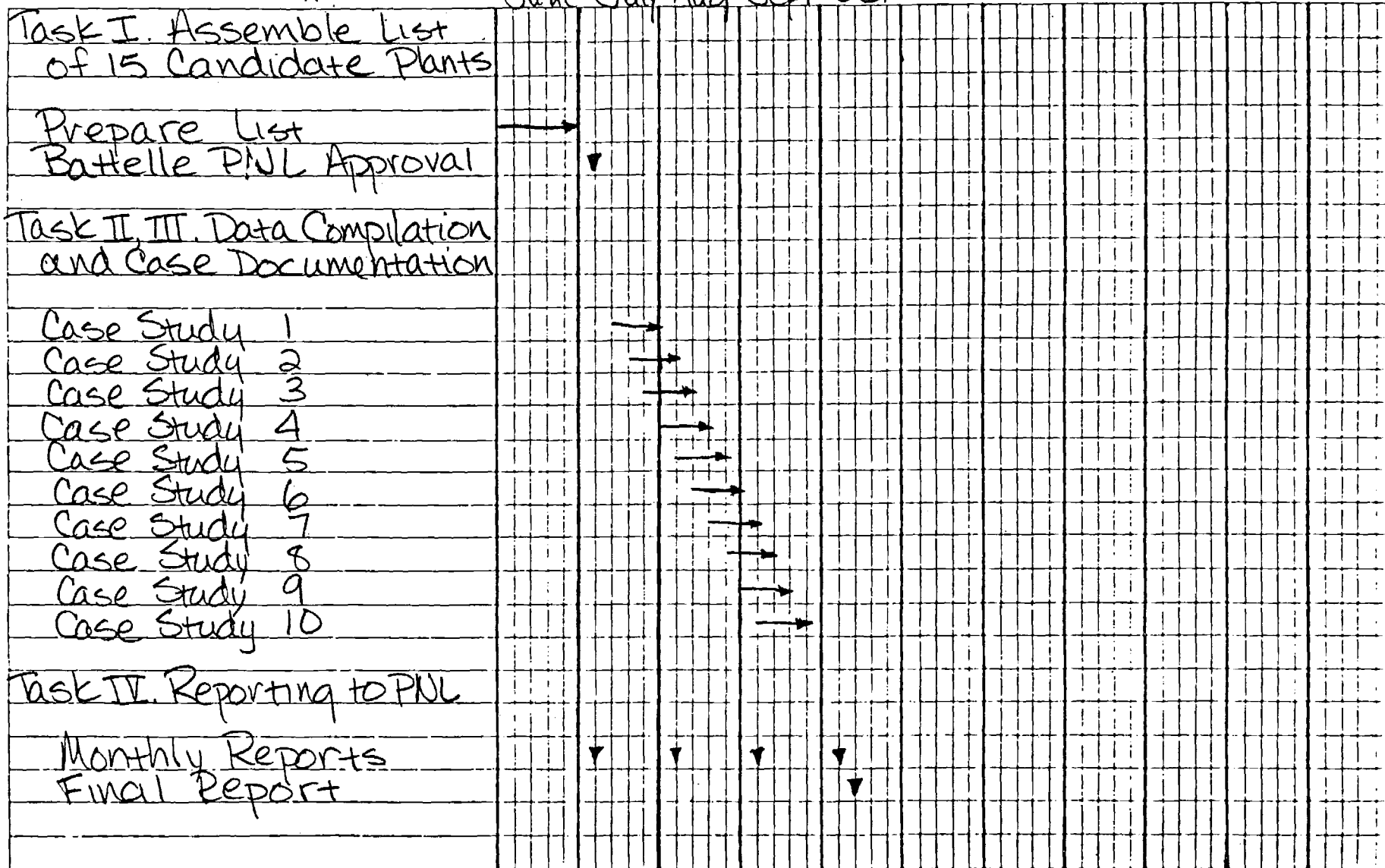
Project No. A-2969

PROJECT PLAN

Project Title Battelle Case Studies

Project Director CL. Aton

June July Aug Sept Oct



LEGEND

11-207

Georgia Institute of Technology

ENGINEERING EXPERIMENT STATION

ATLANTA, GEORGIA 30332

September 1, 1981

Ms. Ellen McCoy
Subcontract Specialist
Battelle
Pacific Northwest Laboratories
Box 999
Richland, Washington 99352

Subject: Assessment of Energy Conservation in the Textile Industry
Program Monthly Technical and Administrative Report for
EES/GIT Research Project A-2969 for August 1981

Dear Ms. McCoy,

This report summarizes the technical and administrative activities on
Research Project A-2969 for the month of August 1981.

August Activities

1. Technical and Administrative Highlights:

- Completed all plant contacts and obtained 16 plants that agreed to participate. The results are summarized in the attached table.
- Completed the following case studies:
 - Water Chlorination and Recycling
Salem Carpets
Chickamauga, Georgia
 - Bump and Run
Salem Carpets
Chickamauga, Georgia
 - Dyebath Reuse
E & B Carpets
Dalton, Georgia
 - Tandem Bleach/Scour Line
Niota Textile Mill
Ft. Payne, Alabama
 - Wood Fired Boiler
Integrated Products
Aragon, Georgia
 - Boiler Economizer
Collins and Aikman
Roxboro, North Carolina

Ms. Ellen McCoy
September 1, 1981
Page Two

- Began work on the following case study:

Solar Industrial Process Heat
Johnson and Johnson
Sherman, Texas

2. Comparison to Project Plan

Ahead of schedule since six case studies have been completed instead of five as originally planned. Only five case studies are attached. The sixth is completed but the plant has asked to review the report before it is turned over to Battelle. This report will be included in next month's report.

3. Problems Encountered

None

September Plans

1. Complete the four remaining case studies.
2. Begin preparation of the final report.
3. Meet with Battelle technical monitor for final review.

Respectfully submitted,

Rachel L. Moore
Assistant Project Director

Carol L. Aton
Project Director

mro

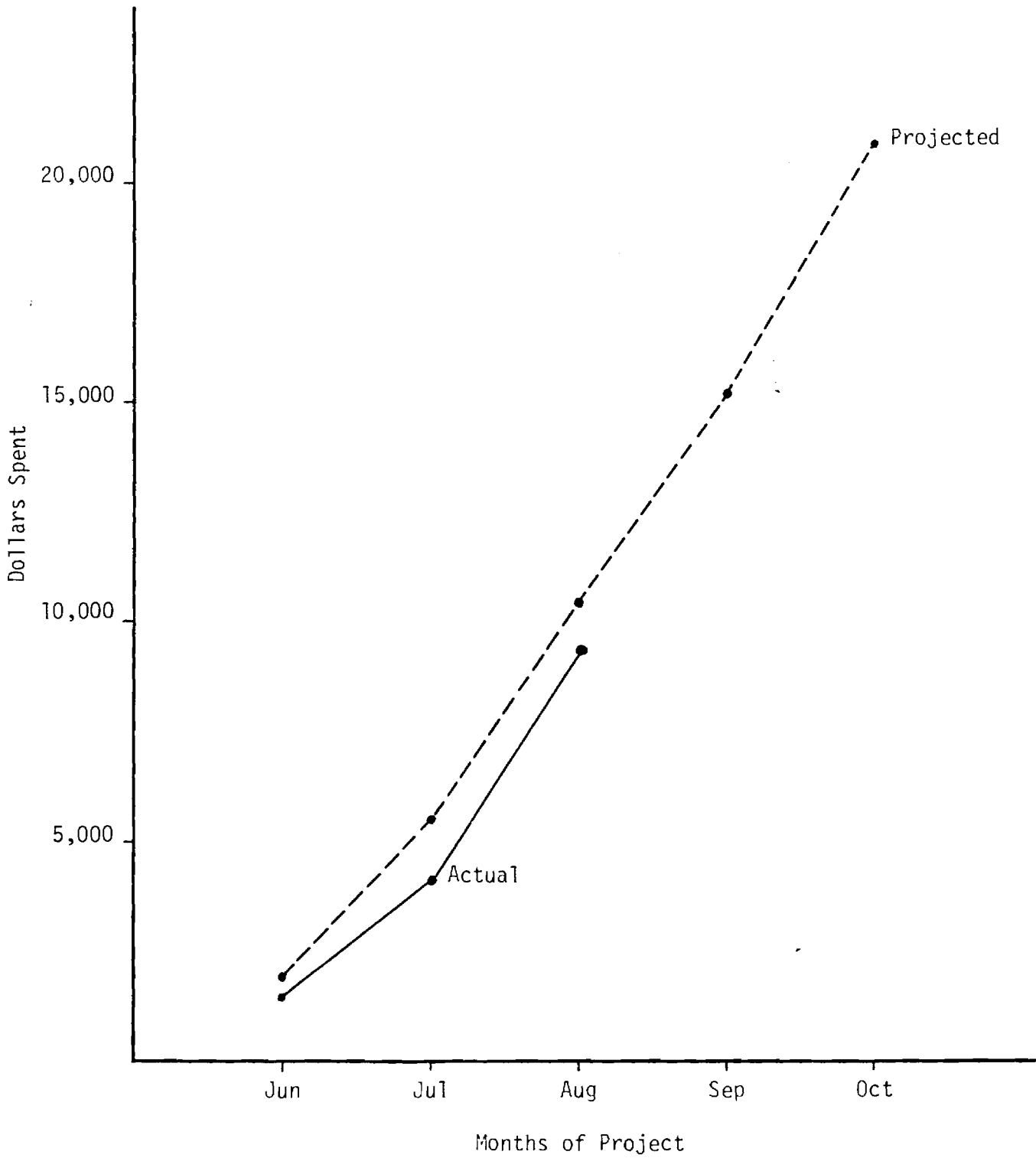
Enclosure

Battelle Case Study Contacts

<u>Technology</u>	<u>Plant Type</u>	<u>Location</u>	<u>Response</u>
Boiler Economizer	Upholstery	NC	Yes
Wood Fired Boiler*	Carpet Yarn Carpet	GA GA	Yes No
Trifuel Boiler	Apparel	NC	Yes
Dryer Controls	Upholstery Carpet	SC GA	Yes No
Dryer Heat Recovery	Apparel Carpet	SC GA	No No
Waste Fired Dryer	Towels	GA	Yes
Water Heat Recovery	Apparel Carpet	GA CA	Yes Yes
Water Recovery	Apparel	GA	Yes
Solar Process Heat*	Gauze	TX	Yes
Ion Control	Yarn Yarn	VA GA	No No
Foam Finishing*	Sheeting Corduroy	NC SC	Yes No
Bump and Run*	Carpet	GA	Yes
Beck Modifications	Carpet	GA	No
Indirect Beck Heating	Carpet	GA	No
Steam Controls	Carpet	GA	No
Carpet Backing	Carpet	GA	No
Dyebath Reuse*	Hosiery Carpet	NC GA	No Yes
Hyperfiltration*	Uphostery	SC	Yes
Machnozzle	Sheeting	SC	No
Combined Preparation	Towels	AL	No
Low Temperature Dyeing	Carpet	CA	No

<u>Technology</u>	<u>Plant Type</u>	<u>Location</u>	<u>Response</u>
Caustic Recovery	Sheeting	AL	No
Low Temperature Curing	Upholstery	GA	No
Hot Melt Slashing	Yarn	GA	No
Water Chlorination	Carpet	GA	Yes
Tandem Bleach/Scour	Hosiery	AL	Yes
Poly/Cotton Dyeing	Sheeting	GA	No
Remaflam	-	-	No
Triatex MA	Apparel	GA	No
Foam Dyeing	Carpet	GA	No
Dryer Counterflow	Apparel	VA	Yes

*DOE Sponsored



Comparison of Personal Services Funds Spent to
Budget Projection for Project A-2969

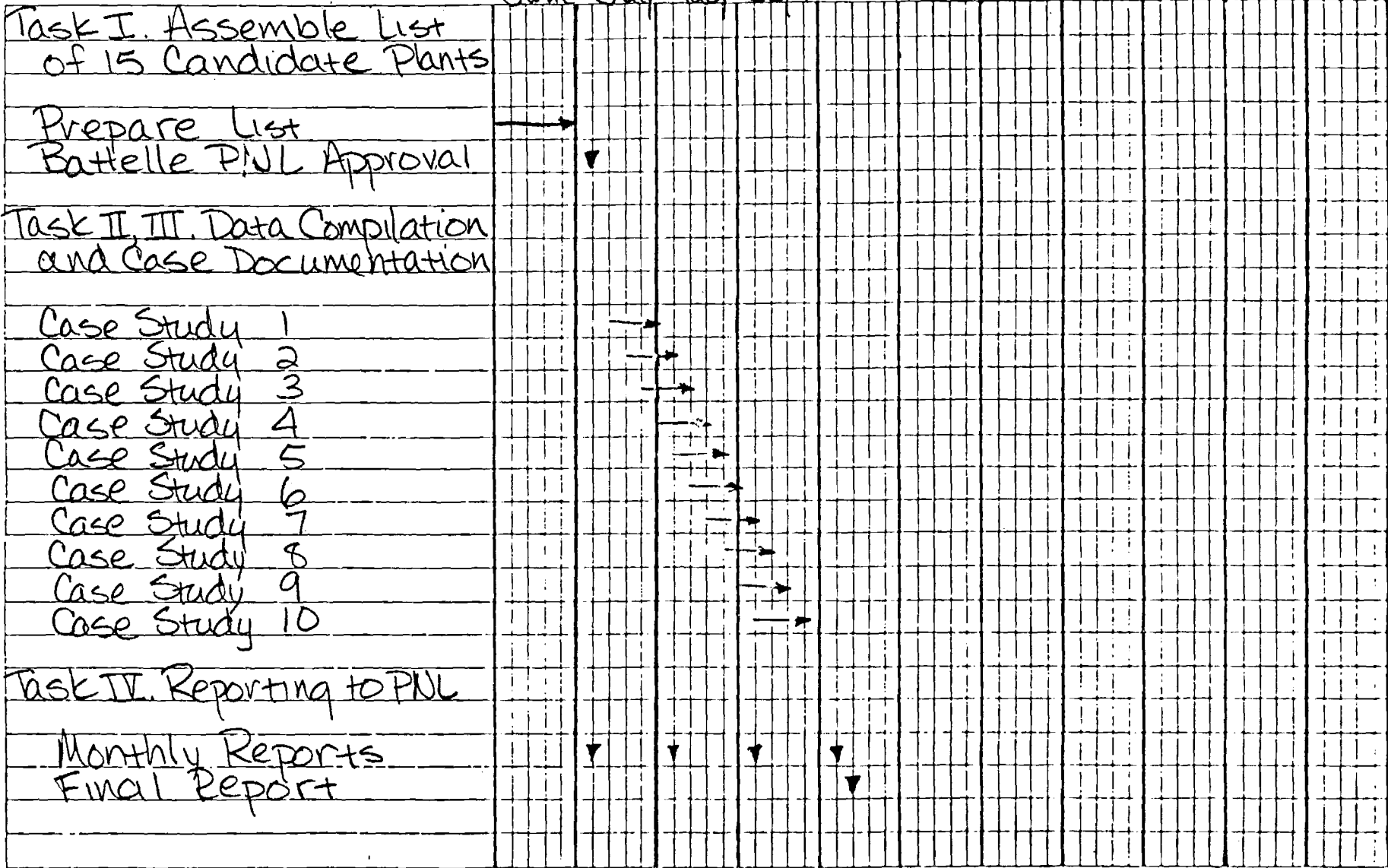
Project No. A-2969

PROJECT PLAN

Project Title Battelle Case Studies

Project Director CL. Aton

June July Aug Sept Oct



LEGEND

TEXTILE ENERGY CONSERVATION CASE STUDY:

WATER CHLORINATION AND REUSE

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

Douglas M. Moore

August 4, 1981

WATER CHLORINATION AND REUSE

Introduction

The textile industry consumes approximately 125 billion gallons of water per year. Most of this water is discharged from the plant with substantial quantities of organic and inorganic chemicals such as dyes, surfactants, auxiliaries, pH control agents, and lubricants. These chemicals require extensive treatment at the waste water plant and contribute to the pollution problems associated with textile processing. The pollution problem has, in the past, been met by the construction and expansion of waste treatment facilities. Each year, requirements become more stringent and this requires the investment of more capital to bring the waste treatment plants up to standards. Many areas are restricting the quantities of waste water that can be discharged into municipal waste treatment facilities as a result of these problems. The industrial facilities must then find ways to reduce their wastewater discharge or spend large sums of their own capital into a non-income-producing waste water treatment facility.

In addition to the problems associated with water supply and pollution control, the increasing cost and decreasing supply of energy represents a major problem for the textile industry. Thus, technologies providing solutions for all of these problems are continually sought by the industry. One such solution that has been implemented by the textile industry will be discussed.

Traditional Operation

Salem Carpets, headquartered in Ringgold, Georgia, operates a carpet dyeing and finishing plant in nearby Chickamauga, Georgia. This plant houses both batch and continuous dyeing, two highly energy intensive processes. Energy is supplied to the process equipment primarily in the form of medium pressure steam produced by two 1600 HP boilers. These boilers use natural gas as a primary fuel, with no. 6 fuel oil as a standby. The plant operates 14 dye becks and 1 continuous line and operates 24 hours per day, 7 days per week, with a two-day weekend shutdown once per month.

By virtue of its nature, batch dyeing is more energy intensive and consumes much larger quantities of water than continuous dyeing. Beck

dyeing is a batch process in which the carpet is loaded into a large stainless steel vat-like container called a dye beck. The beck is filled with water, normally 3000 to 5000 gallons per fill for carpet, and the dyes and chemicals added. The dyebath is heated to the dyeing temperature (180°F to 212°F) to set the dyes. When the correct color is obtained, the water is discharged to the drain. The beck is filled again with fresh water, the carpet rinsed, and this water is also discharged to the drain.

A substantial amount of energy is required to heat the water to boiling and hold it at temperature during the dye cycle. All of that energy is lost each time a dyebath is discharged to the drain. Tremendous quantities of water are also required by the beck operation. This water was supplied by the city and by a number of drilled wells on the plant property. Sewerage of the wastewater has posed a problem also, in terms of both disposal cost and the limitations of the city's waste treatment facility.

Process Modifications

By the end of 1974, Salem's growth and expansion and the normal growth of the community had begun to tax the capability of the local water and sewer facilities to the point that the city imposed a limit on the maximum amount of effluent that could be discharged from the plant. In order to continue to expand their operation, plant engineers were forced to find ways to reduce water consumption and the resulting effluent. Many alternatives were considered, and the alternative showing the best results was a water chlorination system. The system, pictured in Figure 1, was chosen for its excellent cost-benefit ratio, which was greatly enhanced by the energy savings afforded by the system. Installation of the system was completed by July 1975 at a cost of \$412,000, and provided a total cost savings of \$215,500 during its first year of operation.

The system chosen by Salem uses chlorine gas to oxidize the dye particles remaining in the spent dyebath into colorless chemical fragments. After dyeing or rinsing, at an average temperature of 125°F, the spent bath is pumped to one of four fiberglass treatment tanks where chlorine gas is bubbled through the water. The pH of the water is then adjusted to neutral with a weak base, since the formation of hypochlorous acid occurs during the chlorine treatment and lowers the pH. The water, still at an elevated

temperature and containing the chemical fragments, is then pumped into one of four fiberglass storage tanks. The temperature of the water returned to the process can be as high as 120°F. However, since the tanks are located outdoors and are not insulated, the returned water supply temperature averages 85°F on an annual basis. The energy savings provided by the system arise from the return of the water at an elevated temperature, thus eliminating the energy used to heat incoming water from 60°F to 85°F.

Savings

Salem's water reclamation system has been in operation for six years and in that time has saved the company over \$1.4 million in avoided energy, water, and sewer costs. Water usage and the resulting sewer discharge has been reduced from 1.2 million gallons per day to 440,000 gallons per day, thus allowing the plant to continue its normal operation. An added benefit from the system is the energy saved by returning 85°F water instead of 60°F. Based on an average steam plant efficiency of 75%, with 50% of the water used for beck dyeing being the recycled water, an energy savings of 35,875 million BTU per year is possible. The resulting cost savings are as follows:

	1975		1981	
	<u>Unit Cost</u>	<u>Annual Cost</u>	<u>Unit Cost</u>	<u>Annual Cost</u>
Water	\$0.60/1000gal	\$ 155,000	\$0.60/1000gal	\$ 155,000
Sewer	\$0.15/1000gal	\$ 38,800	\$0.21/1000gal	\$ 54,300
Energy	\$2.50/MMBTU	\$ 89,600	\$4.40/MMBTU	\$ 158,000
Total		\$ 283,400		\$ 367,300

The operating costs of the system are summarized below. At least two people are present at all times and are responsible for the system operation. These operators control the addition of chlorine gas, sulfite, soda ash, and other chemicals to control the water quality. The labor and chemical costs, however, are more than offset by the savings in water costs alone.

	<u>1975</u>		<u>1981</u>	
	<u>Unit Cost</u>	<u>Annual Cost</u>	<u>Unit Cost</u>	<u>Annual Cost</u>
Labor				
Supervisor	\$4.65/hr	\$ 12,600	\$7.35/hr	\$ 20,000
Operators (4)	\$3.15/hr	\$ 34,100	\$5.00/hr	\$ 54,100
Chemicals	\$0.08/1000gal	\$ 21,200	\$0.13/1000gal	\$ 33,600
Total		\$ 67,900		\$ 107,700

Thus, the net benefits resulting from the total system operation are:

	<u>1975</u>	<u>1981</u>
Total Savings	\$283,400	\$367,300
Operating Costs	\$ 67,900	\$107,700
Net Savings	\$215,500	\$259,600

Although the savings from the system are substantial, there are several drawbacks that should be evaluated when considering the installation of a water chlorination and reuse system. The returned water contains chemical fragments of unknown composition that, although colorless, can contribute to dyeing problems. These problems could be difficult to solve due to the unknown composition of the chemical fragments in the recycled water. Dyes and chemicals in the water are destroyed by the process, and therefore no chemical savings are possible. Recent research has shown that under certain conditions polychlorinated biphenyls (PCB's) can be formed by bubbling chlorine gas through aqueous solutions containing biphenyl and related aromatic carriers commonly used in dyeing polyester.

Summary

In analyzing this investment, Salem's management chose the simple payback technique. At 1975 costs, the initial cost of the system was paid back in only 1.76 years. Although this payback period is longer than the normal 1 year payback sought by the company, the economics were greatly enhanced

by the fact that total plant production was limited by the available water supply, and the effects of this lost revenue were taken into consideration.

From an overall viewpoint, it can be seen that Salem's water recycling system provides several benefits. From the standpoint of energy, it provides a facility that is significantly more energy efficient than comparable operations, while allowing the plant to achieve otherwise unobtainable production levels. The conservation of water, an increasingly scarce resource, is another commendable feature offered by the system that may someday provide sufficient justification for such a system of its own accord.

-for further information contact

Mr. Dave Dake
Engineering Projects Manager
Salem Carpet Mills, Inc.
Ringgold, Georgia

TEXTILE ENERGY CONSERVATION CASE STUDY:

BUMP-AND-RUN

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

Douglas M. Moore

August 11, 1981

BUMP-AND-RUN

Introduction

Salem Carpets, Inc., headquartered in Ringgold, Georgia, has proven the effectiveness of a modified carpet dyeing procedure for open beck dyeing that can cut steam consumption during a conventional dye cycle by 38%. The procedure, tagged "bump-and-run" by its developers, was fully automated at their plant in Chickamauga, Georgia with the addition of a simple timer, at a cost of only \$50 per beck. The installation costs were paid back in just a few days of operation.

Beck dyeing is a batch dyeing process in which the carpet is loaded into a large stainless steel vat-like container referred to as a dye beck. The beck is then filled with water to which various chemicals and dyes are added. The batch is heated to some predetermined temperature, usually at or near boiling, to set the dyes. Substantial amounts of energy are required to heat the water in the beck to the boiling point and to hold it at that temperature. An exhaust hood and fan are required to remove the large volume of water vapor and steam produced at the surface of the bath.

Experiments conducted previously by Georgia Tech researchers revealed that 45% to 60% of the total energy consumption of a dye beck is lost through the exhaust stack. The need to reduce this loss is clearly indicated. The technology of bump-and-run, in which the dyebath temperature is allowed to drift for the last 85% of the hold time instead of being maintained by active steam sparging, has been shown to cut stack losses by 75% with no detectable reduction in quality.

Traditional Operation

Salem Carpet's dyeing and finishing plant in Chickamauga, Georgia houses both beck and kuster dyeing operations. Energy is supplied to the process equipment primarily in the form of medium pressure steam, produced by two 50,000 lb/hour boilers. These boilers utilize natural gas as their primary fuel, with No. 6 fuel oil standby. Natural gas is also the primary energy source for the carpet dryers, with propane as the standby fuel. The plant currently has fourteen dye becks, and operates twenty-four hours per day, seven days per week, with a two-day shutdown one weekend per month.

Before adoption of the bump-and-run procedure, Salem followed a conventional dye recipe, which called for at least one and sometimes two or more hold cycles in which the dye bath was held at a rolling boil for 30 minutes. This resulted in tremendous energy loss through the stack, as indicated in Figure 1. Traditional alternatives were considered and then rejected including automatic damper controls, which operate to limit exhaust air flow from the beck in order to maintain a slight negative pressure, thus preventing steam from escaping into the room. Capital costs for this system are high, at \$3000 or more per beck, and the controllers have been found to be high maintenance items.

A second alternative considered was low temperature dyeing. In this process, chemicals are added to the dye bath which open up the fibers, allowing the dyes to set at temperatures near 140°F. Cost analyses revealed, however, that the energy cost savings would be more than offset by the additional chemical costs. Also, the low temperature is not adequate to fully develop the "bloom" or bulk of the carpet. This possibility therefore was also rejected.

Procedural Modifications

The concept of bump-and-run was first proposed by Mr. John J. Toon of Piedmont Chemical Company, and avoids many of the drawbacks of low temperature dyeing. As indicated by Figure 1, previous research had shown that approximately 49% of the energy consumed by the dye beck was lost to the stack, while radiation and convection losses accounted for only 2% of total energy consumption. The process of bump-and-run takes advantage of the low radiation loss while minimizing stack losses at the boil.

In this process, the dyebath is heated or "bumped" to boiling temperature and held there for 5 minutes at which point steam injection is halted, the exhaust fan is stopped, the exhaust damper is closed, and the beck doors or curtains are closed. At this point, the beck acts like a closed kettle, and the temperature is allowed to drift for the next 25 minutes of the conventional 30 minute hold cycle (the "run" portion of the process). Experience has shown that a temperature drop of only about 20°F is to be expected during the run period. The remainder of the cycle is the same as with the conventional procedure.

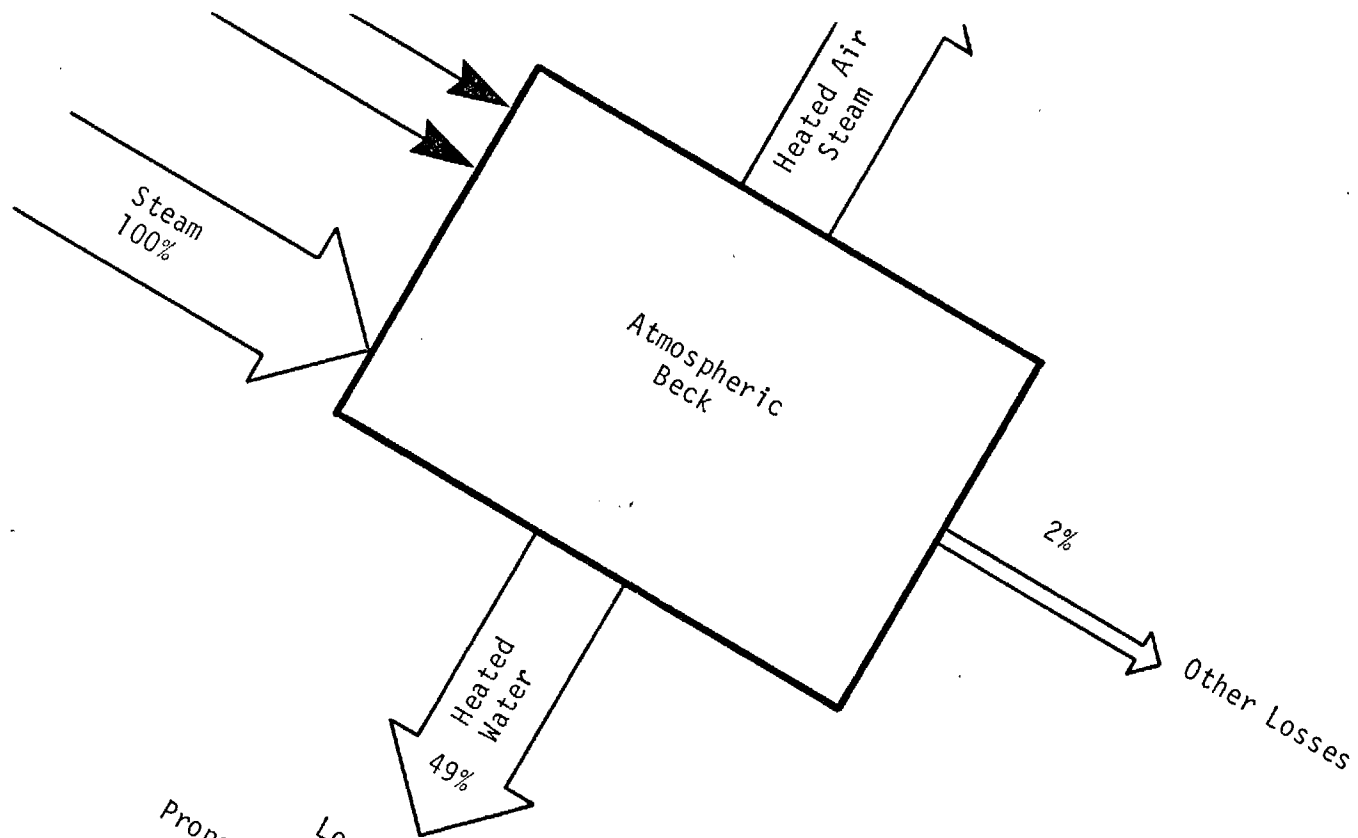


Figure 1. Atmosphere Beck Flows

Although this modification was initially implemented at no capital cost, simply by changing operating procedures, it soon became apparent that the temperature control operators were having to set the controllers four times each cycle rather than two as they were accustomed. To alleviate this situation, electronic automatic reset timers (Omron STP-MYH-AH) were installed at each beck controller, energized by the wire that ran to the end of cycle lamp. This lamp was then wired through a normally open contact on the timer. With this setup, the control operator sets the beck controller for a 5 minute hold at the boil in the usual manner. When the 5 minute hold is complete, current is routed to the auxiliary timer, which is preset for the 25 minute run portion of the cycle. At the end of this period, the end of cycle lamp is illuminated. The use of the timers allows the controllers to operate the system in exactly the same manner as had been previously done.

The auxiliary timers were installed on all of the becks, at an average cost including installation of \$50 each. The other necessary equipment, including beck doors and stack fan dampers were already installed, resulting in an almost immediate payback on the company's investment. Salem currently uses bump-and-run for all of its nylon carpet production, which accounts for 30% of the total plant production. The process is not presently used on polyester since some crockfastness problems have arisen with this substrate.

Savings

Energy consumption for both conventional dyeing procedures and for dyeing using bump-and-run was monitored by Georgia Tech engineers at Salem's Chickamauga plant under a grant from the Department of Energy. Steam consumption during the conventional process was monitored for ten cycles and a base line average obtained. Consumption for ten cycles using bump-and-run was also monitored resulting in an average savings of 38%, as summarized below for a normalized dye cycle:

Steam Consumption - Conventional Process	10,814 lbs
Steam Consumption - Bump-and-Run	6,677 lbs
Reduction in Steam Consumption	4,137 lbs
Reduction in Energy Consumption	3,920,000 BTU
Percent Savings	38 %

Incorporation of bump-and-run was accomplished plant-wide at Salem in March 1980. After a full year of operation under this system, plant engineers reported a net yearly energy cost savings of \$63,500. Based on an installed cost of \$50 per timer, the total cost to modify all fourteen of the company's becks was \$700, giving a simple payback of four days.

The above savings were achieved by using bump-and-run on the plants nylon production only, which accounts for 30% of total production. The procedure has not been successfully used with polyester fibers because crockfastness problems have been observed. Salem is studying this problem and hopes to eventually use bump-and-run with all of its production. On the other hand, there has been absolutely no detectable loss of quality among the nylon goods.

The potential for energy savings if bump-and-run could be expanded to Salem's entire product line is impressive. If the assumption is made that energy costs will increase by 15% during the next twelve month period, the potential for energy cost savings using bump-and-run plantwide amounts to over \$240,000.

Bump-and-run also makes the technology of dyebath reuse easier and less costly to implement. At the end of the final hold cycle (level cycle), several patches were taken across the carpet width and checked for color level. By this time, the temperature of the dye bath had dropped to 170°F to 180°F, allowing the carpet to be easily removed while leaving the dye bath in the machine. With dyebath reuse the spent dyebath is analyzed,

reconstituted, and reused for a number of subsequent dyeings. Bump-and-run therefore eliminates the need for holding tanks and pumping systems normally associated with dyebath reuse. Final rinsing of the carpet is done in the wet-out box preceding the dryer.

Summary

Bump-and-run is an excellent example of the somewhat rare variety of energy conservation opportunity that offers substantial energy savings at an insignificant initial cost. The ability to discover opportunities of this type depends on the willingness of plant managers and plant personnel to carefully analyze current operating procedures and evaluate each step of each process. An open mind is essential, as established practices must be scrutinized. Cooperation of plant personnel must be willingly offered in order to obtain the results anticipated. This requires excellent communication between management and labor, and a general awareness of the importance of energy conservation within the plant. These qualities are key elements of any successful energy conservation program.

In the case of bump-and-run, plant operations were hardly disturbed at all; the dyer used the same chemicals as in the conventional process, management had to provide negligible capital, and even the beck operator was satisfied. Savings to the plant were substantial, and neither the quality control engineers nor the dyers saw any dyeing problems. In short, it is difficult to argue with bump-and-run.

-for further information contact

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TEXTILE ENERGY CONSERVATION CASE STUDY:

TANDEM HOSIERY BLEACH/SCOUR LINE

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

Rachel L. Moore

August 28, 1981

TANDEM HOSIERY BLEACH/SCOUR LINE

Introduction

The textile industry is faced with many problems such as air and water pollution, increasing energy costs, increasing dye and chemical costs, and the shortage of water that, if not solved, could limit or halt the existence of the industry in the United States. Thus, the push to make all preparation, dyeing, and finishing operations continuous rather than batch has resulted. Great strides toward this goal have been made in the carpet and fabric segments of the textile industry. However certain other segments, due to their nature, have had difficulty in adapting to continuous processing. Two notable segments are the hosiery and small rug producers, which both process small individual items rather than one continuous length of goods. An innovative new concept is being introduced into the hosiery industry, using in a tandem operation the same paddle machines now utilized to prepare and dye hosiery and small rugs. This concept has the potential to be expanded for use in other operations, thus leading to even greater energy savings.

Traditional Operation

Niota Textile Mill, located in Ft. Payne, Alabama, produces cotton and acrylic athletic tube socks. The socks are knitted at other locations and shipped to the plant in boxes. The socks are bleached or scoured, dried, boarded, folded, and packaged for shipping. The cotton goods are bleached and the acrylic goods are scoured. The plant operates two 10 hour shifts per day, five days per week, 50 weeks per year.

Before the installation of the tandem bleach/scour line, all of the goods processed were either bleached or scoured in one of three large paddle machines. All cotton goods are still bleached in these machines, but the acrylic goods are now scoured on the new line. Each of the large machines holds 650 pounds of goods in 1200 gallons of water. The scouring procedure for the acrylic goods in the large machines was as follows:

- Fill machine with cold water
- Add hosiery
- Add scouring chemicals

- Heat bath to 140°F
- Hold 10 minutes
- Drain bath
- Fill again with cold water
- Add softening chemicals
- Heat bath to 100°F
- Hold 5 minutes
- Drain bath

Thus, both times the bath was discharged to the sewer, all of the heat in the water and all of the chemicals were lost. However, these losses can be eliminated when the tandem line is used.

Process Modifications

The tandem bleach/scour line, shown in Figure 1, is a modification of the paddle machine used to prepare and dye hosiery and small rugs. Each of the machines in the line at Niota Textile Mill processes 400 pounds of acrylic in 750 gallons of water. The capacity of these machines are less than the single machines, but the same amount of goods or more can be processed in a day due to the time and personnel savings.

The first machine is used to scour and the second to soften the socks. For the first run, the water is added to the first machine, the goods and scouring chemicals entered, the bath heated to 140°F and held for 10 minutes. At the end of the cycle, the goods are transferred to the second machine by means of a perforated basket that fits inside the machine and raises out to move the goods and leave the bath in place. The socks are added to the second bath, the softening chemicals added, the bath raised to 100°F and held for 5 minutes. The goods are removed from the second machine and placed in a bag to be dried.

Once the goods have been removed from the first machine, a new load can be placed in the bath that is still hot and contains most of the chemicals necessary for processing. Every third load, the full amount of chemicals are added back to the bath. Both the scouring and softening baths can be used for an entire day without replacement and steam is only added intermittently to keep the baths at the correct temperature. Thus energy, water, and chemical savings result when the tandem machine configuration is used

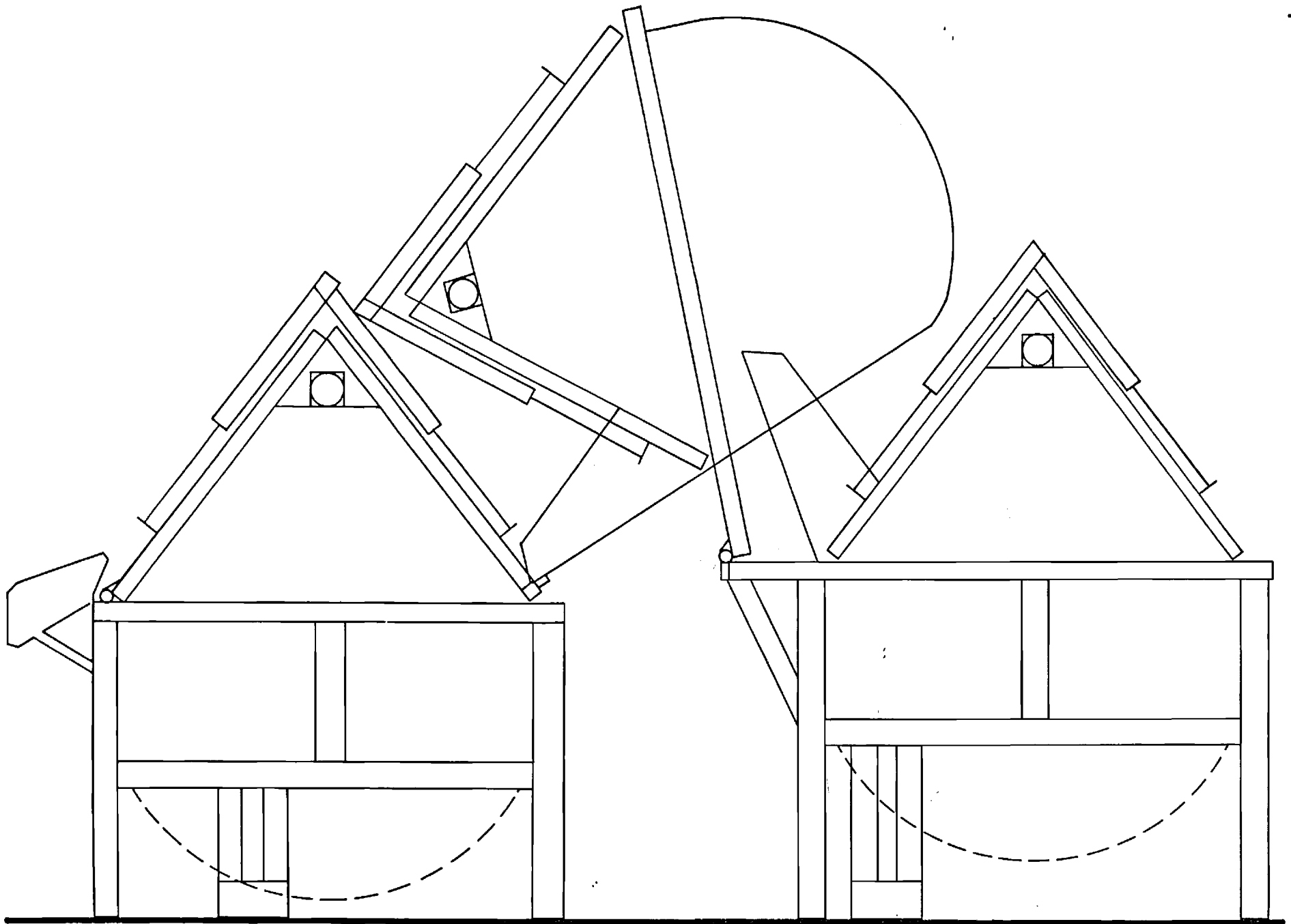


Figure 1. Tandem Scour Line at Niota Textiles

rather than the single machines. Fewer operators are required to run the tandem line. Time is saved by not draining the machine after each run and also by not having to heat the bath each time.

Savings

When comparing machines of the same capacity, the following savings result when using the tandem machines:

	<u>Annual Volume Savings</u>	<u>Annual Cost Savings</u>
Energy	3,295 MMBTU	\$19,275
Chemicals	58,500 pounds	\$25,100
Water/Sewer	7,125,000 gallons	\$11,045
Total		\$55,420

These savings are based on an average annual production rate of 2 million pounds of acrylic.

The system at Niota Textile Mill required a capital investment of \$17,275. This cost was slightly more than half of the cost of a new system, since one of the paddle machine was already installed in the mill and was used as a part of this system. The new machine that was added was constructed from 316 stainless steel so as to be able to withstand bleaching and scouring chemicals and also had a special high lift basket. Thus, the cost was slightly higher than a regular machine.

At present energy, water/sewer, and chemical costs the payback period before taxes is 4 months. The system has been installed for 6 months, and has thus paid for itself. Plant personnel wanted the system for its

resulting water, chemical, and energy savings and did not require the system to meet any specific payback criteria.

Summary

Niota Textile Mill has installed a new bleach/scour machine using in a tandem configuration two of the paddle machines used for the preparation and dyeing of hosiery. This new line allows the preparation bath to be saved after each use thus conserving energy, water, and chemicals. This system has the potential to be expanded into other areas such as small rug processing and dyebath reuse that will result in further energy savings.

-for more information contact

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TEXTILE ENERGY CONSERVATION CASE STUDY:

WOOD-FIRED BOILER

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

William B. Himes, Jr.

August 28, 1981

CASE STUDY: WOOD-FIRED BOILER

Introduction

Integrated Products, is a textile manufacturing firm producing yarn for the carpet industry. Located in Aragon, Georgia, the plant employs approximately 450 people and manufactures products for both domestic and international markets.

The manufacturing process spins nylon fibers into yarn. A twist in the yarn is "heat set" in large autoclaves using steam. The yarn is then dried in steam heated dryers to complete the process. During winter months steam is also used for space heating.

The steam required for these processes is now supplied by a wood energy system. Rising prices for conventional fuels made converting to a wood-fired boiler economically attractive.

Traditional Operation

Prior to conversion to wood fuel, the plant boilers operated on natural gas or No. 2 fuel oil. Approximately 85% of the energy consumed was provided by natural gas and the remaining 15% was No. 2 fuel oil. The plant is operated 24 hours per day, 6 days per week, 50 weeks per year. Yearly consumption of each fuel is shown below:

Fossil Fuel Consumption Prior to Wood Conversion

May 1978 - April 1979

<u>Fuel</u>	<u>Quantity</u>	<u>BTU</u>
Natural Gas	519,348 therms	51.934 x 10 ⁹
No. 2 Fuel Oil	53,464 gals.	7.485 x 10 ⁹
Total		59.419 x 10 ⁹

Modifications

In order to use wood fuel to produce steam, a completely new system had to be designed. The new wood system was required to supply all of the process and space heating requirements and no backup by the fossil fuel boilers was to be employed (except in emergencies).

Sizing of the boiler was based on the existing energy consumption, size and utilization of existing boilers, and plans for future expansion. Based on these considerations, a 400 HP boiler was judged to be adequate.

The boiler chosen is a horizontal return tube firetube boiler designed to produce 13,200 lb/hr of saturated steam at 130 psig from feed water supplied to the unit at 220°F. Wood with a 50% moisture content (wet basis) such as sawdust, bark, and chips can be burned as fuel.

After determining the boiler size, fuel requirements for the chosen boiler were used to determine the volume and area necessary to store an adequate fuel supply for the reliable operation of the system. At rated capacity, a 400 HP boiler consumes fuel at the rates shown below:

Fuel Requirements for 400 HP System

<u>Wood Consumption</u>	<u>100% Capacity</u>	<u>70% Capacity</u>
tons/hr	2.654	1.858
ft ³ /hr	221	155
truckloads/day	3	2
tons/year	19,100	13,300

A poured concrete silo, 48 feet high by 24 feet in diameter, is used to store fuel for the automatic fuel feeding system. The usable storage capacity of the silo is 14,464 cubic feet and is sufficient to store wood fuel approximately 72 hours when the boiler is operating at 70% load. For long term storage, an open area with a concrete floor of approximately 6,000 square feet provides sufficient space to store wood for approximately 15 days.

For a plant of this size, an automatic fuel receiving hydraulic truck dump would be an expensive investment. Simpler systems, such as the use of a front-end loader or fuel delivered by live bottom trailers, are more economical.

Self-unloading trailers bring the wood chip fuel to the plant. They can unload the fuel in the open storage area or in the fuel staging area, located close to the storage silo. The wood fuel in the staging area is moved to the receiving hopper by means of a front-end loader. From the hopper, a screw conveyor delivers the fuel to a bucket elevator, which raises it into the storage silo. Screw conveyors transfer the fuel from the silo first to the metering bin and then to the air sweep feeders where it enters the combustion area. Figure 1 shows the layout of the system.

Results

The energy savings analysis shown below includes the operating cost associated with the new wood system and the old oil and gas system, the first year savings, and the simple payback period. The installed cost of the system was \$460,000. First year federal tax credits of \$92,000 resulted in an adjusted capital investment of \$368,000. Based on the financial analysis, an annual cost savings of \$59,071 should result. The simple payback for this system before taxes was 6 years.

System Financial Analysis

<u>Cost Component</u>	<u>Wood System</u>	<u>Existing System</u>
Annual Cost of Capital	\$ 49,268	\$ 0
Amortization (20 years @ 12%)		
Operating Costs	\$ 40,552	\$ 20,744
Electricity, labor, front end loader, maintenance		
Insurance and Property Tax	\$ 4,500	\$ 4,000
Fuel Costs		
Wood fuel @ \$8/ton	\$ 73,136	---
Gas @ \$3/MCF		
Oil @ \$0.86/gal		\$201,783
Total Cost Per Year	<u>\$167,456</u>	<u>\$226,527</u>

Two additional factors have a bearing on the economic analysis and actual payback period of the system at Integrated Products. The first is a \$146,000 United States Department of Energy demonstration grant that reduced the actual adjusted capital investment to \$222,000 and the projected payback period to 2.8 years. The second factor was the slow economy in the first half of 1980 that forced the plant to operate at a greatly reduced capacity. This lengthened the payback period since the annual cost of capital, operating costs, insurance and property taxes remained relatively constant and the fuel savings decreased.

Summary

The demonstration grant from the United States Department of Energy was an important factor in the decision to invest in wood energy for Integrated Products, however many other factors also made the conversion attractive. Adequate local supplies of waste fuel at economical prices, combined with a desire to move away from dependence on fossil fuels also influenced the decision. Integrated Products also has a competent technical staff that was interested in designing and operating an innovative cost savings system.

Despite the reduced plant output, the new system is performing well and corporate management is very pleased. Exact cost savings are difficult to define because fuel is being inventoried and production is approximately 20% below capacity, however, the cost savings are still approximately \$5,000 per month or \$60,000 annually. With the grant taken into consideration, the simple payback period is less than 3 years.

The benefits of the project reach farther than just Integrated Products. The installation of the wood energy system at Aragon demonstrates the feasibility of using wood fuel in nonforest industries. Conversions to renewable energy systems stimulate economic activity at a local level and reduce dependence on foreign energy supplies.

-for further information contact

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TEXTILE ENERGY CONSERVATION CASE STUDY:

BOILER ECONOMIZER

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

LuAnn T. Rockett

September 4, 1981

BOILER ECONOMIZER

Introduction

Faced with rising energy costs and the decreasing availability of fossil fuels, the textile industry has been forced to conserve energy in as many ways as are economically feasible. Collins and Aikman Corporation is a large diversified textile, paper and wallcovering manufacturer with 42 plants in North America. They are involved in all phases of textile manufacturing from spinning yarn to dyeing and finishing textile products. One of the largest divisions is located in Roxboro, North Carolina. The plant produces woven and knitted pile upholstery and apparel, namely velvets, velores and fake furs.

Because 80% of all energy is consumed by fossil fuels and the boilers consume more fuel to generate steam than any other process, Collins and Aikman has concentrated a large energy conservation effort toward improving boiler efficiency.

Improvements in boiler efficiency result primarily from reductions in waste heat energy losses in the stack gases and expelled water. Maximum efficiency results when combustion of the fuel is complete and the heat losses are minimized. Reduction of excess air intake must be held to a minimum to optimize boiler efficiency. Because most boilers are designed to operate with more air flow than is needed for complete combustion, regular tune-ups must be made to ensure that the O₂ level is optimized. Other losses are due to radiation and convection from boiler surfaces. This is especially true in older, less insulated systems.

Traditional Operation

The boiler at the Collins and Aikman Roxboro plant is tuned-up on a regular basis. The plant runs 24 hours a day, 7 days a week; however for calculation purposes, a 7000 hr/yr operating schedule is assumed. The boiler operation is detailed in Figure 1. The boiler has an 80,000 pound per hour steam capacity, and at an average projected load of 60,000, operates at an efficiency of 80.4%. The system presently burns No. 6 fuel oil and, without an economizer, burned 1.71 million gallons per year at a price of \$0.33 per gallon.

Modifications

A boiler economizer is a heat exchanger located in the boiler stack which is designed to recover some of the waste heat from the products of combustion. The greatest waste heat from a boiler escapes up the stack in exit gases. The economizer consists of a series of tubes through which feedwater flows on the way to the boiler. Water enters at one end of the economizer and is directed through a series of bends and headers before returning to the steam drum. The feedwater is thus preheated and requires less oil to generate an equal amount of steam.

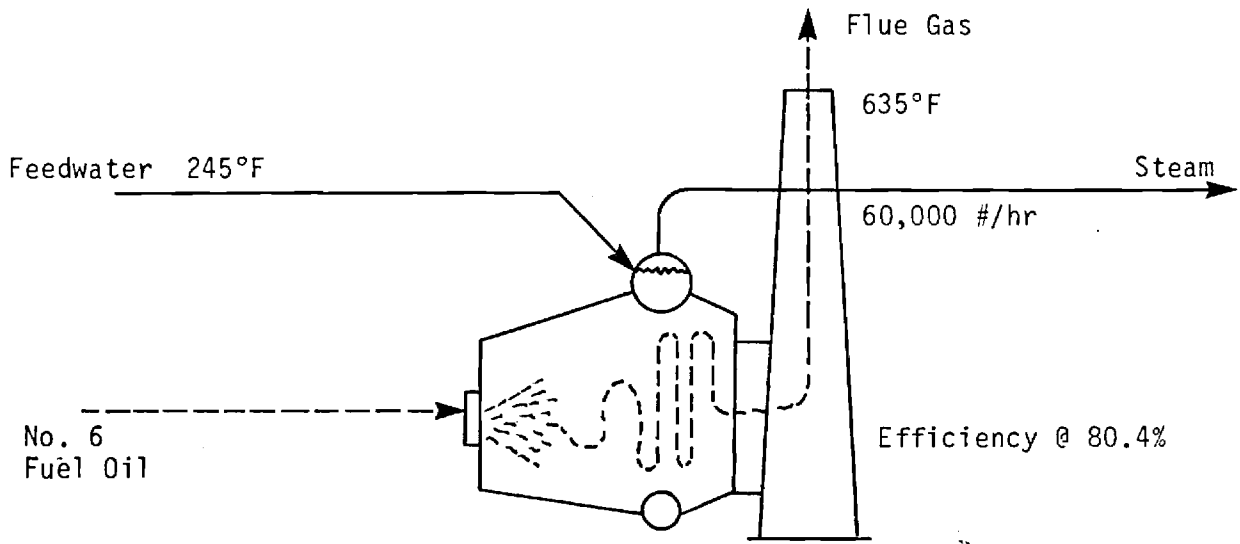
Collins and Aikman Corporation's Cavelle Division at Roxboro, North Carolina successfully installed an economizer on their 80,000 pound per hour oil/gas boiler. Start-up was May, 1979. The system has been operating without any problems since that time. The economizer at Roxboro was based on the successful implementation of another economizer at a "pilot plant" site in Albermarle, North Carolina.

The economizer was installed in a bypass arrangement with the boiler. This arrangement has three advantages:

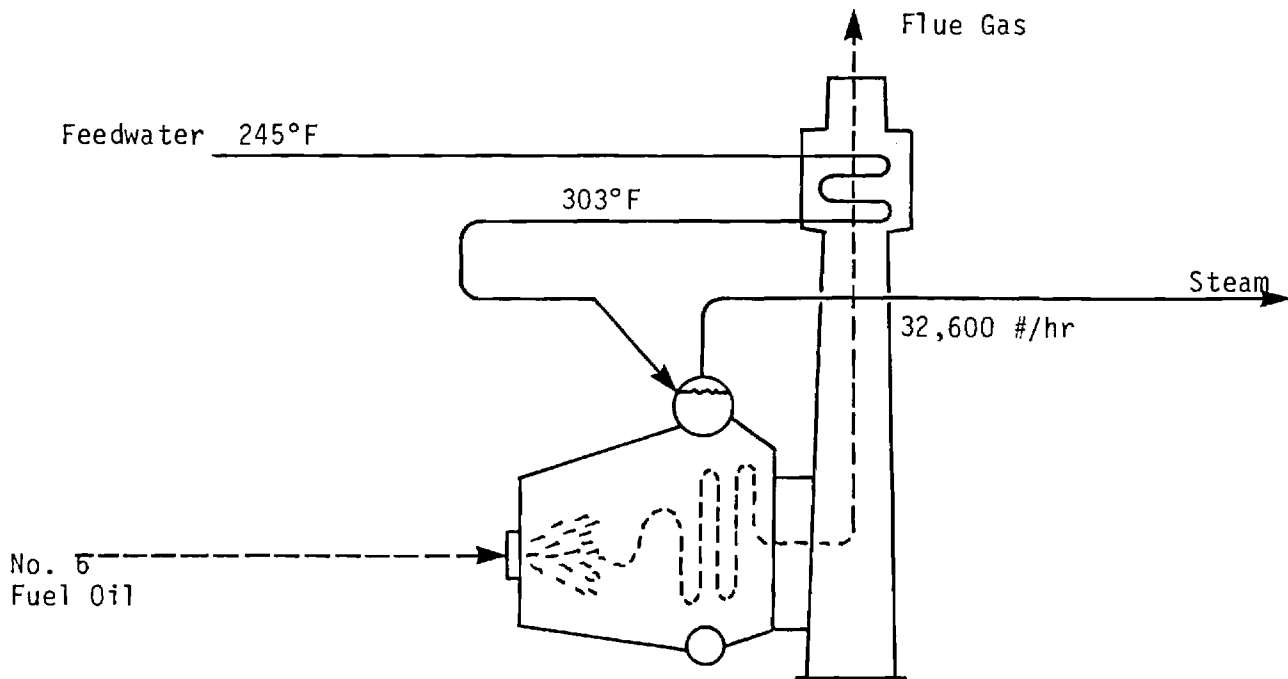
- The feedwater flows upward, preventing recirculation and steaming in the feedwater line.
- The economizer can be shut down completely for general maintenance while the boiler remains in operation.
- Greater BTU recovery is possible since the system may be "over designed" to absorb too much heat and the damper adjusted to optimize overall efficiency.

Installation was based on the boiler operating at 60,000 pounds per hour for 7000 hours per year, and was designed to increase boiler efficiency from 80.4% to 86.4%. (See Figures 1 and 2.)

The only modifications made to the system involved operational criteria. During 1980, the system averaged a steam load of 32,600 pounds per hour; well below the forecast load.



Boiler Operation Before Adding Economizer
Figure 1.



Boiler Operation After Adding Economizer
Figure 2.

	<u>Avg. Steam Load</u>	<u>Steam Generated</u>
Forecast	60,000 pounds per hour	3.92 x 10 ⁶ pounds
Actual	32,600 pounds per hour	2.06 x 10 ⁶ pounds

Results/Savings

Although the system only operated at an average load of 32,600 pounds per hour, significant savings were achieved in fuel cost and consumption. The dollar savings in fact, exceeded the original forecast. This was due, however, to the tremendous increase in fuel costs. Number 6 fuel oil increased in price from 33¢ per gallon to 80¢ per gallon during the time of the study. The savings are summarized below:

	<u>\$/yr</u>	<u>gal/yr</u>	<u>MMBTU/yr</u>
With economizer (forecast at 56,000 pph)	74,769 (33¢/gal)	1.71 x 10 ⁶	36,209
With economizer (at 32,600 pph actual)	74,971 (80¢/gal)	1.62 x 10 ⁶	14,019

The Roxboro economizer has operated without any down-time due to problems of fouling. Regular cleaning and maintenance is performed, as are general tune-ups on the boiler.

Summary

The decision to invest in the economizer was based on:

- Feasibility studies based on the Albermarle pilot site.
- A projected payback of approximately 3.4 years.

The actual total cost of the system was \$148,230 installed. Based on dollar savings of \$74,971 per year, the system will have a payback of 1.98 years. Again, this savings is directly attributable to the ever increasing cost of No. 6 fuel oil.

Because of the success of the economizers at both Roxboro and Albemarle, the company is planning to install between one and three more at existing plant sites.

-for more information contact

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11 2969

Georgia Institute of Technology

ENGINEERING EXPERIMENT STATION

ATLANTA, GEORGIA 30332

October 1, 1981

Ms. Ellen McCoy
Subcontract Specialist
Battelle
Pacific Northwest Laboratories
Box 999
Richland, Washington 99352

Subject: Assessment of Energy Conservation in the Textile Industry
Program Monthly Technical and Administrative Report for
EES/GIT Research Project A-2969 for September 1981

Dear Ms. McCoy:

This report summarizes the technical and administrative activities on
Research Project A-2969 for the month of September 1981.

September Activities

1. Technical and Administrative Highlights:

- Completed the following case studies:

Solar Industrial Process Heat
Johnson and Johnson
Sherman, Texas

Dryer Counterflow
Dan River
Danville, Virginia

Foam Finishing
United Merchants
Old Fort, North Carolina

Wastewater Heat Recovery
Tuftex
Los Angeles, California

- Jim Clark, a Research Engineer II, was brought in for September and will help complete the solar process heat case study. Jim is the head of the Solar Applications Branch of the Technology Applications Lab and is familiar with the solar installation at Johnson and Johnson. He has had experience writing solar case studies for the textile industry from numerous other projects.
- The funds charged to A-2969 through August are low because no charges have been made against the sub-budget given to the School of Textile Engineering. This is a result of internal budget modifications that had to be made and were not processed until the end of August. Back charges for July and August will appear this month and bring the charges up to the projected amount.
- Georgia Tech project personnel met with Nancy Moore on September 22. She checked through the six case studies that were completed at that time and made suggestions for changes. These changes were made and the six reports were sent to her for her visit to DOE in October.
- The outline for the final report is attached for Battelle approval.

2. Comparison to Project Plan

On schedule

3. Problems Encountered

No problems have been encountered thus far, however delays in the case study review by DOE may make a request for a no-cost extension necessary.

October Plans

1. Make corrections based on DOE review of the case studies.
2. Prepare camera ready copies of all case studies.
3. Prepare the final report.

Ms. Ellen McCoy
October 5, 1981
Page 3

Respectfully submitted,

Rachel L. Moore
Assistant Project Director

Carol L. Aton
Project Director

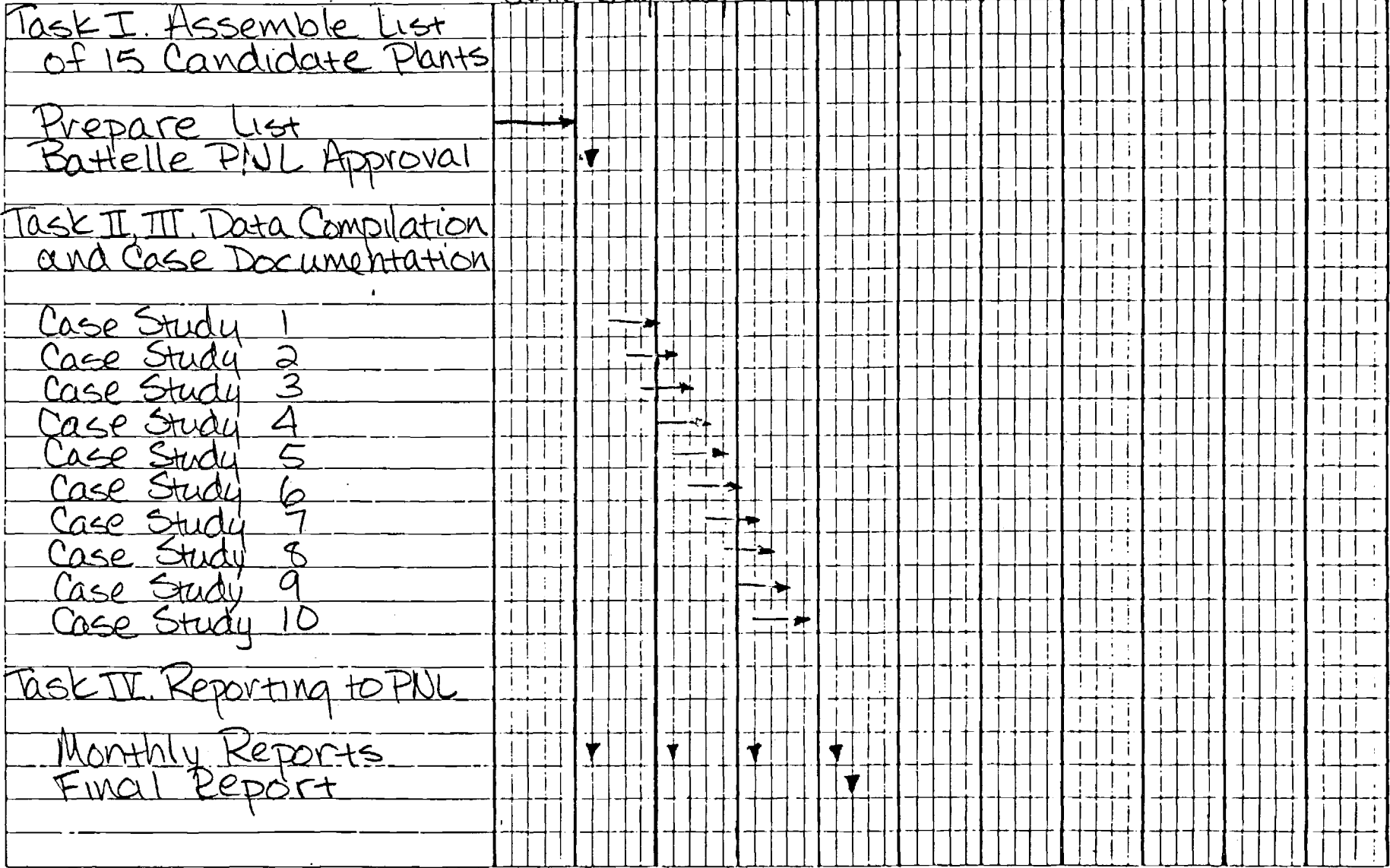
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Project No. A-2969

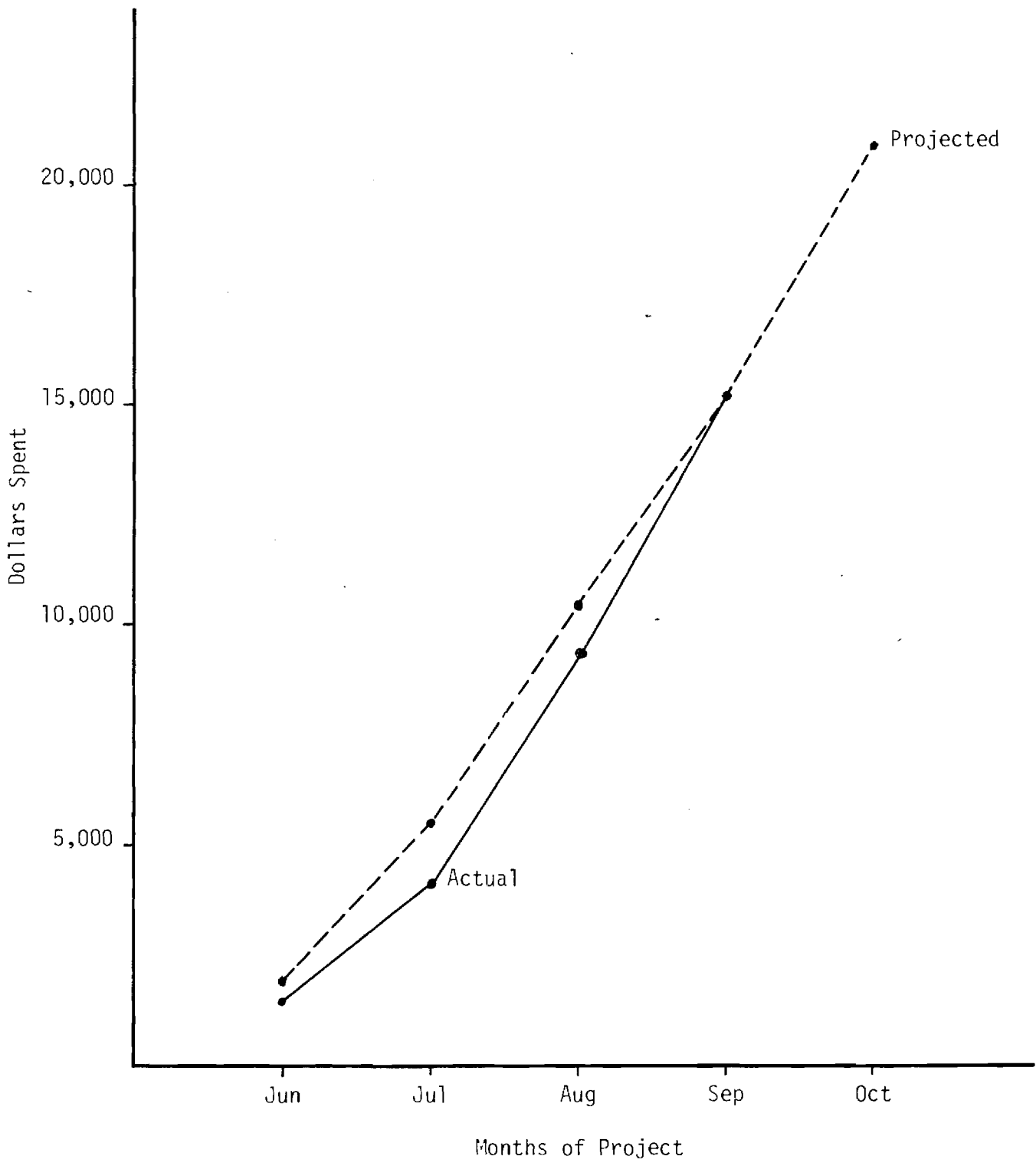
PROJECT PLAN

Project Title Battelle Case Studies

Project Director Cl. Aton June July Aug Sept Oct



LEGEND



Comparison of Personal Services Funds Spent to
Budget Projection for Project A-2969

FINAL REPORT OUTLINE

- I. Introduction
- II. Purpose of study
- III. Telephone survey results
- IV. Choice of plants to be studied
- V. Plant visit strategy
- VI. Case study summary
- VII. Case study copies
 - A. Foam Finishing
 - B. Dyebath Reuse
 - C. Bump-and-Run
 - D. Tandem Hosiery Preparation Line
 - E. Wastewater Heat Recovery
 - F. Water Chlorination and Reuse
 - G. Dryer Exhaust an Counterflow
 - H. Boiler Economizer
 - I. Wood-Fired Boiler
 - J. Solar Industrial Process Heat

TEXTILE ENERGY CONSERVATION CASE STUDY:

SOLAR INDUSTRIAL PROCESS HEAT

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

James L. Clark

September 29, 1981

SOLAR INDUSTRIAL PROCESS HEAT

- o Johnson and Johnson
U.S. Highway 75 South
Sherman, Texas 75090
- o Mr. Don C. Whetzle
Staff Engineer
214 892-2191
- o The U.S. Department of Energy has sponsored the installation at the Johnson and Johnson plant of a solar energy system to produce steam to augment that provided by conventional boilers. The system incorporates an 11,520 square foot array of tracking parabolic through concentrators as the solar collector and a 5000 gallon flash boiler. Treated water is delivered from boiler feed pumps to the flash boiler. It is circulated at high pressure through the collectors where it is heated. The pressure is reduced as the water is throttled back to the boiler, and a portion is flashed to steam. As pressure builds in the boiler, steam is released into a 110 psig plant steam header for the process areas.
- o Johnson and Johnson produces a variety of pharmaceutical products including sterile bleached gauze and sanitary cotton tampons.
- o The solar energy system does not serve an individual process for which energy consumption, costs, and savings may be identified. The estimated total energy provided to the plant during the first year of the system's operation was 632 million BTU. This includes steam metered into the plant header plus steam leaked to the condensate line by faulty traps and later recovered. The current cost of conventional fuel is \$3.00 per million BTU with future price increases already announced.
- o Johnson and Johnson's investment criteria include a required 15% after tax internal rate of return and a maximum simple payback period of eight years. An added benefit of the solar system was the plant's reduced dependence on fossil fuels.

SOLAR INDUSTRIAL PROCESS HEAT

Introduction

Most industrial energy conservation efforts are directed at procedures and equipment that will reduce total energy consumption. In recent years, however, there has been increased emphasis on the use of renewable energy resources rather than conventional fuels. Many devices have been designed to capture energy from the sun, the wind, ocean currents and tides, inland waterways, and biomass systems.

The suitability of some of these designs to provide industrial process heat from the sun has been investigated through a series of field tests sponsored by the U.S. Department of Energy. One of these tests was conducted at the Johnson and Johnson plant in Sherman, Texas. This test program has demonstrated the technical feasibility of providing a portion of a plant's thermal energy needs with solar energy by means of a steam generating system interfaced with a conventional steam plant.

The economic viability of the technique is still under evaluation because of the high development costs associated with the system, the low current price for conventional fuel, and the current economic environment that stresses near-term benefits over future benefits. The company has developed plans for the expansion of the system, which will be implemented when financial investment criteria are met.

Conventional Operation

The Johnson and Johnson plant processes a variety of sanitary pharmaceutical products. The plant uses several processes requiring heat including gauze bleaching, cotton bleaching, sterilization, and space heating. These needs are served by a central steam plant that operates at 110 psig.

The details of the manufacturing processes are considered confidential. They have not been fully described in reports of the solar energy field test nor were they open for investigation under this study. However, this does not prohibit evaluation of the energy conservation measures. The solar energy system interfaces with the central steam plant at a main steam header, rather than directly operating a manufacturing process. Thus, the process is not measurably affected by the source of the energy used.

Solar Energy System

The solar energy system installed at the Johnson and Johnson plant is illustrated in Figure 1. Pressurized water is circulated from a flash boiler, through an array of tracking, parabolic trough solar collectors and back to the boiler. Water in the collector loop may reach a temperature of 395°F. A control valve in the return line maintains the water pressure in the collector to 165 psi higher than the pressure in the boiler. As the water is throttled back to the lower pressure in the boiler, a portion of the water is flashed to steam. As steam is produced and the pressure in the boiler increases above that in the plant steam main, a control valve releases the steam to the main to be used in the process areas.

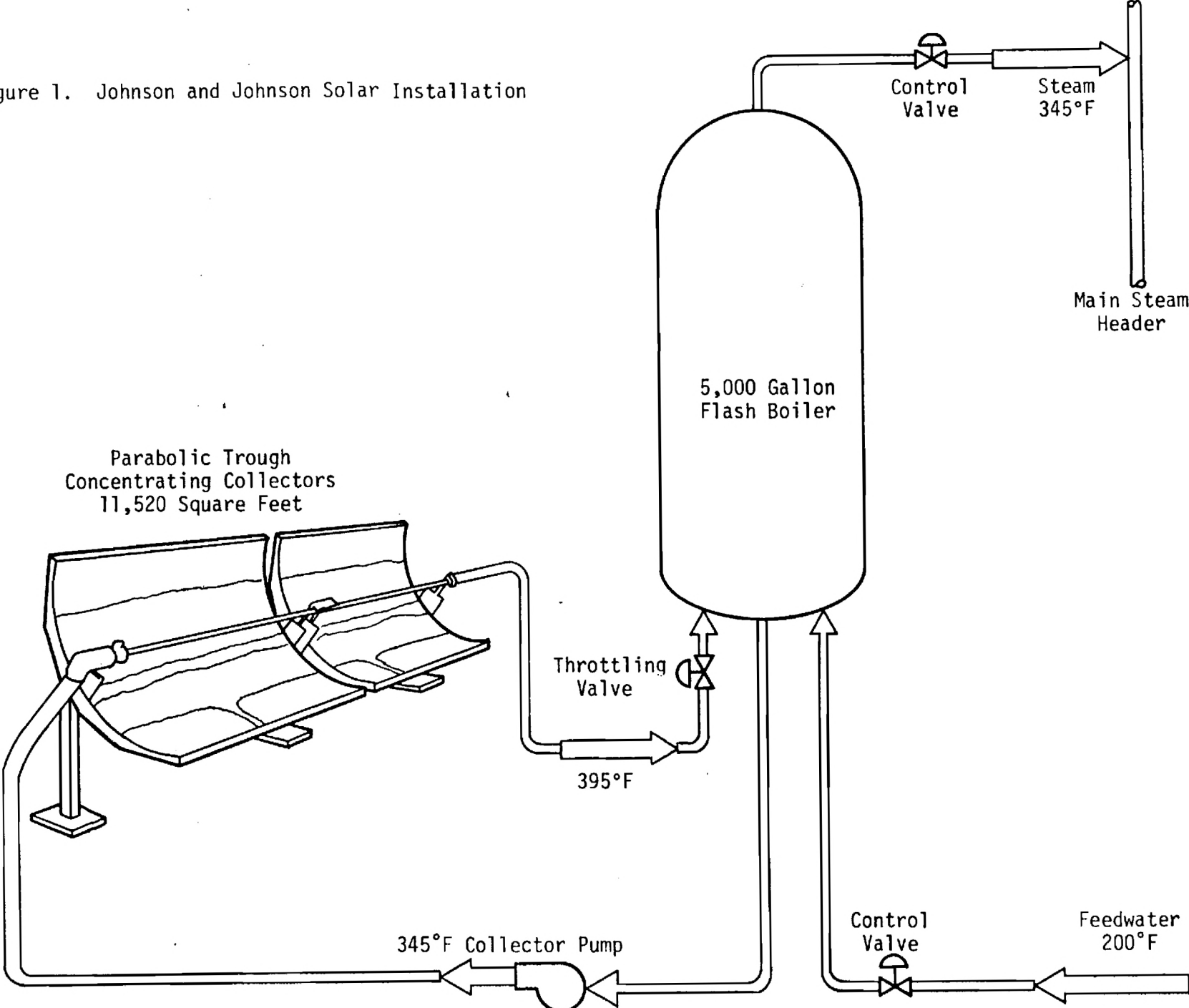
The collector fluid is pure water, obtained from the existing treatment plant for boiler feedwater. Because the collector fluid is eventually flashed and used as process steam, no antifreeze additives are used. Make-up water is pumped into the flash boiler vessel by the plant's boiler feed pumps.

The solar collector array is composed of 192 modules of Acurex Model 3001 parabolic trough for a total collection area of 11,520 square feet. Each module has an aperture of 6 feet and a length of 10 feet. Each drive unit operates a section of eight modules, four on each side of the drive. Tracking of each section is controlled by a sensor located at the drive unit.

The array configuration is eight rows with three drive sections (24 modules) in each row. The array is divided into four parallel flow loops with six sections of troughs per loop. Performance of the collector array is slightly dependent on orientation. Rather than the desired north-south axis, the installation uses a northeast-southwest axis. This was chosen for aesthetic considerations related to the orientation of the plant building and the public visibility of the array site. This non-optimum orientation results in a minor performance deterioration.

Several design variations for the collector modules have been developed and marketed by Acurex. Reflective surfaces have included 3M FEK film, silvered glass, and polished metal. The array installed at the Johnson and Johnson plant uses a polished aluminum reflector surface. The module design currently being marketed has an increased collection area with an aperture

Figure 1. Johnson and Johnson Solar Installation



of 7 feet and a length of 20 feet. The larger area provides proportionately increased energy output with only a minor cost increase.

A central control system monitors solar insolation and determines when the array should begin tracking. In the event of high winds (above 35 mph) or a loss of sunlight for more than 20 minutes, the control system will return the collectors to their stowed (face down) position. The system also controls the operation of the circulation pump in both the operating and freeze protection modes.

The flash boiler is an ASME pressure vessel rated for 160 psig at 370°F; however, it is only required to operate at pressures less than 125 psig. Pressure in the steam main is 110 psig, and only a 5 psi differential pressure is required for release of steam from the flash boiler.

The boiler has a capacity of 5,000 gallons which provides a limited energy storage capability. In addition to offering a smoothing effect on energy output, the storage capacity provides the energy required for freeze protection. At times when the ambient temperature is below 35°F, the circulation pump operates at low speed even if there is inadequate solar insolation for the system to provide energy. By the circulation of hot water from the boiler through the collector array, freezing and damage to the collectors and piping are avoided.

The two-speed pump is driven by a 25 horsepower motor and operates at 3500 rpm (68 gpm) in the operating mode and 1120 rpm in the freeze protection mode.

System Performance

The solar energy system was installed during the latter half of 1979 and began operation in January 1980. Operation responsibilities were turned over to Johnson and Johnson from Acurex in April 1980. During the first year of operation, the system was available for operation 97% of the days and actually delivered energy 70% of the days. The remainder of the time, there was insufficient solar insolation or the plant was not operating.

The number of days the system operated does not give a good indication of its contribution to the plant's energy requirements. On many days the

system delivered energy to the flash boiler without generating adequate pressure for steam to be released to the plant steam header.

During the first year 472,350 pounds of steam were delivered to the steam main. This figure is significantly below that expected, and analysis revealed that a substantial amount of energy was being released from the boiler to the condensate line by faulty steam traps. Since all condensate was recovered, most of the energy was eventually available to the plant, though at a lower temperature.

It was estimated that the total energy delivered to the plant during the first year of operation was 632 MMBTU. Delivery of solar energy to the boiler was at an average efficiency of 25.4%, while delivery of energy from the boiler to the plant (including the steam leaked to the condensate line) was estimated to be at 76% efficiency.

Even by the initial design projections, the system provides only 2% of the plant's energy needs. Thus, the system is a field test of equipment rather than a major energy-producing installation. Nevertheless, the design provides for possible expansion of the collector array.

Johnson and Johnson has already been notified of a 33% increase in natural gas prices to take place in the next year. The opportunity for an investment in additional solar energy equipment will be evaluated in light of the anticipated financial environment and established corporate decision criteria.

Summary

A potential barrier to the implementation of solar energy technology exists in the disparity between actual and claimed performance levels of early systems. For example, technical reports from Acurex note that first year output from the Johnson and Johnson installation was 631.9 MMBTU while Acurex marketing brochures claim the system provides 1.5 billion BTU per year. Potential users of the technology may be expected to lose confidence in light of a 137% overstatement of performance.

Nevertheless, the Solar Industrial Process Heat field test installation at the Johnson and Johnson plant has demonstrated the technical feasibility of providing process steam with solar energy and has identified several implementation problems which have since been addressed.

In order for such an installation to be economically attractive to the industrial sector, capital costs must be reduced substantially and/or conventional fuel prices must be significantly higher. As fuel prices escalate more rapidly than the general cost of manufactured goods and as solar energy system costs are reduced through mass production and modular design, such installations will become more viable as industrial alternatives.

-for further information, contact:

Mr. Don C. Whetzle
Staff Engineer
Johnson and Johnson

TEXTILE ENERGY CONSERVATION CASE STUDY:
DRYER EXHAUST AIR COUNTERFLOW

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

William B. Himes, Jr.

September 30, 1981

DRYER EXHAUST AIR COUNTERFLOW

- Dan River, Inc.
P.O. Box 261
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- Mr. B.C. Haraway
Technical Superintendent, Finishing
804-799-4961
- Dan River, Inc. has modified 10 tenter frame dryers and predryers with a system that ducts the predryer exhaust into the tenter and counterflows the tenter exhaust. These changes reduce the total exhaust from the predryer and tenter by approximately 47%.
- The primary product at Dan River is a shirting weight composed of a 65/35 blend of polyester and cotton.
- For the year prior to the installation the price of natural gas averaged \$1.94 per MMBTU. For 1980, the natural gas cost averaged \$3.60 per MMBTU.
- Since the modifications, Dan River has had an average annual energy savings of 24,250 MMBTU, and a cost savings of \$87,302 based on 1980 natural gas prices.
- The average payback period of Dan River energy conservation projects is one year or less, however, programs with a payback period of five years or less are still considered.

DRYER EXHAUST AIR COUNTERFLOW

Introduction

One of the major energy consuming industries in the United States is the textile industry. In an effort to reduce the industry's energy requirement of over 67 million barrels of oil equivalent annually, much work is being done to determine ways to conserve energy in textiles. A major textile processing area that shows promise for energy conservation is the drying operation.

The major method for removing water from textile materials is convective drying using tenter frames and predryers. This operation consumes roughly 25% of the energy required to produce finished textile goods. Most of the dryers used in textile operations today were designed and built during the time when energy costs did not make a significant impact on the cost of finished goods. Consequently, from an energy standpoint, the efficiency of most textile dryers is low. The energy efficiency of older textile ovens and dryers can be improved through some relatively inexpensive modifications.

The thermal energy consumed in a convective drying operation arises from the following four drying requirements:

- o Thermal energy is needed to heat water in the textile material to the evaporation temperature, evaporate it, and then raise the vaporized water from the vaporization temperature to the exhaust temperature.
- o Thermal energy is required to raise the textile material from the entrance temperature to the exit temperature.
- o Thermal energy is required to replace the heat lost by radiation and convection from the dryer housing.
- o Thermal energy is required to replace the heat lost when the hot air which carries away the vaporized water is exhausted.

Traditional Operation

Dan River Inc., in Danville, Virginia, has been successful in substantially reducing the quantity of gas consumed in drying without

significantly affecting product quality or production rates. Their primary product is a 65/35 percent blend of polyester and cotton in dress goods and shirting weight material. Polyester and cotton fiber is brought into the plant in bales. The fiber is processed into yarn, which is woven or knitted into fabric. Depending on the type of material, it is either prepared, dyed, or finished.

Before modifications were made to the dryers Dan River, the drying process began in the gas fired infrared predryer (see Figure 1). Ten gas fired burners divided into three banks provided the initial drying, reducing the moisture content of the fabric to around 35%.

The tenter frame dryer was the next step in the drying process. The tenter frame was divided into three zones, each of which had exhaust ducts. Burners in each zone were separately controlled to vary the operating temperature in each zone.

Air was exhausted from the dryer to remove vaporized water, smoke, solvents, and particulate matter from the dryer housing. Prior to any modification, Dan River was only exhausting air from the first and third zones of the tenter. The exhaust air left the dryer housing at the average temperature inside each zone. Fresh make-up air, usually at room temperature, was taken into the dryer to replace the exhausted air and heated to the dryer operating temperature. The energy required to heat this large volume of air constitutes approximately 50% of the energy used in drying.

Modification

It is in the area of hot air exhaust reduction that Dan River found the potential for significant savings. The modification implemented on the tenter frames involved the counterflow of the tenter exhaust air and the ducting of the predryer exhaust into the tenter housing instead of to the atmosphere (see Figure 2).

Prior to modification, the exhaust from the predryer averaged approximately 12,000 to 15,000 CFM at 360°F. This air had a low moisture content and was very clean and was thus able to be ducted into the dryer. After the change, the volume of air through the predryer was reduced to an

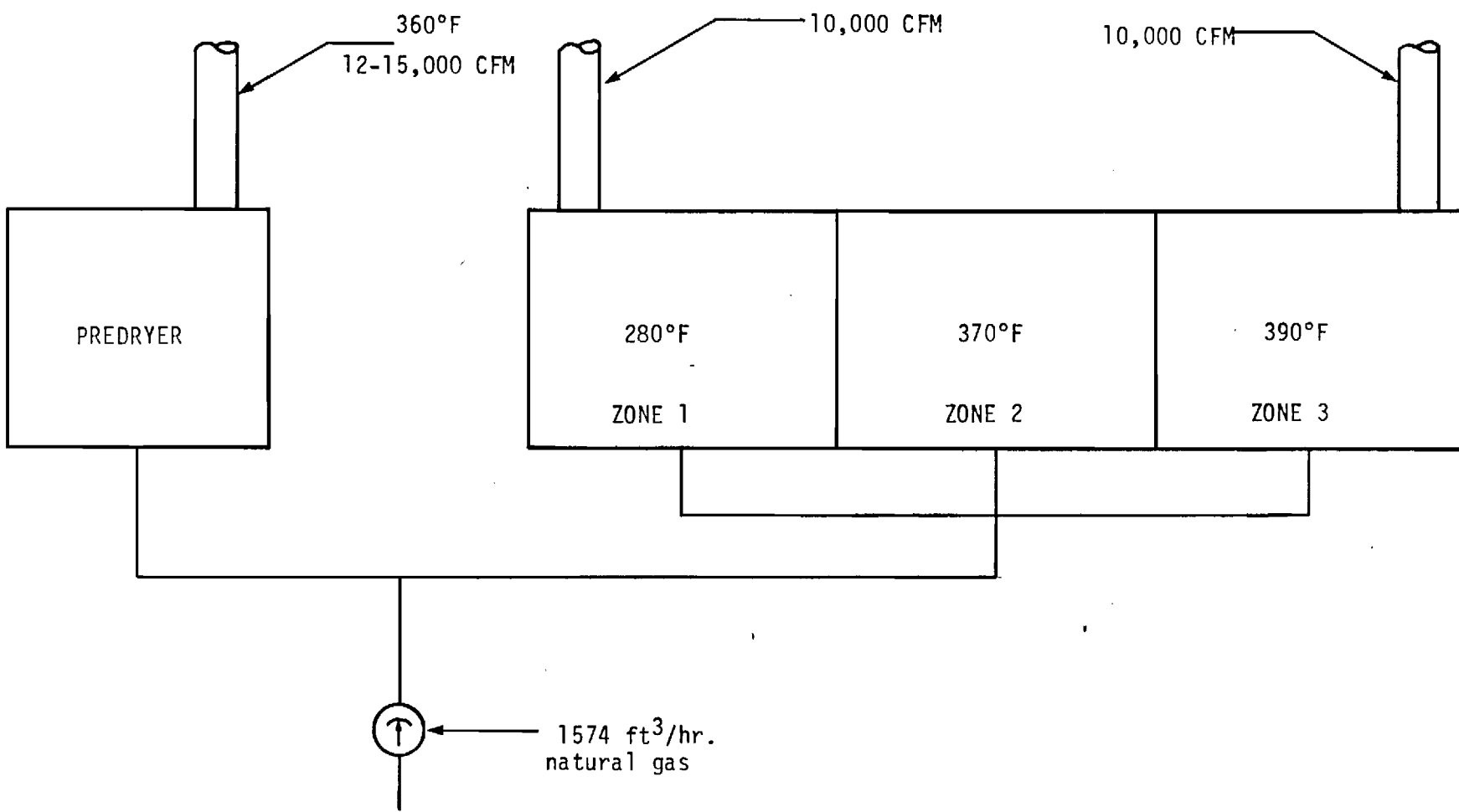


FIGURE 1.
TYPICAL UNMODIFIED CONVECTIVE DRYING ARRANGEMENT

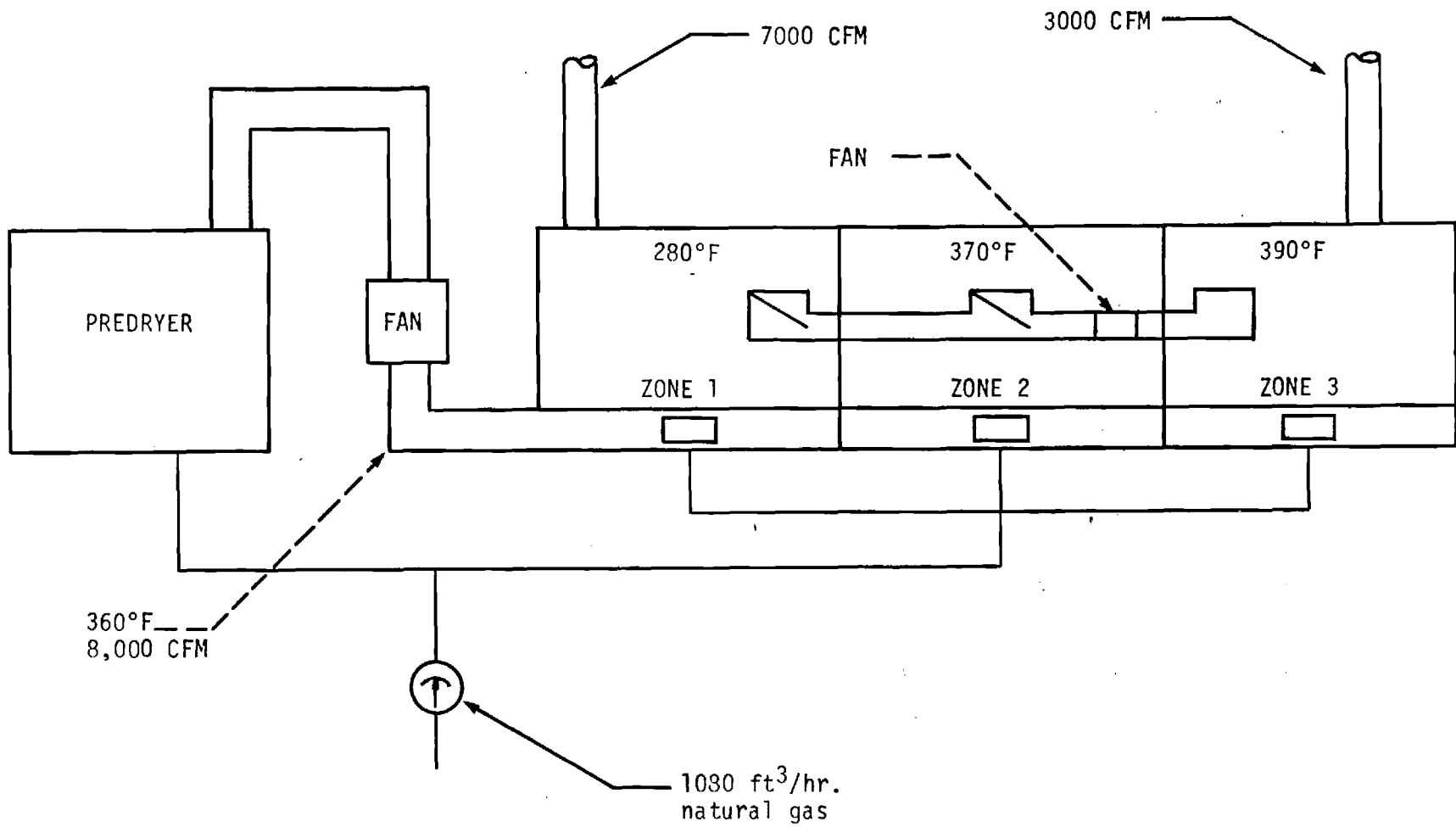


FIGURE 2.
 TYPICAL COUNTERFLOW CONVERSION

average of 7,000 to 8,000 CFM and the entire exhaust was ducted into the tenter housing, with a portion entering each of the three tenter zones.

To counterflow the air inside the tenter, a duct with a fan inside was constructed on the side of the tenter housing. This duct carried air from the third zone back into the first and second zones.

The volume of air exhausted prior to conversion was equally divided between the first and third zones, and was approximately 10,000 CFM from each zone. After the changes the exhaust from the first zone was reduced to 7,000 CFM and the exhaust from the third zone was reduced to 3,000 CFM. Table I shows the results of the first complete tenter modification, at a cost of \$17,920.

Table I
EFFECTS OF COUNTERFLOW MODIFICATIONS

	<u>Before</u>	<u>After</u>	<u>Reduction</u>
Exhaust Volume	33,500 CFM	17,500 CFM	47%
Natural Gas Consumption	1,575 CFM	1,080 CFM	31%

Based on the reductions shown above, the decision was made to convert nine more tenter frames in early 1977 at a total cost of \$150,061 or \$16,673 per dryer.

Savings

The exact amount of exhaust reduction possible will vary from tenter to tenter based on initial operating conditions and several other factors, such as the amount of oils and resins that are evaporated along with water that can cause smoke. Reducing the amount exhaust air increases the tendency of this smoke to blow out the entrance and exit slots. Insurance companies also have regulations that must be strictly adhered to

when combustibles are being evaporated. Each of these factors has an effect on the amount of reduction possible. The results of Dan River's modification are shown for the first year of operation and for 1980 in Table II.

Table II
ENERGY AND COST SAVINGS

<u>Year</u>	<u>Natural Gas Cost</u>	<u>Energy Savings</u>	<u>Cost Savings</u>
1977	\$1.94/MMBTU	24,250/MMBTU	\$47,046
1980	\$3.60/MMBTU	24,250/MMBTU	\$87,302

The payback period in 1977 was 3.6 years, however, at 1981 natural gas prices the conversions return their investment in less than two years.

Summary

Dan River's management is conservative in cost considerations, yet at the same time is imaginative and innovative and always seeking new opportunities to provide a better product at a competitive price. Each plant annually submits to corporate management an estimate of capital needs for energy improvements. The average return that is accepted is approximately one year or less however, five year is still attractive.

TEXTILE ENERGY CONSERVATION CASE STUDY:
FOAM FINISHING

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

LuAnn T. Rockett

and

Fred L. Cook

October 1, 1981

FOAM FINISHING

- United Merchants and Manufacturers
Old Fort Finishing Plant
Old Fort, North Carolina 28762
- Mr. Floyd Parker
Plant Manager
704-668-7611
- United Merchants has retrofitted a conventional finishing range with a foam finishing system. The foam reduces the wet pick-up of the fabric to 25% to 35%, thus reducing drying time and chemical usage, and increasing line production.
- United Merchants produces cotton/polyester apparel fabrics.
- Before foam finishing was introduced, the plant consumed 23,100 MMBTU per year in the finishing operation. Since foam finishing has been used, the plant has averaged 10,100 MMBTU per year in the finishing operation.
- For the year prior to the installation of the foam system, propane averaged \$2.61 per MMBTU. In 1980, propane has averaged \$5.01 per MMBTU.
- Since the foam system was installed, United Merchants has had an average weekly total savings of \$5,203 and energy savings of \$1,303. Since the system promised a payback period of less than six months, United Merchants decided to invest in the procedure.
- The major benefit realized from installing the foam system was a substantial increase in production capacity.

FOAM FINISHING

Introduction

Foam finishing is a process whereby the finish is applied to the fabric in an air-blown foam, rather than a pure liquid state. This results in the following advantages over conventional aqueous systems:

- Reduction in energy consumption for drying per pound of fabric,
- More efficient use of chemicals,
- Application to wet fabric without first drying, and
- Reduction in water content of the finish resulting in higher production rates, decreased dryer temperatures and decreased fuel consumption.

Foam finishes may include fluorocarbons, permanent press resins, softeners or water repellants. Foam has been successfully used on nylon and polyester/cotton fabrics in pile, woven, and knitted forms.

The foam process consists of preparing a concentrated solution (or dispersion) of the chemical or chemicals in water, and then incorporating suitable foaming aids. The concentrate is then mechanically foamed and is applied to the fabric by means of equipment such as a knife over a roll coater. The foam is then forced to collapse and flow over the fibers. This can be done by passing the foam-coated fabric through a pad mangle or by using a foam which collapses when heated. The coated fabric is then passed through a conventional oven to remove the small amount of water used in the concentrate and to cure the finish.

To date, foam finishing has gained wider acceptance than foam dyeing, mainly because of the wider latitude in uniformity allowed for colorless finishes than for dyes and pigments. Foam finishing also helps alleviate the wash/drying steps after curing. This is just one more example of the payback and energy savings possible with foam finishings.

Traditional Operation

United Merchants and Manufacturers Old Fort Finishing Plant in Old Fort, North Carolina, has been successfully using foam finishing since 1976. The Old Fort plant produces apparel fabrics ranging from 1.2 to 4.0 yards per pound. The average fabric weight is 2.5 yards per pound. The

fabrics are generally 50% polyester/50% cotton blends, with polycellulosics accounting for 80% of the total production. All fabrics produced in the plant are finished with foam processing.

Until 1977, the plant operated with conventional finishing ranges. The ranges typically ran at 40 to 80 yards per minute, and generally consumed 32 yards per gallon of finishing mix. Drying and curing temperatures ranged from 350° to 375°F when performed in the same step. During this time, total plant gas consumption in the finishing area was 23,100 MMBTU at an average annual cost of \$2.61 per MMBTU.

Modifications

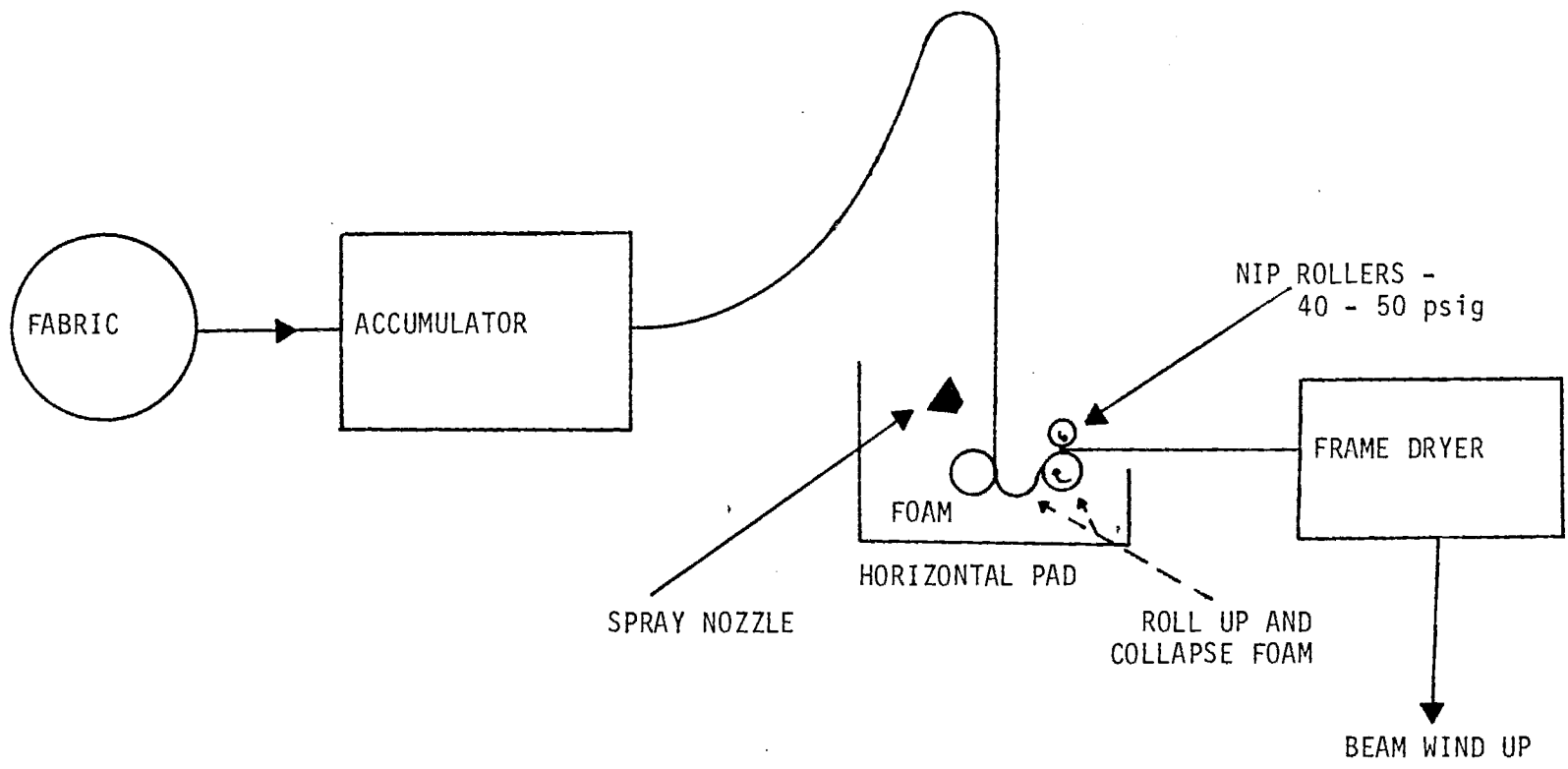
In 1977, United Merchants retrofitted their conventional finishing ranges with foam systems at a cost of \$25,000 per range. The incentives to invest were two-fold -- projected energy savings and increased production.

The system is shown in Figure 1. Using this type of foam finishing technology, both sides of the fabric are finished at the same time. Production speeds were increased to 70 to 110 yards per minute and plant personnel project that with new drying equipment speeds of over 200 yards per minute could be achieved. Using foam, the wet pick-up has averaged 25% to 35%. The details of the foaming system itself are pictured in Figure 2. The frame dryer in the foam system can operate two ways:

- (a) Drying and curing are accomplished in the same step at 350° to 375°F, or
- (b) Fabric is dried first and is then roller cured at 250° to 300°F

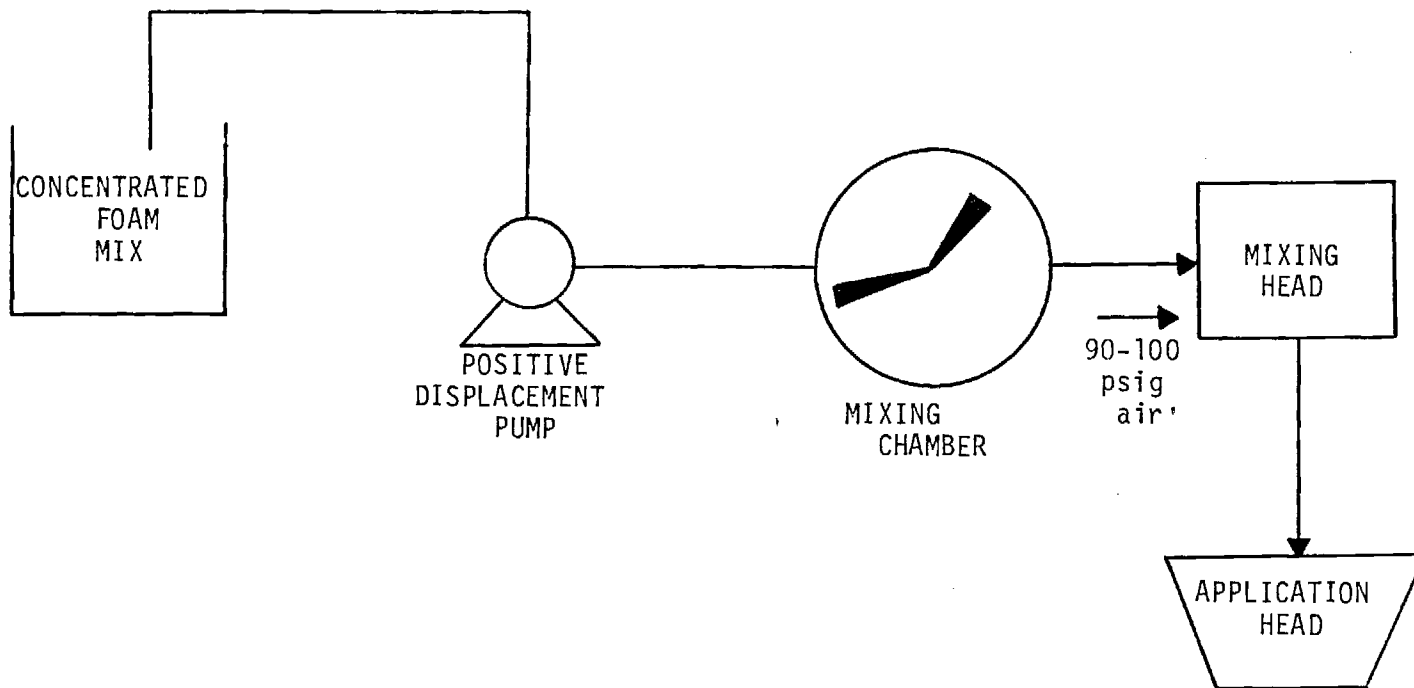
Foam finishing has led to a decrease in chemical usage of 10% to 20%. A typical finish can now be applied at 100 yards per gallon of mix. Energy consumption for finishing has been reduced to 10,100 MMBTU for 1980 at a cost of \$5.01 per MMBTU.

Environmentally, the impact of foam finishing has been minimal. Chemical usage has decreased. In terms of water volume, there has not been a dramatic change since the conventional finishing system did not use an afterwash. However, there has been a percentage decrease in water usage of 50%.



UNITED MERCHANTS AND MANUFACTURERS
FOAM FINISHING SYSTEM

FIGURE 1.



FOAMING SYSTEM
FIGURE 2.

Savings

The initial \$25,000 invested in the system was recovered in 25 weeks with \$1000 per week in savings due to production increases and energy consumption decreases. Because the total payback period was so short, the investment was made without any consideration given to return on investment or other economic analyses.

Total finishing energy consumption is shown in Table I.

Table I
TOTAL FINISHING ENERGY CONSUMPTION

	<u>Propane Cost</u>	<u>Energy Usage</u>	<u>Total</u>
Conventional (1977)	\$0.249/gal	925 BTU/yd	2.31×10^{10} BTU/yr
Foam (1980)	\$0.479/gal	405 BTU/yd	1.01×10^{10} BTU/yr
SAVINGS			13,000 MMBTU/yr

Total savings dollars are based on labor, materials and overhead costs. Energy consumption is also included in this figure. Based on current plant figures, the savings averages shown in Table II were compiled.

Table II
TOTAL FINISHING COST SAVINGS

	<u>Annual</u>	<u>Weekly Average</u>
ENERGY SAVINGS	\$ 65,150	\$ 1,303
TOTAL SAVINGS	\$260,150	\$ 5,203

Summary

United Merchants feels that resistance to change is the major barrier confronting the textile industry with regard to conversion to foam finishing. With less than a 6 month payback to retrofit an existing finishing range, foam finishing quickly produces savings in labor, materials, energy, and overhead. Foam finishing is clearly both an economically and technologically attractive energy conservation alternative.

-For more information contact:

Mr. Floyd Parker
Plant Manager
United Merchants and Manufacturers
Old Fort Finishing Plant

TEXTILE ENERGY CONSERVATION CASE STUDY:
WASTEWATER HEAT RECOVERY

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

Rachel L. Moore

September 28, 1981

WASTEWATER HEAT RECOVERY

- La Mirada Dye Plant
15228 Bona Vista
Santa Fe Springs, California
- Mr. Robert Brissette
Plant Engineer
213-921-6791
- The La Mirada Dye Plant was constructed to include a wastewater heat recovery system that uses hot wastewater from the dyehouse to preheat incoming water to the dyehouse and water for boiler feed.
- La Mirada Dye Plant produces finished nylon carpets.
- From August 1980 to July 1981, the La Mirada Dye Plant consumed 297,865 MMBTU at a total cost of \$1,153,960.
- The wastewater heat recovery system has saved an estimated 21,149 MMBTU annually, or 63,447 MMBTU since the plant began operation in September 1978. At current fuel costs, this results in an annual cost savings of \$121,606.
- The cost of the wastewater heat recovery unit was included in the initial construction cost of the plant, since management personnel knew that it would provide a quick payback and solutions to other potential problems.
- The use of the wastewater heat recovery system helped the plant meet state emissions standards for wastewater. No wastewater over 120°F could be discharged from the plant, and the wastewater exiting the heat exchangers is at an average temperature of 110°F. Dye cycle time was also reduced, since the incoming water was at 100° instead of 68°F.

WASTEWATER HEAT RECOVERY

Introduction

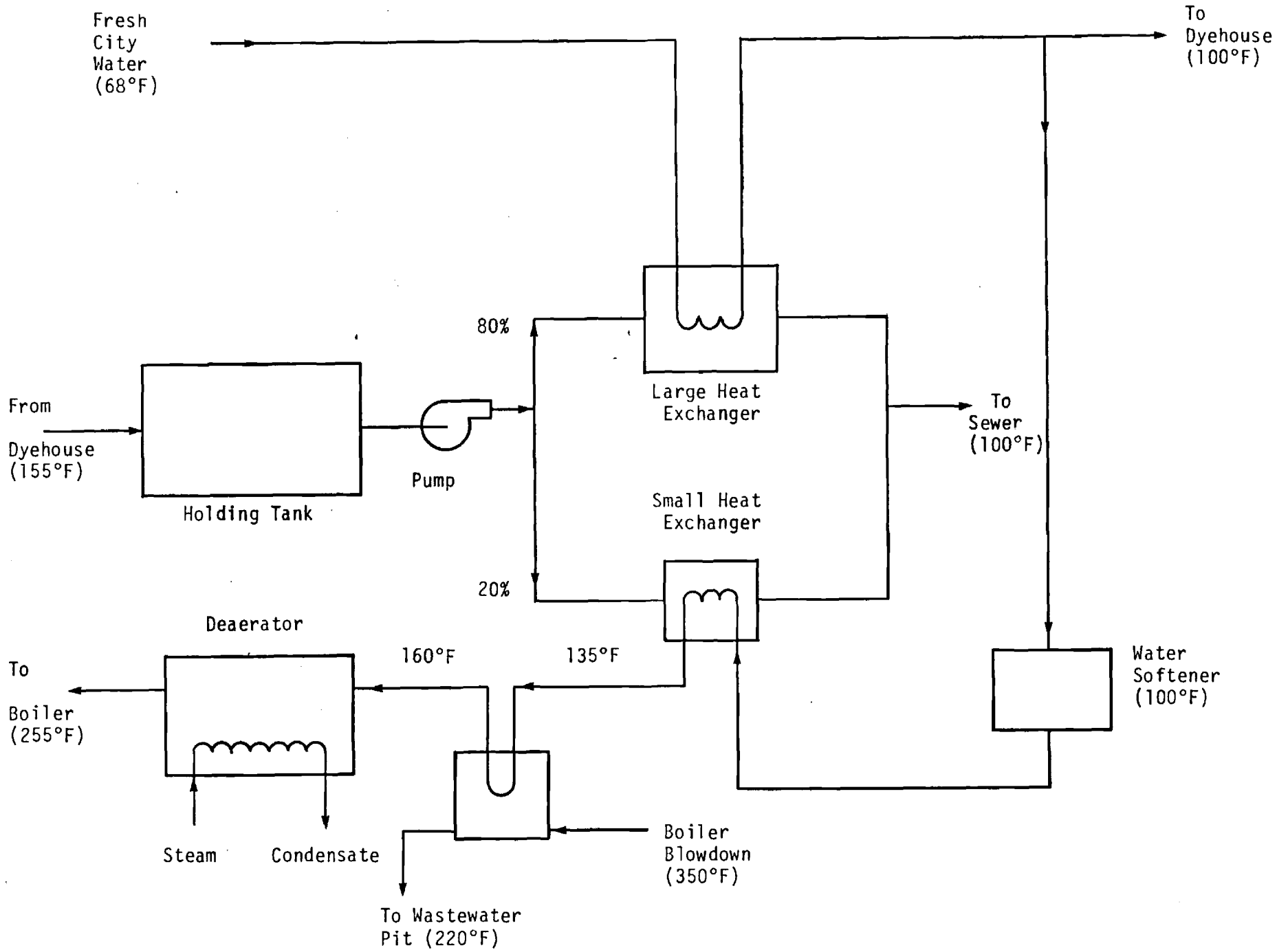
The textile industry consumes over 125 billion gallons of water and 290,000 million BTU each year in its wet processing operations. Increasing energy costs and shortages in energy and water supplies have stimulated the implementation of technologies that reduce energy and water consumption. A large portion of the energy and water consumed in wet processing is used in batch operations. Because batch operations are much more energy intensive than continuous operations, research work has concentrated on ways to conserve energy and water in batch dyeing. New batch dyeing procedures have been perfected that can save as much as 50% of the energy consumed in conventional procedures. Some of these procedures also reduce the amount of hot wastewater that is discharged from the plant. However, some wastewater discharge will still occur and the heat in this water should be recovered. A carpet mill in California uses wastewater heat recovery to provide warm dyehouse water and boiler feedwater.

Plant Operation

La Mirada Dye Plant, located in Los Angeles, California, produces finished nylon carpet. Beck dyeing, resist printing, and drying are the major plant operations. The plant is operated 24 hours per day, 5 days per week, 52 weeks per year.

La Mirada uses two heat exchangers to preheat boiler feedwater and beck fill water using the outgoing hot wastewater from the dye becks as shown in Figure 1. The dye becks are equipped with two separate drain systems, one that directs water of 120°F or less to the sewer and one that directs water above 120°F into a holding tank. From the holding tank, the hot wastewater at an average temperature of 155°F is pumped into one of the two heat exchangers, which are connected in parallel. The large four-tube heat exchanger heats water to 100°F, which goes either to the dyehouse or back through the small three-tube heat exchanger. The pipe leading to the small exchanger has a flow restriction that allows approximately 20% of the wastewater to flow through, with the remaining 80% flowing through the large heat exchanger. The wastewater exiting from the exchangers is at an average temperature of 110°F and is discharged to the sewer.

Figure 1. Wastewater Heat Recovery at La Mirada Dye Plant



Part of the fresh water that exits from the large heat exchanger passes through a water softening operation and then through the small exchanger where the temperature is boosted to 135°F. The water is then sent through where it is further heated with continuous boiler blowdown to 160°F. The next step for the boiler feedwater is to be heated to 225°F in the deaerator tank by steam coils, and then it goes into the boiler. Thus, the dyehouse receives water at 100°F and the boiler feedwater is preheated to 160° instead of having water entering into both operations at 68°F.

The plant uses 930,000 gallons of water per day. The boiler requires an average of 100,000 gallons per day of feedwater. Thus, the dyehouse uses an average of 830,000 gallons per day, producing a flow of 575 gallons per minute. Approximately 250 gallons per minute of this flow is used hot. Thus, the average wastewater flow into the heat exchangers is estimated to be 300 gallons per minute and the fresh water flow into the large heat exchanger is approximately 270 gallons per minute. The system is designed to handle a peak flow of 1200 gallons per minute. The flow to the small exchanger and then to the boiler is 70 gallons per minute. Approximately 24 gallons per minute of surface blow off at 350°F enters the holding tank, heats the softened boiler water from 135°F to 160°F, and is discharged to the wastewater sump at 220°F.

The La Mirada Dye Plant began its operations in September 1978. The plant, built with the heat exchanger systems as an original part of the plant, has used the system continuously since startup except when maintenance was being performed.

The plant management has been very pleased with the operation of the system. Maintenance is minimal; the system is back washed (flow reversal) once per day for 15 minutes. Once every six months, a caustic solution is run through the system to eliminate any chemical buildup. Lint has not been a problem in the system because a lint screen is used before the water enters the holding tank.

Savings

For an average flow to the dyehouse of 200 gallons per minute of fresh water at 100°F instead of 68°F, the savings resulting from using the system based on current energy prices are shown in Table I.

Table I
DYEHOUSE ENERGY SAVINGS

Annual Energy Savings	19,215 MMBTU
Annual Cost Savings	\$110,488

For an average flow of softened water to the boiler feedwater system of 70 gallons per minute at 160°F instead of 68°F, the savings resulting from using the system based on current energy costs are shown in Table II.

Table II
BOILER SYSTEM ENERGY SAVINGS

Annual Energy Savings	1,934 MMBTU
Annual Cost Savings	\$11,118

Thus, the total savings resulting from the installation of the wastewater heat recovery system are shown in Table III.

Table III
TOTAL SAVINGS

Annual Energy Savings	21,149 MMBTU
Annual Cost Savings	\$121,606

Summary

La Mirada Dye Plant designed a sophisticated wastewater heat recovery system to be a part of the original plant equipment. The plant management knew that substantial energy savings would result from the installation and also knew that the system could solve other potential problems. The city code stated that no water above 120° could be discharged to the sewer. With the heat recovery system, the wastewater effluent from the plant was reduced to 110°F. The availability of warm water would also allow the dye cycle times to be shorter since it would take at least 10 minutes to heat the dyebath from 68°F to 100°F.

-For more information contact:

Mr. Robert Brissette
Plant Engineer
La Mirada Dye Plant
Los Angeles, California

FINAL REPORT
PROJECT A-2969

ENERGY CONSERVATION IN THE TEXTILE INDUSTRY

Investigators:

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Rachel L. Moore
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Prepared for

**BATTELLE
PACIFIC NORTHWEST LABORATORIES
RICHLAND, WASHINGTON**

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GEORGIA INSTITUTE OF TECHNOLOGY

**A Unit of the University System of Georgia
Engineering Experiment Station
Atlanta, Georgia 30332**



ENERGY CONSERVATION IN THE TEXTILE INDUSTRY

FINAL REPORT

INVESTIGATORS

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I. INTRODUCTION

Battelle, Pacific Northwest Laboratories (PNL) in Richland, Washington, has supported the Office of Industrial Programs (OIP) of the Department of Energy in various conservation programs. The Office of Industrial Programs has set forth as a goal the evaluation of new energy efficient technologies in selected industries and the assessment of the impact of OIP funding on the energy conservation activities of specific users. The Engineering Experiment Station of the Georgia Institute of Technology was chosen to assist Battelle PNL in the evaluation of activities in the textile industry. The preparation of case histories documenting energy conservation opportunities implemented by the textile industry was designated as the method of presentation of the results of the evaluation. These case histories document energy and cost savings resulting from the energy conserving technologies implemented, as well as information on the fundamentals of the technologies and ancillary benefits.

This project was conducted by the Technology Applications Laboratory of the Georgia Tech Engineering Experiment Station. The work was directed by the laboratory's Technology Transfer Branch with assistance from the School of Textile Engineering.

The program involved the selection of 15 energy conserving technologies that had been implemented by the textile industry. Of these 15 technologies, 10 were selected by Battelle PNL for further study. A visit was made to each industrial firm to survey plant operations and to study the technology implemented. A case history report was then prepared, summarizing the fundamentals of the technology and the resulting energy and cost savings.

This report summarizes the objectives, activities, and findings of the program. Copies of the individual case studies are included as appendices.

II. PROGRAM OBJECTIVES AND TASKS

The Energy Conservation in the Textile Industry project has been a multi-purpose program. The major objectives include the following:

- Identify energy conservation opportunities that have been implemented by the textile industry.
- Determine the energy and cost savings resulting from the implementation of these technologies.
- Highlight ancillary benefits of the energy conservation opportunities implemented.
- Determine the criteria by which industry evaluates energy conservation investments.

These objectives have been addressed through direct contact with engineering and managerial personnel at a number of textile firms throughout the country. The general methods utilized were specified in the project contract and were separated into three program tasks.

Task 1. Selection of Candidate Firms

Georgia Tech project team members contacted 35 textile companies that had implemented energy conserving technologies. The preliminary selection was based on factors including type of technology, energy and cost savings, ease of industry-wide commercialization, economics, DOE sponsorship, and liaison with Georgia Tech. Of these companies, 14 textile firms, which had implemented 16 energy conserving technologies, agreed to give full disclosure of all technical information. From these 16 candidate technologies, Battelle PNL selected 10 for detailed study.

Task 2. Plant Visits

Each of the plants selected by Battelle PNL was visited by a member of the Georgia Tech project team. The purpose of the visit was to gather information about plant operations, energy consumption and costs, specifics of the energy conservation opportunity implemented, and criteria for investment decision making.

Task 3. Case Study Reports

A comprehensive case history report was prepared for each energy conservation opportunity that was implemented. The report documented the information that was gathered during the plant visit. These reports were sent to the plant contact, the Battelle PNL technical monitor, and the DOE technical monitor for approval.

III. SELECTION OF CANDIDATE PLANTS

Under the contract requirements, 15 candidate technologies were to be selected for submission to Battelle PNL. Georgia Tech project team members from the Engineering Experiment Station and the School of Textile Engineering met and compiled a list of energy conserving technologies that had been implemented by the textile industry. They used their extensive background of industry contacts, as well as their association with trade organizations, to compile the initial list of plants to be contacted. The list consisted of 38 energy conserving technologies that had been implemented by textile firms throughout the United States, which produced a wide variety of different textile products. Some of the technologies were developed and demonstrated through funding from the Department of Energy. Table 1 summarizes the technologies considered for study, DOE sponsored projects, and major product and location of the companies contacted.

Each of these plants was contacted concerning participation in the project. The purpose of the project, the scope of work, and the requirements for participation were explained to each plant contact. Fourteen firms agreed to participate in the program, with two of these firms having implemented two different energy conservation opportunities.

The major reasons given by firms choosing not to participate in the program were unwillingness to disclose information and insufficient time available to handle telephone responses to the published reports. Appendix K gives a brief summary of some of the energy conserving technologies originally considered that were not studied because the companies chose not to participate in this project. These summaries include background information on the technologies and the application and need of the technology in the textile industry.

The 16 energy conserving technologies submitted to Battelle PNL as candidates for case studies are shown in Table 2, along with estimated impact on the textile industry. The industry impact was estimated based on the investigator's knowledge of the textile industry, using as a guideline the process production data found in the final report for Phase I of the Energy Conservation in the Textile Industry project, directed by Dr. F. L. Cook of Georgia Tech and completed in January 1978.

Table 1
LIST OF TECHNOLOGIES IMPLEMENTED
BY THE TEXTILE INDUSTRY

<u>Technology</u>	<u>DOE Sponsored</u>	<u>Major Product</u>	<u>Location</u>
Hot Melt Slashing		Yarn	GA
Combined Preparation		Towels	AL
Tandem Preparation Line		Hosiery	AL
Caustic Recovery		Sheeting	AL
Beck Modifications		Carpet	GA
Indirect Beck Heating		Carpet	GA
Dyebath Reuse	*	Hosiery	NC
Dyebath Reuse	*	Carpet	GA
Bump-and-Run	*	Carpet	GA
Low Temperature Dyeing		Carpet	CA
Foam Dyeing	*	Carpet	GA
Polyester/Cotton Dyeing		Sheeting	GA
Remaflam		-	-
Triatex MA		Apparel Fabric	GA
Low Temperature Curing		Upholstery Fabric	GA
Foam Finishing	*	Apparel Fabric	NC
Foam Finishing	*	Corduroy	SC
Steamer Control		Carpet	GA
Wastewater Heat Recovery		Apparel Fabric	GA
Wastewater Heat Recovery		Carpet	CA
Water Reuse		Apparel Fabric	GA
Wastewater Chlorination		Carpet	GA
Hyperfiltration	*	Upholstery Fabric	SC
Machnozzle	*	Sheeting	SC
Dryer Controls		Upholstery Fabric	SC
Dryer Controls		Carpet	GA
Dryer Counterflow		Apparel Fabric	VA
Dryer Heat Recovery		Apparel Fabric	SC
Dryer Heat Recovery		Carpet	GA
Waste-Fired Dryer		Towels	GA
Ion Control		Yarn	VA
Ion Control		Yarn	GA
Carpet Backing		Carpet	GA
Boiler Economizer		Upholstery Fabric	NC
Wood-Fired Boiler	*	Carpet Yarn	GA
Wood-Fired Boiler	*	Carpet	GA
Trifuel Boiler		Apparel Fabric	NC
Solar Process Steam	*	Gauze	TX

Table 2
LIST OF CANDIDATE TECHNOLOGIES

<u>Technology</u>	<u>Major Product</u>	<u>Location</u>	<u>Estimated Industry Impact</u>	<u>DOE Sponsored</u>
Tandem Preparation Line	Hosiery	AL	15%	No
Dyebath Reuse	Carpet	GA	30%	Yes
Bump-and-Run	Carpet	GA	30%	Yes
Foam Finishing	Apparel	NC	40%	Yes
Wastewater Heat Recovery	Apparel	GA	50%	No
Wastewater Heat Recovery	Carpet	CA	50%	No
Wastewater Chlorination	Carpet	GA	20%	No
Hyperfiltration	Upholstery	SC	30%	Yes
Water Reuse	Apparel	GA	20%	No
Dryer Controls	Upholstery	SC	50%	No
Dryer Counterflow	Apparel	VA	50%	No
Waste-Fired Dryer	Towels	GA	40%	No
Boiler Economizer	Upholstery	NC	70%	No
Wood-Fired Boiler	Carpet Yarn	GA	70%	Yes
Trifuel Boiler	Apparel	NC	70%	No
Solar Process Steam	Gauze	TX	50%	Yes

Of these 16 technologies, 10 were chosen by Battelle PNL to be evaluated for case studies. The criteria for selection were as follows:

- DOE sponsored projects
- Location
- Industry impact
- Energy and cost savings
- Low implementation cost
- Ancillary benefits
 - Reduced usage of fossil fuels
 - Reduced water usage
 - Reduced wastewater discharge
 - Improved process efficiency

The technologies selected were chosen for two or more of the above criteria. A mix of DOE and internally funded projects was desired. It was also desired to study textile firms in as many geographic locations as possible. Energy conserving technologies chosen also had institutional and environmental benefits as well as energy savings. Based on these factors, the technologies listed in Table 3 were chosen for further study.

Table 3
LIST OF CASE STUDY PLANTS

<p>Tandem Preparation Line Niota Textile Mill Fort Payne, AL</p> <ul style="list-style-type: none"> ● 15% industry impact ● Reduced water usage ● Reduced wastewater discharge ● Reduced chemical usage ● Estimated 30% energy savings 	<p>Water Chlorination and Reuse Salem Carpets Chickamauga, GA</p> <ul style="list-style-type: none"> ● 20% industry impact ● Reduced water usage ● Reduced wastewater discharge ● Increased process efficiency ● Estimated 30% energy savings
<p>Dyebath Reuse E & B Carpets Dalton, GA</p> <ul style="list-style-type: none"> ● DOE sponsored ● 30% industry impact ● Dye and chemical savings ● Reduced water usage ● Reduced wastewater discharge ● Increased process efficiency ● Estimated 20% energy savings 	<p>Dryer Counterflow Dan River Danville, VA</p> <ul style="list-style-type: none"> ● 50% industry impact ● Increased process efficiency ● Estimated 30% energy savings
<p>Bump-and-Run Salem Carpets Chickamauga, GA</p> <ul style="list-style-type: none"> ● DOE sponsored ● 30% industry impact ● Estimated 35% energy savings 	<p>Boiler Economizer Collins and Aikman Albemarle, NC</p> <ul style="list-style-type: none"> ● 70% industry impact ● Increased process efficiency ● Estimated 20% energy savings
<p>Foam Finishing United Merchants Old Fort, NC</p> <ul style="list-style-type: none"> ● DOE sponsored ● 40% industry impact ● Reduced wastewater discharge ● Reduced water usage ● Estimated 35% energy savings 	<p>Wood-Fired Boiler Integrated Products Rome, GA</p> <ul style="list-style-type: none"> ● DOE sponsored ● 50% industry impact ● Reduced fossil fuel dependence
<p>Wastewater Heat Recovery Tuftex La Mirada Dye Plant Los Angeles, CA</p> <ul style="list-style-type: none"> ● 50% industry impact ● Increased process efficiency ● Estimated 35% energy savings 	<p>Solar Industrial Process Heat Johnson and Johnson Sherman, TX</p> <ul style="list-style-type: none"> ● DOE Sponsored ● 50% industry impact ● Reduced fossil fuel dependence ● Estimated 10% energy savings

IV. PLANT VISIT STRATEGY

In order to prepare the highest quality reports, members of the Georgia Tech project team visited each of the textile firms participating in the program. Interviews with plant engineering and management personnel were conducted to obtain background information on plant operations and management strategy. Initial information on the energy conserving technology that had been implemented was also obtained. Project team members then observed the installation and collected operating data for the energy conserving technology. The following information was obtained during the plant visit:

- Plant employee contact
- Description of products
- Energy consumption in years before and after the energy conserving technology was implemented
- Energy costs in years before and after the energy conserving technology was implemented
- Energy savings since the energy conserving technology was implemented
- Description of investment decision-making processes
- Description of any institutional and environmental considerations

This information was used as a basis for the case study reports, and a summary sheet outlining these items was included in each case study.

V. CASE STUDY SUMMARY

Georgia Tech project team members prepared case study reports for ten energy conserving technologies that had been implemented by the textile industry. The technologies studied are representative of a wide variety of technologies implemented by the industry, and are applicable to most types of textile plants.

Saving energy is the goal of all of the technologies. Some result in an immediate reduction in plant energy consumption; while others save energy by reducing or eliminating the plant's dependence on fossil fuels. However, all of the technologies have ancillary benefits ranging from reduced water usage to improved process efficiency. Implementation of the technologies studied resulted in a total energy savings of 136,742 MMBTU annually and an energy cost savings of \$635,089 for the ten plants. The majority of the textile companies that participated in this study evaluate investments based on payback period. Most firms contacted required a payback of two years or less; however, some would consider a payback of three to five years as acceptable.

Several of the technologies implemented were funded by Department of Energy grants. Other technologies studied were implemented by the companies based on the results of demonstration programs sponsored by DOE. The DOE sponsored projects have helped the textile industry determine which new energy conserving technologies work successfully and provide a good economic return. Technologies to reduce the industry's future dependence on fossil fuels have also been demonstrated through DOE sponsored programs.

A summary of the case history data is shown in Table 4. Annual energy consumption for the process or system to which the energy conserving technology was applied is given before and after implementation, as are energy costs. Annual energy savings are thus shown based on the consumption figures. Annual energy cost savings are calculated based on annual energy savings and current energy costs.

TECHNOLOGY	COMPANY	MAJOR PRODUCT	ANNUAL ENERGY CONSUMPTION IN MMBTU		ENERGY COSTS PER MMBTU			ANNUAL ENERGY SAVINGS	ANNUAL ENERGY COST SAVINGS	INVESTMENT DECISION CRITERIA	ANCILLARY BENEFITS
			Before	After	Before	After	Gas				
Tandem Preparation Line	Niota Textiles	Athletics Socks	4,580	1,286	Gas \$3.90			3,295 MMBTU	\$19,275	Fast Payback	Reduced Water and Chemical Use and Wastewater Discharge
Dyebath Reuse	E & B Carpets	Carpet	78,618	74,387	Gas \$2.79	Oil \$3.41		4,321 MMBTU	\$17,135	Two Year Discounted Payback	Reduced Water and Chemical Use and Wastewater Discharge
Bump-and-Run	Salem Carpets	Carpet	75,570	55,410	Gas \$2.36	Oil \$3.43		20,160 MMBTU	\$63,500	DOE Sponsored Project	Improved Economics of Dyebath Reuse
Foam Finishing	United Merchants	Apparel Fabrics	23,100	10,100	Propane \$2.61			13,000 MMBTU	\$65,150	Six Month Payback	Improved Process Efficiency
Wastewater Heat Recovery	Tuftex Carpets	Carpet	---	297,865	---			21,149 MMBTU	\$121,606	Included in Initial Cost of Plant	Improved Process Efficiency
Wastewater Chlorination and Reuse	Salem Carpets	Carpet	300,000	265,000	Gas \$0.85	Oil \$1.27		35,875 MMBTU	\$123,800	Reduced Wastewater Discharge Enhanced 1.8 Year Payback	Reduced Wastewater Discharge
Oven Exhaust Air Counterflow	Dan River	Apparel Fabric	70,157	45,907	Gas \$1.94			24,250 MMBTU	\$87,302	Up to 5 Year Payback Accepted	Improved Process Efficiency
Boiler Economizer	Collins and Aikman	Upholstery Fabric	624,725	315,765	Oil \$2.20			14,057 MMBTU	\$74,971	Three Year Payback	Improved Process Efficiency
Wood-Fired Boiler	Integrated Products	Carpet Yarn	59,419	35,415	Gas \$3.00	Oil \$6.14	Wood ---	59,419 MMBTU of Fossil Fuel Displaced	\$60,000	DOE Funding Reduced Payback to 3 Years	Reduced Fossil Fuel Usage
Solar Industrial Process Heat	Johnson and Johnson	Gauze	---	---	Gas \$3.00			632 MMBTU	\$2,350	DOE Sponsored Project	Reduced Fossil Fuel Usage

Table 4
Case Study Summary

Appendix A
CASE STUDY REPORT
TANDEM PREPARATION LINE

TEXTILE ENERGY CONSERVATION CASE STUDY:
TANDEM PREPARATION LINE

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

Rachel L. Moore

August 28, 1981

TANDEM PREPARATION LINE

- Niota Textile Mill, Inc.
Rt. 3
Ft. Payne, Alabama 35967
- Mr. Bill Chestnut, Jr.
President
615-568-2191
- Niota Textiles produces cotton and acrylic socks.
- Niota Textiles has installed in a tandem configuration two of the paddle machines normally used to prepare and dye hosiery. The tandem configuration allows the goods to be bleached or scoured in the first machine and rinsed and softened in the second machine without losing either bath. Thus, one load can be processed immediately after another, taking advantage of the water that is already hot and already has most of the chemicals necessary to process the next load. Substantial energy, water, and chemical savings result from the use of this system.
- Before Niota Textiles installed the tandem preparation line, which is now used to process all acrylic goods, the energy required to scour acrylic socks was 4,580 MMBTU per year.
In the six months that the tandem preparation line has been in use, 643 MMBTU has been required to process acrylic goods.
- Prior to the installation of the tandem preparation line, natural gas costs averaged \$3.90 per MMBTU. Average plant steam costs were estimated to be \$4.88 per MMBTU.
Since the tandem preparation line has been in use, natural gas costs have averaged \$4.85 per MMBTU. Average plant steam costs were estimated to be \$6.05 per MMBTU.
- In the six months that the tandem line has been in use, Niota Textiles has saved 1647 MMBTU in the preparation of acrylic goods, which projects to an annual savings of 3295 MMBTU and \$19,275.
- The tandem preparation line provides many other benefits besides energy savings. Since the bath does not have to be dropped between loads, wastewater discharge and water consumption are substantially reduced. The chemicals that remain in the bath after scouring are also reused.

TANDEM PREPARATION LINE

Introduction

The textile industry is faced with many problems such as increasing energy costs, air and water pollution, increasing dye and chemical costs, and the shortage of water that, if not solved, could limit or halt the existence of the industry in the United States. Thus, the push to make all preparation, dyeing, and finishing operations continuous rather than batch has resulted. Great strides toward this goal have been made in the carpet and fabric segments of the textile industry. However, certain other segments have had difficulty in adapting to continuous processing. Two notable segments are the hosiery and small rug producers, which both process small individual items rather than one continuous length of goods. An innovative new concept is being introduced into the hosiery industry for bleaching and scouring, using in a tandem operation the same paddle machines now utilized to prepare and dye hosiery and small rugs. This concept has the potential to be expanded for use in other operations such as dyeing, thus leading to even greater energy savings.

Traditional Operation

Niota Textile Mill, located in Ft. Payne, Alabama, produces cotton and acrylic athletic tube socks. The socks are knitted at other locations and shipped to the plant in boxes. The socks are bleached or scoured, dried, boarded, folded, and packaged for shipping. The cotton goods are bleached and the acrylic goods are scoured. The plant operates two 10 hour shifts per day, 5 days per week, 50 weeks per year.

Before the installation of the tandem preparation line, all of the goods processed were either bleached or scoured in one of three large paddle machines. All of the cotton goods are still bleached in the large machines, but the acrylic goods are now scoured on the new tandem line. Each large machine holds 650 pounds of goods in 1200 gallons of water. The scouring procedure that was used for the acrylic goods when the large machines were used was as follows:

- Fill machine with cold water
- Add hosiery
- Add scouring chemicals
- Heat bath to 140°F
- Hold 10 minutes
- Drain bath
- Fill again with cold water
- Add softening chemicals
- Heat bath to 100°F
- Hold 5 minutes
- Drain bath

Thus, both times the bath was discharged to the sewer, all of the heat in the water and all of the chemicals were lost. However, these losses can be eliminated when the tandem line is used.

Process Modifications

The tandem preparation line, shown in Figure 1, is a modification of the paddle machine used to prepare and dye hosiery and small rugs. Both machines in the tandem line at Niota Textile Mill process 400 pounds of acrylic in 750 gallons of water. Although the capacity of these machines is less than the large single machines, the same amount of goods or more can be processed in a day due to the time and personnel savings.

The first machine is used to scour the socks and the second to soften. For the first run, the water is added to the first machine, the goods and scouring chemicals entered, the bath heated to 140°F and held for 10 minutes. At the end of the cycle, the goods are transferred to the second machine by means of a perforated basket that fits inside the machine and raises out to move the goods and leave the bath in place. The socks are added to the second bath, the softening chemicals added, the bath raised to 100°F and held for five minutes. The goods are removed from the second machine and placed in a bag to be dried.

Once the goods have been removed from the first machine, a new load can be placed in the bath that is still hot and contains most of the chemicals

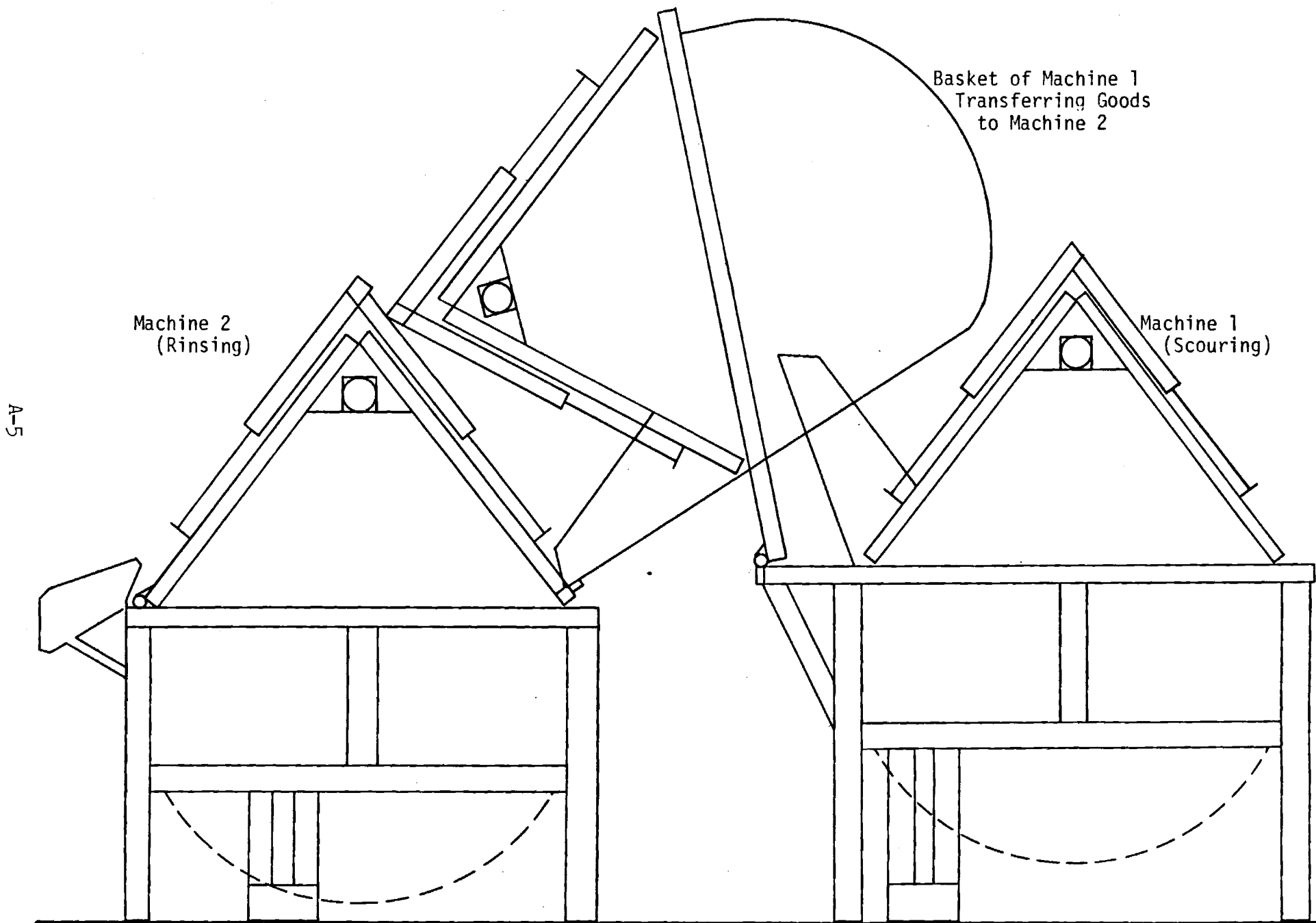


Figure 1. Tandem Preparation Line at Niota Textiles

necessary for processing. Every third load, the full amount of chemicals is added back to the bath. Both the scouring and softening baths can be used for an entire day without replacement, and steam is only added intermittently to keep the baths at the correct temperature. Thus energy, water, and chemical savings result when the tandem machine configuration is used rather than the single machines. Fewer operators are required to run the tandem line. Time is saved by not draining the machine after each run and also by not having to heat the bath each time.

Savings

When comparing machines of the same capacity as the machines in the tandem line, the savings shown in Table I result when using the tandem line rather than one single large machine.

Table I
SAVINGS RESULTING FROM THE USE OF THE TANDEM LINE

	<u>Annual Volume Savings</u>	<u>Annual Cost Savings</u>
Energy	3,295 MMBTU	\$19,275
Chemicals	58,500 pounds	\$25,100
Water/Sewer	7,125,000 gallons	\$11,045
 TOTAL SAVINGS		 \$55,420

These savings are based on an average annual production rate of two million pounds of acrylic.

The system at Niota Textile Mill required a capital investment of \$17,275. This cost was slightly more than half of the cost of a new system,

since one of the paddle machines was already installed in the mill and was used as a part of this system. The new machine that was added was constructed from 316 stainless steel so as to be able to withstand bleaching and scouring chemicals and also had a special high lift basket. Thus, the cost was slightly higher than a regular machine.

At present energy, water/sewer, and chemical costs the payback period before taxes is 4 months. The system has been installed for 6 months, and has thus paid for itself. Plant personnel wanted the system for its resulting water, chemical, and energy savings and knew that it would have a very short payback.

Summary

Niota Textile Mill has installed a new preparation machine using in a tandem configuration two of the paddle machines used for the preparation and dyeing of hosiery. This new line allows the preparation bath to be saved after each use thus conserving energy, water, and chemicals. This system has the potential to be expanded into other areas, such as small rug processing and dyebath reuse, which will result in further energy savings.

-for further information contact

Bill Chestnut, Jr.
President
Niota Textile Mill, Inc.
Niota, Tennessee

Appendix B
CASE STUDY REPORT
DYEBATH REJSE

TEXTILE ENERGY CONSERVATION CASE STUDY:

DYEBATH REUSE

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

Rachel L. Moore

August 14, 1981

DYEBATH REUSE

- E & B Carpet Mills, Inc.
1020 Riverbend Drive
Dalton, Georgia 30720
- Mr. Mark E. Cawthon
Plant Projects Engineer
404-278-3197
- E & B Carpets produces nylon and polyester carpet.
- E & B Carpets has implemented a dyeing procedural modification called dyebath reuse, in which spent dyebaths are analyzed and reused. The bath can be analyzed and reconstituted quickly so the bath temperature does not drop substantially. Thus energy, water, dyes, and chemicals are all reused resulting in substantial cost savings. E & B has installed a special pumping and control system linking several dye becks to facilitate the movement of the dyebaths.
- Before the first set of becks was converted, polyester dyeing required 78,618 MMBTU annually.
Since 25% of the polyester is now being dyed using dyebath reuse, the dyeing of polyester consumes 74,387 MMBTU annually.
- From July 1979 to June 1980, the year before dyebath reuse was implemented, natural gas averaged \$2.79 per MMBTU and No. 6 fuel oil averaged \$3.41 per MMBTU. An average plant steam cost was estimated to be \$3.60 per MMBTU.
From July 1980 to June 1981, the year that dyebath reuse was used to dye 25% of the polyester production, natural gas costs averaged \$2.57 per MMBTU and No. 6 fuel oil averaged \$4.99 per million BTU. An average plant steam cost was estimated to be \$4.05 per MMBTU.
- E & B Carpets has saved 4,231 MMBTU and \$17,135 in energy costs in the year since dyebath reuse was implemented.
- E & B Carpets requires a 2 year or shorter discounted payback to make an investment, which dyebath reuse bettered in the initial analysis and met in the first year of operation.
- Dyebath reuse has many other benefits besides energy savings. Since the dyebath is used many times, wastewater discharge from the plant is reduced. The expensive dyes and chemicals still in the bath at the end of the dyeing can now be used. The plant's water requirements are also substantially reduced.

DYEBATH REUSE

Introduction

Wet processing consumes 60% of the energy required to produce a finished textile product. Two different types of wet processing are used by the textile industry, batch dyeing and continuous dyeing. Because batch dyeing is much more energy intensive than continuous dyeing, more effort has been devoted to the development of energy conserving technologies that apply to batch dyeing. Dyebath reuse is one such technology.

Dyebath reuse is a procedural modification that can be applied to most types of batch dyeing. When implemented, dyebath reuse can result in energy, water, chemical, and dye savings as well as a reduced wastewater discharge. Successful laboratory and plant trials have been conducted for the atmospheric dyeing of nylon, carrier polyester, and carrierless polyester carpet as well as nylon hosiery. Dyebath reuse has also been developed for pressure dyeing of nomex fabric, polyester knit fabric, and polyester yarn. Experimentation is still in progress to determine the applicability of dyebath reuse to the dyeing of acrylic hosiery and polyester/cotton blend fabrics and yarn. The concept of dyebath reuse and most of the subsequent pilot and plant scale work was conducted under Department of Energy grants.

Traditional Operation

In a conventional batch dyeing process, the dyeing machine is filled with water, the goods are added, and the material is moved through the dyebath. Chemical auxiliaries and dyes are then added to the bath. The water is raised to the dyeing temperature and held for a specified length of time. When the dye cycle is completed, the goods are checked for shade. If the color is correct, the hot dyebath is discharged to the drain. A final rinse is normally performed that can be hot or cold and with or without the addition of chemicals.

The dyebath that is discharged to the drain is usually at a high temperature and contains all of the dyes and chemicals that were not exhausted onto the material during the dyeing. If these items can be reused in a subsequent dyeing, substantial cost savings will result.

Procedural Modifications

Dyebath reuse consists of reconstituting the dyebath between dyeing cycles. The amount of dye remaining in the spent dyebath can be analyzed spectrophotometrically and the exact amount needed to dye the next shade determined. The amount of chemical auxiliaries to be added does not need to be as exact as for the dyes, and can be estimated depending on whether the chemical is exhausted onto the fiber like a dye or remains in the bath. Some water will be lost to evaporation, and some will remain in the material when it is removed. The amount of water to be added each time can be easily determined if a site glass is installed on the dyeing machine.

There are several different methods of materials handling that can be incorporated when using dyebath reuse. Either the dyebath or the material can be moved after each dyeing. The simplest method of operation is to move the dyebath from one machine to another. However, a substantial capital investment must be made to provide for holding tanks and a pumping and piping system. The other method involves removing the material from one dyeing machine and placing it in another, or using some other means of rinsing before drying. This method does not require a capital investment, but poses a problem for the dyeing machine operator who has to handle hot goods. Several modifications have been made to these two initially proposed systems that have proven to be viable alternatives. A carpet dyeing and finishing company in north Georgia is using a modified materials handling procedure that involves pumping the dyebath from beck to beck instead of into holding tanks.

Plant Operations

E & B Carpets in Dalton, Georgia, is now dyeing 45% of their carrier polyester production using dyebath reuse. Two separate beck systems have been modified to accommodate the movement of dyebaths. One system connects five large becks and the other system connects six smaller becks, as shown in Figure 1. Dyebaths can be transferred between any two becks in a system. The system with five becks has been in operation for one year, and the system with six becks has been on line for one month.

B-5

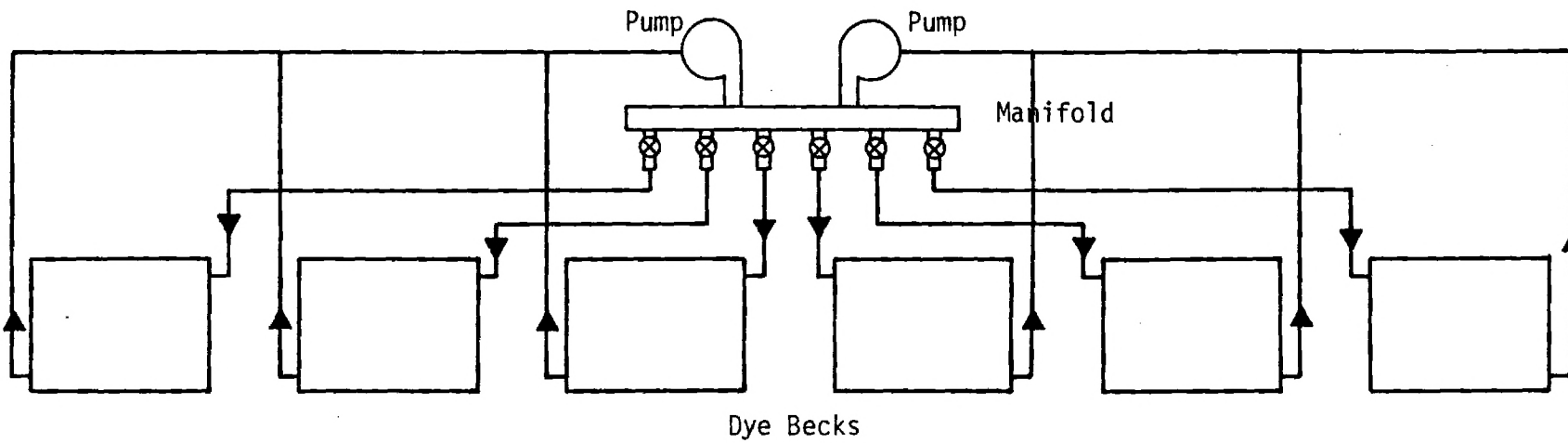
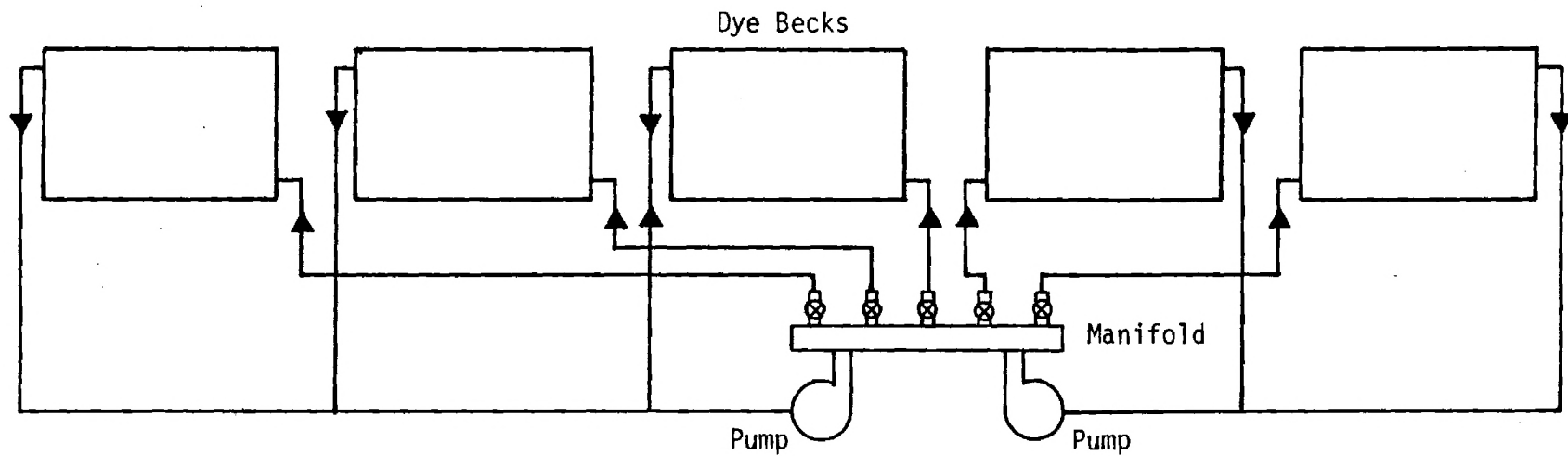


Figure 1. Beck System For Dyebath Reuse at E & B Carpets

A small microprocessor unit sequences the valves and pumps between any two of the becks in a system. Two control panels, one for each system, are located in the dyehouse lab and are used by the dyer to direct the dyebaths. The dyer controls which shades are dyed in each beck and decides where each dyebath will go once the dyeing is completed. He keys this information into the control panel. When the first dyeing is completed and the second beck empty, the microprocessor signals the proper valves and pump to transfer the dyebath and the operator activates the pump. The pumping procedure involves adding back enough water to bring the bath up to the proper level, transferring the bath to the next beck, and then rinsing the remaining carpet with cold water to cool it down.

At E & B if scheduling permits, the same shade is dyed each time with a reused dyebath. If this is not possible, the dyer chooses a sequence that goes from light shades to dark shades. According to plant management, the same shade can be scheduled about 90% of the time since each dyebath is used only three or four times. The presence of a surfactant in the bath used for scouring the goods limits dyebath use. After three or four dyeings, the dye no longer exhausts sufficiently onto the fiber to produce first quality goods and the dyebath must be discarded.

Trials were run in the plant to establish the dyebath reuse procedure. During these trials it was determined that the dyeings were sufficiently consistent to assume an addition of 90% of the dyes normally added, 50% of the carrier, and 25% to 50% of the leveling agent depending on the shade. This particular procedure has been successful at E & B, since only six dyes are used for all of the polyester shades. If more dyes were used, the dyebath chemical analysis procedure would be required before each reuse.

The major problem that E & B has faced while using dyebath reuse is scheduling the production so that several loads are dyed the same shade in a sequence, especially when business is slow. Dyebath reuse is suspected to be the cause of crockfastness problems. Crocking on dark shades has been linked to reuse, but there is still doubt as to whether it is the only cause. Both of these problems are minor, however, in comparison to the savings resulting from dyebath reuse; and the plant management is pleased with the overall results.

Savings

The system was justified at E & B by a full-scale trial run in the plant on a manual basis, testing 40,000 square yards of goods. The trial resulted in a projected energy savings of 4500 BTU per square yard. Chemical savings were projected to be from \$0.045 to \$0.060 per square yard of goods dyed. Thus, the resulting savings were estimated to be \$250,000 for the first year of operation, based on dyeing all polyester production by dyebath reuse. For an initial capital investment of \$125,000, a discounted payback of 10 months resulted. This payback was well within the required two years, and the project was implemented.

An evaluation of the five-beck system, which has been installed for approximately one year, was recently performed by plant engineers. The resulting energy, dye and chemical, and water savings are summarized in Table I.

Table I
SAVINGS RESULTING FROM DYEBATCH REUSE
WITH THE FIVE BECK SYSTEM

	<u>Annual Volume Savings</u>	<u>Annual Cost Savings</u>
Energy	4,231 MMBTU	\$17,135
Dyes and Chemicals	---	\$43,400
Water	6,750,000 gallons	\$ 3,700
TOTAL SAVINGS		\$64,235

Based on the first year actual savings, a two year simple payback was obtained. These savings resulted from approximately 25% of the polyester production being dyed by dyebath reuse.

Now that 11 becks have been set up for dyebath reuse work, approximately 45% of the polyester production is being dyed in this manner. The projected savings for the next year are summarized in Table II.

Table II
SAVINGS RESULTING FROM DYEBATH REUSE
WITH THE 11 BECK SYSTEM

	<u>Annual Volume Savings</u>	<u>Annual Cost Savings</u>
Energy	7,616 MMBTU	\$30,845
Dyes and Chemicals	---	\$78,120
Water	10,000,000 gallons	\$ 5,500
TOTAL SAVINGS		\$114,465

These savings are based on current energy, chemical, and water costs. Increasing prices will probably result in higher savings.

Summary

E & B Carpets has been using dyebath reuse in its regular production dyeings for over a year and has been very pleased with the results. No major problems have occurred, and first quality goods have been consistently produced. An acceptable payback resulted from the first

year's actual savings, even though only 25% of the polyester production was dyed using dyebath reuse. Plant personnel are especially pleased with the resulting dye and chemical savings, and feel that the system is justified on this savings alone. The wastewater discharge has also been substantially reduced, which will help E & B continue to meet future federal water quality standards.

-for further information contact

Mark E. Cawthon
Plant Project Engineer
E & B Carpet Mills, Inc.
Dalton, Georgia

Appendix C
CASE STUDY REPORT
BUMP-AND-RUN

TEXTILE ENERGY CONSERVATION CASE STUDY:

BUMP-AND-RUN

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

Douglas M. Moore

August 11, 1981

BUMP-AND-RUN

- Salem Carpets, Inc.
P. O. Box 10
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- Mr. Dave Dake
Engineering Projects Manager
404-935-2241
- Salem Carpets produces nylon and polyester carpet.
- Salem Carpets uses a dyeing procedural modification called bump-and-run. The procedure involves heating the dyebath to the dyeing temperature and then turning the steam off and allowing the bath temperature to drift. If the dyeing machine is well sealed, the bath temperature will only drop a small amount.
- Before Salem Carpets implemented bump-and-run in nylon dyeing, annual energy consumption averaged 75,570 MMBTU.
Since bump-and-run has been incorporated into the nylon dyeing procedure, the annual energy consumption for nylon dyeing has been reduced to 55,410 MMBTU.
- From March 1979 to March 1980, the year before bump-and-run was implemented, natural gas costs averaged \$2.36 per million BTU and No. 6 fuel oil averaged \$3.43 per MMBTU. An average plant steam cost was estimated to be \$3.10 per MMBTU.
From March 1980 to March 1981, the year after bump-and-run was implemented, natural gas averaged \$2.82 per MMBTU and No. 6 fuel oil averaged \$4.82 per MMBTU. An average plant steam cost was estimated to be \$3.93 per MMBTU.
- Salem Carpets has saved 20,160 MMBTU in energy usage and \$63,500 in energy costs in the year that bump-and-run has been utilized.
- Bump-and-run was initially implemented as a part of a Department of Energy project performed by researchers at Georgia Tech.
- Aside from the resulting energy savings, the other major advantage of bump-and-run is the improved economic analysis of dyebath reuse when the two technologies are combined.

BUMP-AND-RUN

Introduction

Beck dyeing is a batch dyeing process in which the textile material is loaded into a large stainless steel container called a dye beck. The beck is then filled with water, to which various chemicals and dyes are added. The bath is heated to some predetermined temperature, usually at or near boiling, to set the dyes. A substantial amount of energy is required to heat the water in the beck to the dyeing temperature and to hold it during the dye cycle. An exhaust hood and fan are required to remove the large volume of water vapor and steam produced at the surface of the bath.

Experiments conducted by Georgia Tech researchers revealed that 45% to 60% of the total energy used in a dye beck is lost through the exhaust stack. The need to reduce this loss is clearly indicated. The technology of bump-and-run, in which the dyebath temperature is allowed to drift for the last 85% of the hold time instead of being maintained by active steam sparging, has been shown to cut stack losses by 75% with no detectable reduction in quality.

Traditional Operation

Salem Carpets, headquartered in Ringgold, Georgia, has proven the effectiveness of a modified carpet dyeing procedure for beck dyeing that can cut steam consumption during a conventional dye cycle by 38%. The procedure, tagged "bump-and-run" by its developers, was implemented at Salem's plant in Chickamauga, Georgia, under a demonstration grant from the Department of Energy. The plant was automated for bump-and-run by the addition of a simple timer, at a cost of only \$50 per beck. The installation costs were paid back after just a few days of operation.

Salem Carpet's dyeing and finishing plant in Chickamauga houses both batch and continuous dyeing operations. Energy is supplied to the process equipment primarily in the form of medium pressure steam, produced by two 50,000 pound per hour boilers. These boilers use natural gas as a primary

fuel, with No. 6 fuel oil as standby. The plant currently has 14 dye becks and operates 24 hours per day, 7 days per week, with a two-day shutdown one weekend per month.

Before adopting the bump-and-run procedure, Salem followed a conventional dyeing procedure that called for at least one and sometimes more hold cycles, in which the dyebath was held at a rolling boil for 30 minutes. This resulted in tremendous energy loss through the stack, as indicated in Figure 1. Several traditional alternatives were considered to reduce these losses, and then rejected for various reasons. Automatic damper controls that limit exhaust air flow from the beck were evaluated. Capital costs for the system were high and the controllers were found to be high maintenance items. A second alternative considered was low temperature dyeing. In this process, special chemicals were added to the dyebath to open up the fiber and allow the dyes to set at temperatures near 140°F. Cost analyses revealed, however, that the additional chemical costs offset any energy cost savings that would accrue. Also, the low temperature was not adequate to fully develop the bulk of the carpet. This possibility, therefore, was also rejected.

Procedural Modifications

The concept of bump-and-run, first proposed by Mr. John J. Toon of the Piedmont Chemical Company, avoids many of the drawbacks of low temperature dyeing. Previous research had shown that about half of the energy used in a dye beck was lost out the stack, while radiation and convection losses accounted for only 2% of total energy consumption. The process of bump-and-run takes advantage of the fact that radiation losses are small, while minimizing stack losses at the boil (see Figure 1).

In this process, the dyebath is heated or "bumped" to boiling temperature and held there for 5 minutes. The steam injection then is halted, the exhaust fan is stopped, the exhaust damper is closed, and the beck doors are closed. At this point, the beck becomes like a closed kettle, and the temperature is allowed to drift for the next 25 minutes of the conventional 30 minute hold cycle (the "run" portion of the process). Experience has

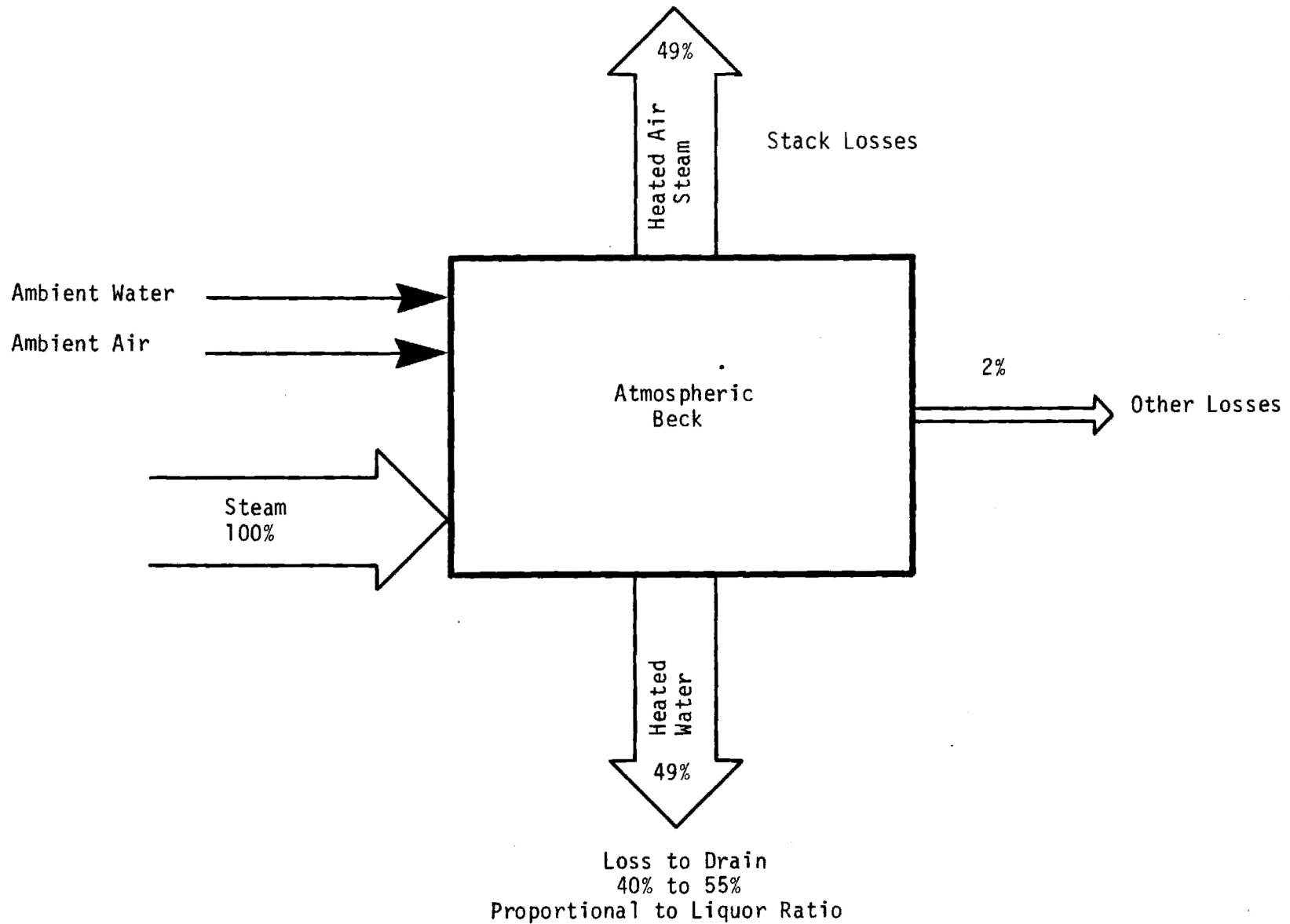


Figure 1. Atmosphere Beck Flows

shown that a temperature drop of approximately 20°F is to be expected during the run period. The remainder of the cycle is the same as with the conventional procedure.

Although this modification was initially implemented at no capital cost by simply changing operating procedures, it soon became apparent that the dyehouse operators were having to set the temperature controllers four times each cycle rather than two. To alleviate this situation, electronic automatic reset timers (Omron STP-MYH-AH) were installed at each temperature controller, energized by the wire that ran to the end-of-cycle lamp. This lamp was then wired through a normally open contact on the timer. With this setup, the dyehouse operator set the beck controller for a 5 minute hold at the boil in the usual manner. When the 5 minute hold was complete, current was routed to the auxiliary timer, that was preset for the 25 minute run portion of the cycle. At the end of this period, the end-of-cycle lamp was illuminated. The use of the timers allowed the operators to control the system in exactly the same manner as had been previously done.

The auxiliary timers were installed on all of the beck temperature controllers, at an average cost including installation of \$50 each. The other necessary equipment including beck doors and stack fan dampers were already being used, resulting in an almost immediate payback on the company's investment. Salem currently uses bump-and-run for all of its nylon carpet production, which accounts for 30% of the total plant production. The process is not presently used on polyester because of crock-fastness problems.

Savings

Energy consumption for both conventional dyeing procedures and for dyeing cycles using bump-and-run was monitored by Georgia Tech engineers at Salem's Chickamauga plant under a grant from the Department of Energy. Steam consumption during the conventional process was monitored for ten cycles and a base line average obtained. Consumption for ten cycles using bump-and-run was also monitored resulting in an average savings of 38%, as summarized for a normalized dye cycle in Table I.

Table I
ENERGY SAVINGS PER DYE CYCLE
RESULTING FROM BUMP-AND-RUN

Steam Consumption - Conventional Process	10,814 lbs
Steam Consumption - Bump-and-Run	6,677 lbs
Reduction in Steam Consumption	4,137 lbs
Reduction in Energy Consumption	3,920,000 BTU
Percent Savings	38 %

Bump-and-run was used for all nylon dyeing at Salem beginning in March 1980. After a full year of operation under this system, plant engineers reported a net yearly energy savings of 20,160 MMBTU and a cost savings of \$63,500. Based on an installed cost of \$50 per timer, the total cost to modify all 14 of the company's becks was \$700, giving a simple payback of four days.

The above savings were achieved by using bump-and-run on the plant's nylon production only, which accounts for 30% of total production. There has been no loss of quality among the nylon goods. The procedure has not been successfully used with polyester fibers because crockfastness problems have been observed. Salem is studying this problem and hopes eventually to use bump-and-run with all of its production.

The potential for energy savings if bump-and-run could be expanded to Salem's entire product line is impressive. If the assumption is made that energy costs will increase by 15% during the next twelve-month period, the potential for annual energy cost savings using bump-and-run plantwide amounts to over \$240,000.

Bump-and-run also makes the technology of dyebath reuse easier and less costly to implement. At the end of the final hold cycle for a dyebath

reuse/bump-and-run dyeing, the carpet was checked for color level. By this time, the temperature of the dyebath had dropped to 170°F, allowing the carpet to be easily removed while leaving the dyebath in the machine. Since dyebath reuse was being utilized the spent dyebath was then analyzed, reconstituted, and reused for a number of subsequent dyeings. Bump-and-run thus eliminated the need for holding tanks and pumping systems normally associated with dyebath reuse to facilitate the movement of hot goods. Final rinsing of the carpet was completed in the wet-out box preceding the dryer.

Summary

Bump-and-run is an excellent example of the somewhat rare variety of energy conservation opportunity that offers substantial energy savings at an insignificant initial cost. The ability to discover opportunities of this type depends on the willingness of plant managers and plant personnel to analyze carefully their current operating procedures and evaluate each step of each process. An open mind is essential, as established practices must be scrutinized. Cooperation of plant personnel must be willingly offered in order to obtain the results anticipated. This requires excellent communication between management and labor, and a general awareness of the importance of energy conservation within the plant. These qualities are key elements of any successful energy conservation program.

In the case of bump-and-run, plant operations were hardly disturbed at all: the dyer used the same chemicals as in the conventional process, management had to provide negligible capital, and even the beck operator was satisfied. Savings to the plant were substantial, and neither the quality control engineers nor the dyers identified any dyeing problems.

-for further information contact

Mr. Dave Dake
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Ringgold, Georgia

Appendix D

CASE STUDY REPORT
FOAM FINISHING

TEXTILE ENERGY CONSERVATION CASE STUDY:

FOAM FINISHING

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

LuAnn T. Rockett

and

Fred L. Cook

October 1, 1981

FOAM FINISHING

- United Merchants and Manufacturers
Old Fort Finishing Plant
Old Fort, North Carolina 28762
- Mr. Floyd Parker
Plant Manager
704-668-7611
- United Merchants produces cotton/polyester apparel fabrics.
- United Merchants has retrofitted a conventional finishing range with a foam finishing system. The foam reduces the wet pick-up of the fabric to 25% to 35%, thus reducing drying time and chemical usage, and increasing line production.
- Before foam finishing was introduced, the plant consumed 23,100 MMBTU per year in the finishing operation. Since foam finishing has been used, the plant has averaged 10,100 MMBTU per year in the finishing operation.
- For the year prior to the installation of the foam system, propane averaged \$2.61 per MMBTU. In 1980, propane has averaged \$5.01 per MMBTU.
- Since the foam system was installed, United Merchants has had an average weekly total savings of \$5,203 and energy savings of \$1,303.
- Since the system promised a payback period of less than six months, United Merchants decided to invest in the procedure.
- The major benefit realized from installing the foam system was a substantial increase in production capacity using existing finishing lines.

FOAM FINISHING

Introduction

Foam finishing is a process whereby the finish is applied to the fabric in an air-blown foam, rather than a pure liquid state. This results in the following advantages over conventional aqueous systems:

- Reduction in energy consumption for drying and curing per pound of fabric,
- More efficient use of chemicals,
- Application to wet fabric without first drying, and
- Reduction in water content of the finish resulting in higher production rates, decreased dryer temperatures and decreased fuel consumption.

Foam finishes may include fluorocarbons, permanent press resins, softeners or water repellants. Foam has been successfully used on nylon and polyester/cotton fabrics in pile, woven, and knitted forms.

The foam process consists of preparing a concentrated solution (or dispersion) of the chemical or chemicals in water, and then incorporating suitable foaming aids. The concentrate is then mechanically foamed and is applied to the fabric by means of equipment such as a knife over a roll coater. The foam is then forced to collapse and flow over the fibers. This can be done by passing the foam-coated fabric through a pad mangle or by using a foam which collapses when heated. The coated fabric is then passed through a conventional oven to remove the small amount of water used in the concentrate and to cure the finish.

To date, foam finishing has gained wider acceptance than foam dyeing, mainly because of the wider latitude in uniformity allowed for colorless finishes than for dyes and pigments. Foam finishing can also result in the elimination of the washing and drying steps after curing, another example of the energy savings possible with foam finishings.

Traditional Operation

United Merchants and Manufacturers Old Fort Finishing Plant in Old Fort, North Carolina, has been successfully using foam finishing since 1977. The Old Fort plant produces apparel fabrics ranging from 1.2 to 4.0 yards per pound. The average fabric weight is 2.5 yards per pound. The

fabrics are generally 50% polyester/50% cotton blends, with polycellulosics accounting for 80% of the total production. All fabrics produced in the plant are finished with foam processing.

Until 1977, the plant operated with conventional finishing ranges. The ranges typically ran at 40 to 80 yards per minute, and generally consumed 32 yards per gallon of finishing mix. Drying and curing temperatures ranged from 350° to 375°F when performed in the same step. During this time, total plant gas consumption in the finishing area was 23,100 MMBTU at an average annual cost of \$2.61 per MMBTU.

Modifications

In 1977, United Merchants retrofitted their conventional finishing ranges with foam systems at an average cost of \$25,000 per range. The incentives to invest were two-fold -- projected energy savings and increased production.

The system is shown in Figure 1. Using this type of foam finishing technology, both sides of the fabric are finished at the same time. Production speeds have been increased to 70 to 110 yards per minute using foam finishing, and plant personnel project that with new drying equipment speeds of over 200 yards per minute can be achieved. Using foam, the wet pick-up has averaged 25% to 35%. The details of the foaming system itself are pictured in Figure 2. The frame dryer in the foam system can operate two ways, by drying and curing in the same step at 350° to 375°F or drying first and then roller curing at 250° to 300°F.

Foam finishing has led to a decrease in chemical usage of 10% to 20%. A typical finish can now be applied at 100 yards per gallon of mix. Energy consumption for finishing has been reduced to 10,100 MMBTU for 1980 at a cost of \$5.01 per MMBTU.

Environmentally, the impact of foam finishing has been minimal. Chemical usage has decreased. In terms of water volume, there has not been a dramatic change since the conventional finishing system did not use an afterwash. However, there has been a percentage decrease in water usage of approximately 50%.

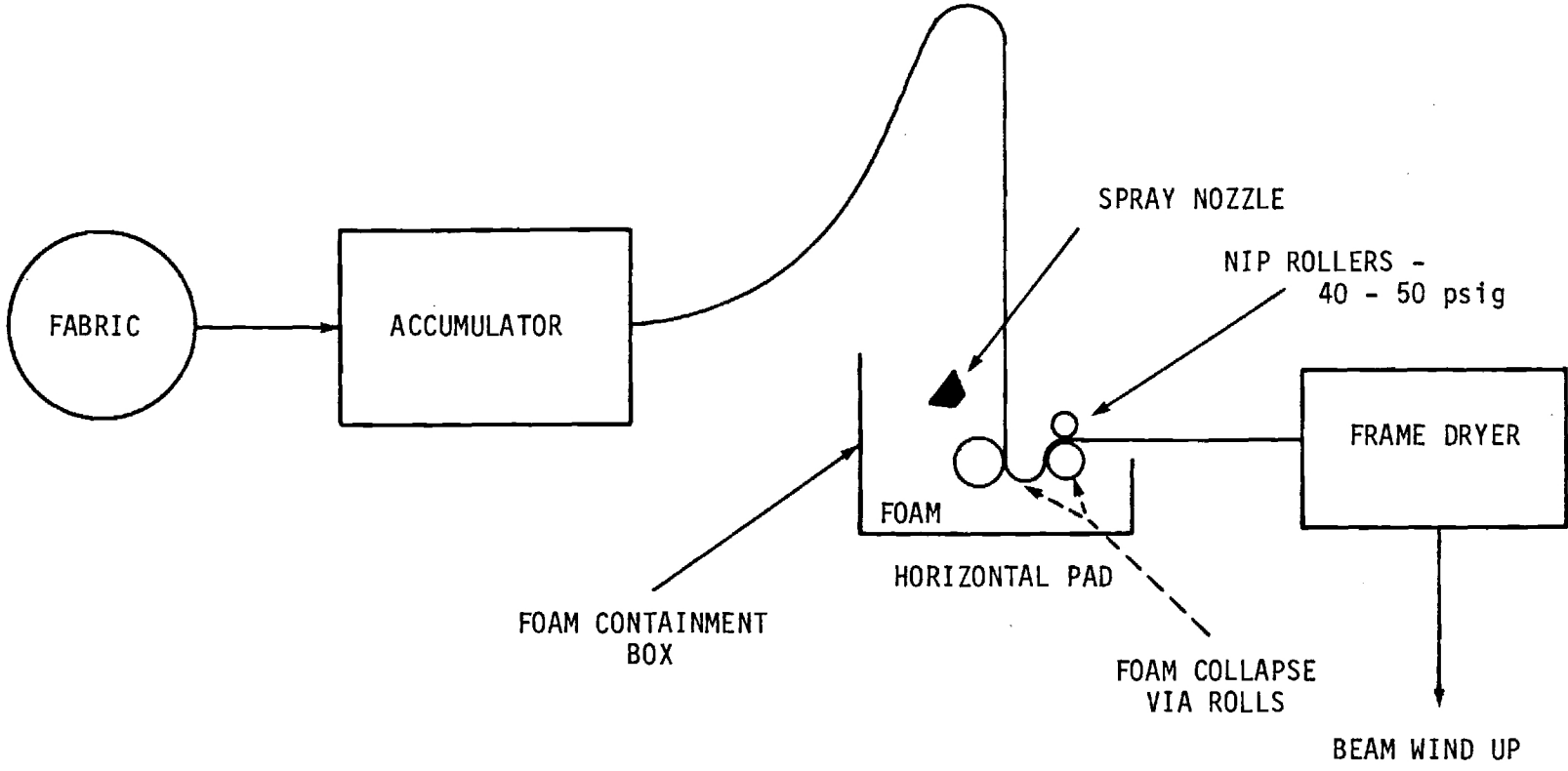


FIGURE 1. UNITED MERCHANTS AND MANUFACTURERS FOAM FINISHING SYSTEM

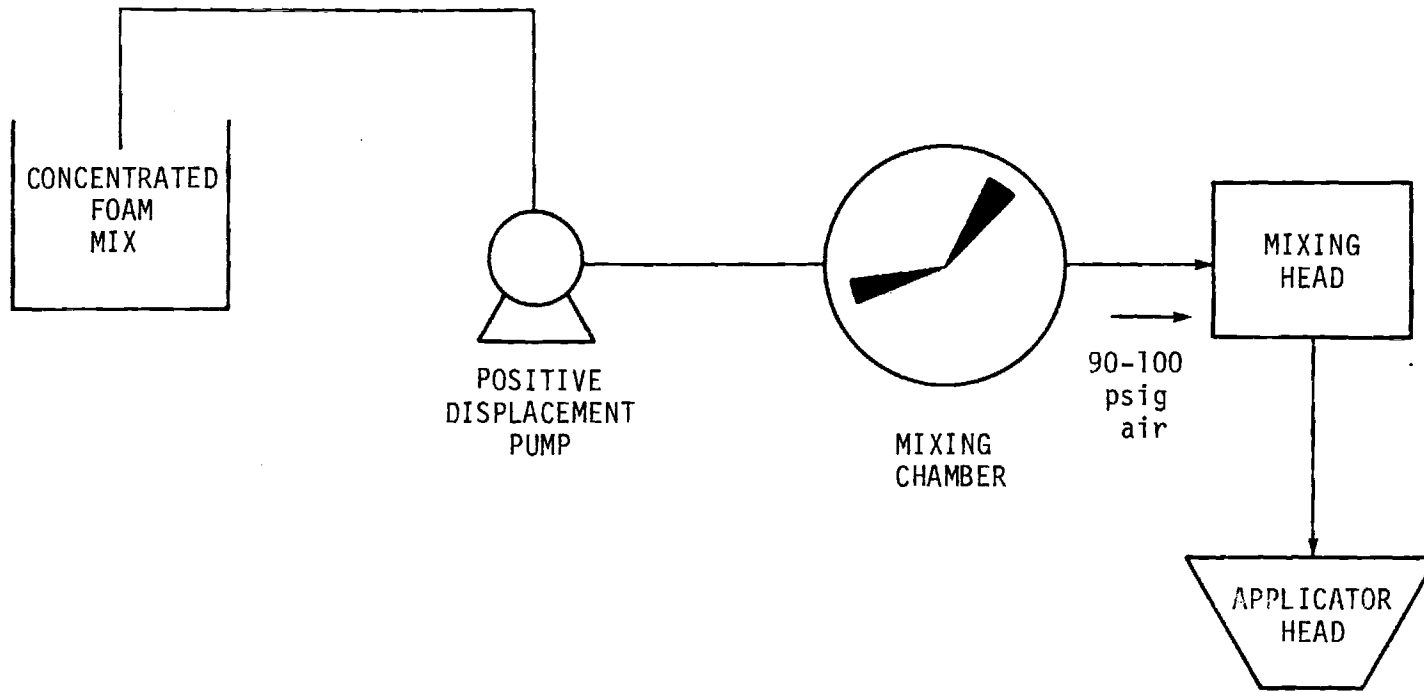


FIGURE 2. FOAMING SYSTEM

Savings

The initial \$25,000 invested in the system was recovered in 25 weeks with \$1000 per week in savings due to the decrease in energy consumption. Because the total payback period was so short, the investment was made without any consideration given to return on investment or other economic analyses. Total finishing energy consumption is shown in Table I.

Table I
TOTAL FINISHING ENERGY CONSUMPTION

	<u>Propane Cost</u>	<u>Energy Usage</u>	<u>Total</u>
Conventional (1977)	\$0.249/gal	925 BTU/yd	2.31×10^{10} BTU/yr
Foam (1980)	\$0.479/gal	405 BTU/yd	1.01×10^{10} BTU/yr
SAVINGS		520 BTU/yd	13,000 MMBTU/yr

Total savings dollars are based on labor, materials and overhead costs. Energy consumption is also included in this figure. Based on current plant figures, the average savings shown in Table II were compiled.

Table II
TOTAL FINISHING COST SAVINGS

	<u>Annual</u>	<u>Weekly Average</u>
ENERGY SAVINGS	\$ 65,150	\$ 1,303
TOTAL SAVINGS	\$260,150	\$ 5,203

Summary

United Merchants feels that resistance to change is the major barrier confronting the textile industry with regard to conversion to foam finishing. With less than a 6 month payback to retrofit an existing finishing range, foam finishing quickly produces savings in labor, materials, energy, and overhead. Foam finishing is clearly both an economically and technologically attractive energy conservation alternative that is being used by an increasing number of plants.

-for further information contact

Mr. Floyd Parker
Plant Manager
United Merchants and Manufacturers
Old Fort, North Carolina

Appendix E

CASE STUDY REPORT
WASTEWATER HEAT RECOVERY

TEXTILE ENERGY CONSERVATION CASE STUDY:
WASTEWATER HEAT RECOVERY

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

Rachel L. Moore

September 28, 1981

WASTEWATER HEAT RECOVERY

- Tuftex Carpet Mills, Inc.
La Mirada Dye Plant Division
15228 Bona Vista
Santa Fe Springs, California
- Mr. Robert Brissette
Plant Engineer
213-921-6791
- The La Mirada Dye Plant produces finished nylon carpets.
- The La Mirada Dye Plant of Tuftex Carpets was constructed to include a wastewater heat recovery system that uses hot wastewater from the dyehouse to preheat incoming water to the dyehouse and water for boiler feed.
- From August 1980 to July 1981, the La Mirada Dye Plant consumed 297,865 MMBTU at a total cost of \$1,153,960.
- The wastewater heat recovery system has saved an estimated 21,149 MMBTU annually, or 63,447 MMBTU since the plant began operation in September 1978. At current fuel costs, this results in an annual cost savings of \$121,606.
- The cost of the wastewater heat recovery unit was included in the initial construction cost of the plant, since management personnel knew that it would provide a quick payback and solutions to other potential problems.
- The use of the wastewater heat recovery system helped the plant meet county emissions standards for wastewater. No wastewater over 120°F could be discharged from the plant, and the wastewater exiting the heat exchangers is at an average temperature of 110°F. Dye cycle time was also reduced, since the incoming water was at 100°F instead of 68°F.

WASTEWATER HEAT RECOVERY

Introduction

The textile industry consumes over 125 billion gallons of water and 290 billion BTU each year in its wet processing operations. Increasing energy costs and shortages in energy and water supplies have stimulated the implementation of technologies that reduce energy and water consumption. A large portion of the energy and water consumed in wet processing is used in batch operations. Because batch operations are much more energy intensive than continuous operations, research work has been directed toward ways to conserve energy and water in batch dyeing. New batch dyeing procedures have been perfected, which can save as much as 50% of the energy consumed in conventional procedures. Some of these procedures also reduce the amount of hot wastewater that is discharged from the plant. However, some wastewater discharge will still occur and the heat in this water should be recovered. A carpet mill in California uses wastewater heat recovery to provide warm dyehouse water and boiler feedwater.

Plant Operation

Tuftex Carpets, located in Los Angeles, California, is a fully integrated carpet mill that produces finished nylon carpet. Beck dyeing, resist printing, drying, and finishing are the major plant operations at Tuftex's La Mirada Dye Plant. The plant is operated 24 hours per day, 5 days per week, 52 weeks per year.

The La Mirada Dye Plant uses two heat exchangers to preheat boiler feedwater and beck fill water using the outgoing hot wastewater from the dye becks as shown in Figure 1. The dye becks are equipped with two separate drain systems, one that directs water of 120°F or less to the sewer and one that directs water above 120°F into a holding tank. From the holding tank, the hot wastewater at an average temperature of 155°F is pumped into one of the two heat exchangers, which are connected in parallel. The large four-tube heat exchanger heats water to 100°F, which goes either to the dyehouse or back through the small three-tube heat exchanger. The pipe leading to the small exchanger has a flow restriction that allows approximately 20% of

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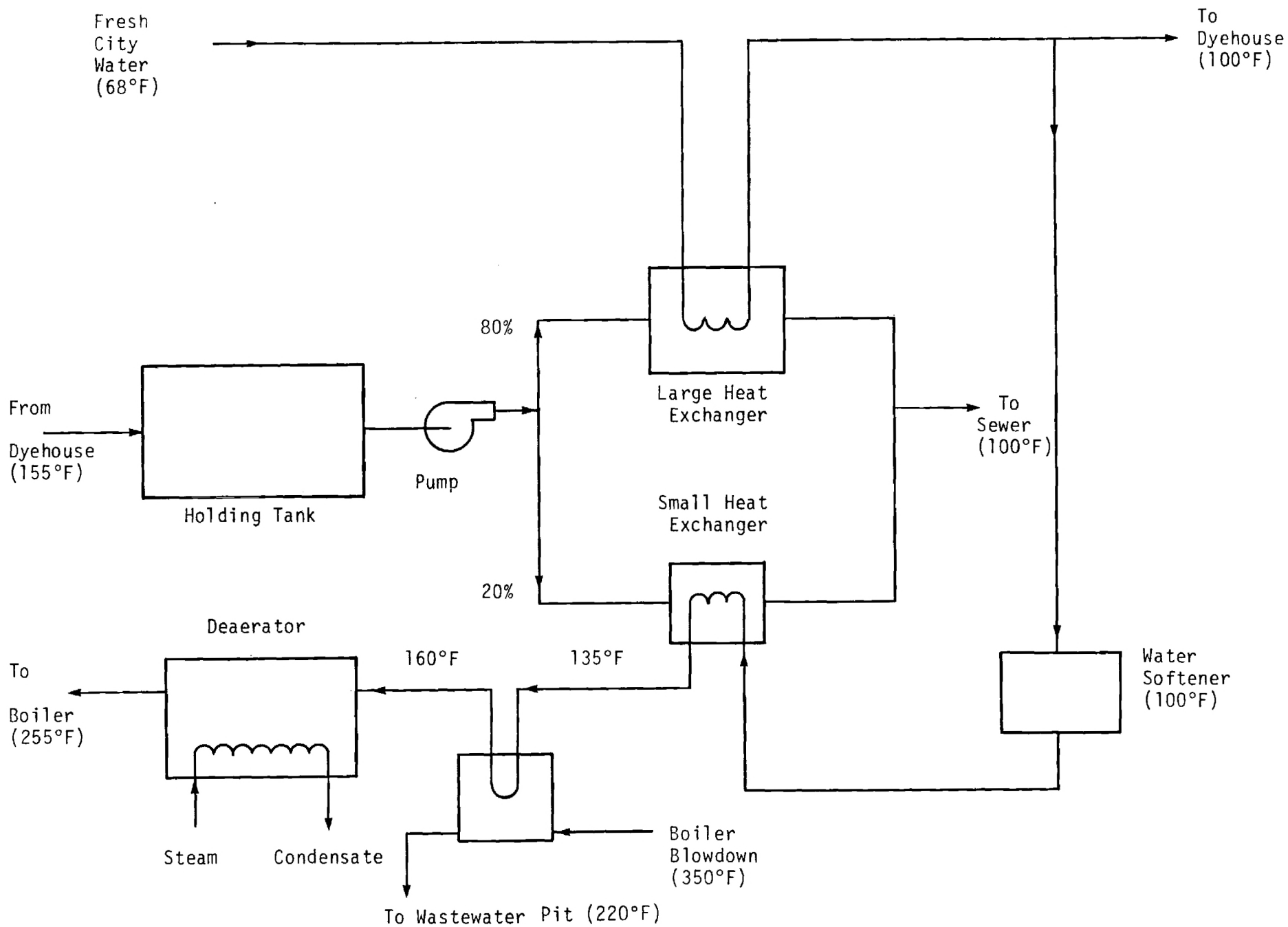


Figure 1. Wastewater Heat Recovery at La Mirada Dye Plant

the wastewater to flow through, with the remaining 80% flowing through the large heat exchanger. The wastewater exiting from the exchangers is at an average temperature of 110°F and is discharged to the sewer.

Part of the fresh water that exits from the large heat exchanger passes through a water softening operation and then through the small exchanger where the temperature is boosted to 135°F. The water is then sent through a tank where it is indirectly heated by continuous boiler blowdown to 160°F. The next step for the boiler feedwater is to be heated to 225°F in the deaerator tank by steam coils, and then the feedwater goes into the boiler. Thus, the dyehouse receives water at 100°F and the boiler feedwater is preheated to 160°, rather than having water entering both operations at 68°F.

The plant uses 930,000 gallons of water per day. The boiler requires an average of 100,000 gallons per day of feedwater. Thus, the dyehouse uses an average of 830,000 gallons per day, producing a flow of 575 gallons per minute. Approximately 250 gallons per minute of this flow is used hot. Thus, the average wastewater flow into the heat exchangers is estimated to be 300 gallons per minute, and the fresh water flow into the large heat exchanger is approximately 270 gallons per minute. The system is designed to handle a peak flow of 1200 gallons per minute. The flow to the small exchanger and then to the boiler is 70 gallons per minute. Approximately 24 gallons per minute of surface blow off at 350°F enters the holding tank, heats the softened boiler water from 135°F to 160°F, and is discharged to the wastewater sump at 220°F.

Tuftex's La Mirada Dye Plant began its operations in September 1978. The plant, built with the heat exchanger systems as an original part of the plant, has used the system continuously since startup except when maintenance was being performed.

The plant management has been very pleased with the operation of the system. Maintenance is minimal; the system is back washed by flow reversal once per day for 15 minutes. Once every six months, a caustic solution is run through the system to eliminate any chemical buildup. Lint has not been a problem in the system because a lint screen is used before the water enters the holding tank and dual filters are used between the pumps and the heat exchangers.

Savings

For an average flow to the dyehouse of 200 gallons per minute of fresh water at 100°F instead of 68°F, the savings resulting from using the system based on current energy prices are shown in Table I.

Table I
DYEHOUSE ENERGY SAVINGS

Annual Energy Savings	19,215 MMBTU
Annual Cost Savings	\$110,488

For an average flow of softened water to the boiler feedwater system of 70 gallons per minute at 160°F instead of 68°F, the savings resulting from using the system based on current energy costs are shown in Table II.

Table II
BOILER SYSTEM ENERGY SAVINGS

Annual Energy Savings	1,934 MMBTU
Annual Cost Savings	\$11,118

Thus, the total savings resulting from the installation of the wastewater heat recovery system are shown in Table II.

Table III
TOTAL SAVINGS

Annual Energy Savings	21,149 MMBTU
Annual Cost Savings	\$121,606

Summary

Tuftex's La Mirada Dye Plant designed a sophisticated wastewater heat recovery system to be a part of the original plant equipment. The plant management knew that substantial energy savings would result from the installation and also knew that the system could solve other potential problems. The county code stated that no water above 120° could be discharged to the sewer. With the heat recovery system, the wastewater discharged from the plant was reduced to 110°F. The availability of warm water would also allow the dye cycle times to be shorter since it would take at least 10 minutes to heat the dyebath from 68°F to 100°F.

-for further information contact

Mr. Robert Brissette
Plant Engineer
Tuftex Carpet Mills, Inc.
La Mirada Dye Plant Division
Los Angeles, California

Appendix F

CASE STUDY REPORT
WASTEWATER CHLORINATION AND REUSE

TEXTILE ENERGY CONSERVATION CASE STUDY:
WASTEWATER CHLORINATION AND REUSE

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

Douglas M. Moore

August 4, 1981

WASTEWATER CHLORINATION AND REUSE

- Salem Carpet Mills, Inc.
P. O. Box 10
Ringgold, Georgia 30736
- Mr. Dave Dake
Engineering Projects Manager
404-935-2241
- Salem Carpets produces nylon and polyester carpet.
- Salem Carpets has installed a system that chlorinates the wastewater that is discharged from the dyehouse. The addition of chlorine to the water renders it colorless, which allows the water to be reused in subsequent dyeings. The wastewater goes directly from the dye becks into the chlorination system, and contains a substantial amount of the heat that was added during the dye cycle.
- Before the water chlorination system was installed, the beck dyeing operation at Salem consumed 300,000 MMBTU per year. Since the water chlorination system has been in use, Salems's beck dyeing operation has averaged 265,000 MMBTU per year.
- For the year prior to the installation of the water chlorination system, natural gas costs averaged \$0.85 per MMBTU and No. 6 fuel oil averaged \$1.27 per MMBTU. For 1980, natural gas has averaged \$5.32 per MMBTU and No. 6 fuel oil has averaged \$4.82 per MMBTU.
- Since the water chlorination system was installed, Salem Carpets has had an average annual energy savings of 35,875 MMBTU and an average energy cost savings of \$123,800 per year.
- Salem Carpets requires a one year or shorter payback on its capital investments. The chlorination system had a 1.8 year payback when all savings were taken into account. The company decided to invest despite the longer payback since the city was limiting their wastewater discharge and consequently reducing their production capacity.
- The other major benefit from the water chlorination system was the reduced wastewater discharge and subsequent reduction in water usage.

WASTEWATER CHLORINATION AND REUSE

Introduction

The textile industry consumes approximately 125 billion gallons of water per year. Most of this water is discharged from the plant and contains substantial quantities of organic and inorganic chemicals such as dyes, surfactants, auxiliaries, pH control agents, and lubricants. These chemicals require extensive treatment at the wastewater plant and contribute to pollution problems associated with textile processing. The pollution problem has, in the past, been met by the construction and expansion of wastewater treatment facilities. Each year water quality standards become more stringent, and this requires the investment of more capital to upgrade waste treatment plant equipment and processes. Many areas are restricting the quantities of wastewater that can be discharged into municipal treatment facilities as a result of these problems. The industrial facilities must then find ways to reduce their wastewater discharge or invest large sums of their own capital in non-income-producing wastewater treatment facilities.

In addition to the problems associated with water supply and pollution control, the increasing cost and decreasing supply of energy represents a major problem for the textile industry. Thus, technologies providing solutions for all of these problems are continually sought by the industry. One such solution that has been implemented by the textile industry is water chlorination and reuse.

Traditional Operation

Salem Carpets, headquartered in Ringgold, Georgia, operates a carpet dyeing and finishing plant in nearby Chickamauga, Georgia. This plant houses both batch and continuous and dyeing, two highly energy intensive processes. Energy is supplied to the process equipment primarily in the form of medium pressure steam produced by two 1600 HP boilers. These boilers use natural gas as a primary fuel, with No. 6 fuel oil as a standby. The plant uses 14 dye becks and one continuous line and operates 24 hours per day, 7 days per week, with a two-day weekend shutdown once per month.

Batch dyeing is more energy intensive and consumes much larger quantities of water than continuous dyeing. Batch dyeing is a batch process in which the carpet is loaded into a large stainless steel container called a dye beck. The beck is filled with water, normally 3000 to 5000 gallons per fill for carpet, and the dyes and chemicals are added. The dyebath is heated to the dyeing temperature (180°F to 212°F) to set the dyes. When the correct color is obtained, the dyeing water is discharged to the drain. The beck is filled again with fresh water, the carpet rinsed, and the rinse water also discharged to the drain.

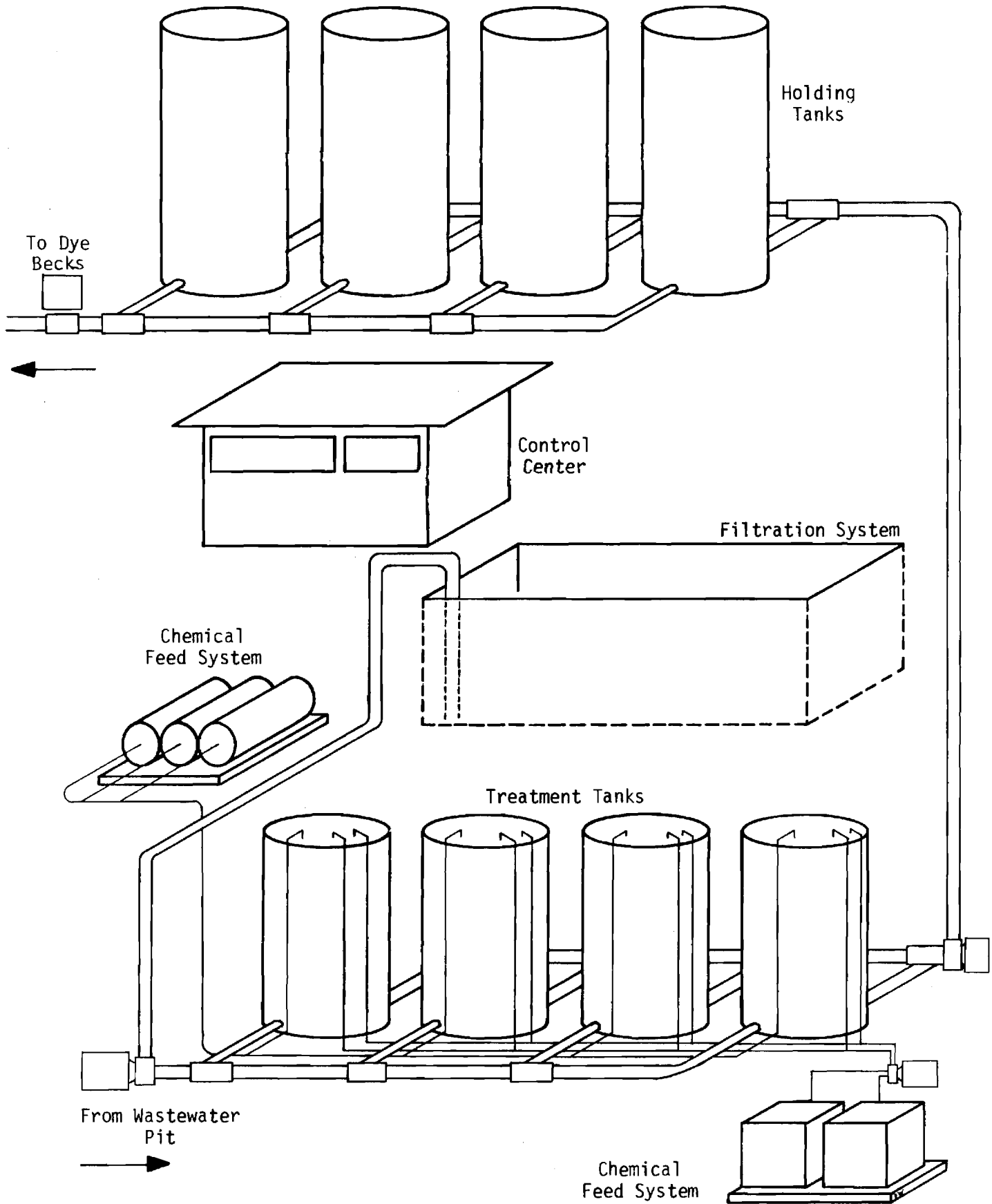
A substantial amount of energy is required to heat the water to the dyeing temperature and hold it during the dye cycle. All of this energy is lost each time a dyebath is discharged to the drain. Tremendous quantities of water are also required by the beck operation. Water is supplied to Salem by the city and by a number of drilled wells on the plant property. Treatment of the wastewater has posed a problem as well, in terms of both the disposal cost and the limitations of the city's waste treatment facility.

Process Modifications

By the end of 1974, growth of industry and community had begun to tax the capability of the local water and sewer facilities. The city therefore imposed a limit on the maximum amount of effluent that could be discharged from the Salem plant. In order to continue to expand their operation, plant engineers were forced to find ways to reduce water consumption and the resulting effluent. Many alternatives were considered, but a water chlorination system showed the best overall results. The system, pictured in Figure 1, was chosen for its excellent cost-benefit ratio, which was greatly enhanced by the energy savings afforded by the system. Installation of the system was completed by July 1975 at a cost of \$412,000, and provided a total cost savings of \$215,500 during its first year of operation.

The system chosen by Salem uses chlorine gas to oxidize the remaining dye particles in the spent dyebath into colorless chemical fragments. Both dyeing and rinsing baths are pumped to one of four fiberglass treatment tanks where chlorine gas is bubbled through the water. The temperature of

Figure 1. Salem Carpets Water Chlorination System



the water entering the system averages 125°F. The pH of the water is adjusted to neutral with a weak base, since the formation of hypochlorous acid occurs during the chlorine treatment and lowers the pH. The water, still at an elevated temperature and containing the chemical fragments, is then pumped into one of four fiberglass storage tanks. The temperature of the water returned to the process can be as high as 120°F. However, since the tanks are located outdoors and are not insulated, the returned water supply temperature averages 85°F on an annual basis. The energy savings provided by the system arise from the return of the water at an elevated temperature, thus eliminating the need to expend energy to heat incoming water from 60°F to 85°F.

Savings

Salem's water reclamation system has been in operation for six years and in that time has saved the company over \$1.4 million in avoided energy, water, and sewer costs. Water usage and the resulting sewer discharge has been reduced from 1.2 million gallons per day to 440,000 gallons per day, thus allowing the plant to continue its normal operation. Energy is saved by returning water at 85°F instead of 60°F to the dyehouse. Based on an average steam plant efficiency of 75%, with 50% of the water used for beck dyeing being the recycled water, an energy savings of 35,875 MMBTU per year is possible. The resulting cost savings for the first year of operation (1975) are shown in Table I.

Table I
WATER CHLORINATION SYSTEM SAVINGS FOR THE FIRST YEAR OF OPERATION

	<u>Volume Savings</u>	<u>Cost Savings</u>
Energy	35,875 MMBTU	\$ 89,700
Water	266 million gallons	\$159,600
Sewer	266 million gallons	\$ 39,900
TOTAL ANNUAL SAVINGS		\$289,200

The operating costs of the system for 1975 are summarized in Table II. At least two people are present at all times and are responsible for the system operation. These operators control the addition of chlorine gas, sulfite, soda ash, and other chemicals to control the water quality.

Table II
WATER CHLORINATION SYSTEM OPERATING
COSTS FOR THE FIRST YEAR OF OPERATION

		<u>Annual Cost</u>
Labor		\$46,700
Supervisor	\$12,600	
Operators (4)	\$34,100	
Chemicals		\$21,200
	TOTAL ANNUAL COSTS	\$67,900

As shown in Table III the labor and chemical costs are more than offset by the savings.

Table III
NET SAVINGS FOR THE FIRST YEAR OF OPERATION

Total Savings		\$289,200
Operating Costs		\$ 67,900
	TOTAL ANNUAL SAVINGS	\$221,300

Due to the tremendous increase in energy costs since 1975, the system savings are even greater for 1980, as shown in Table IV.

Table IV
SYSTEM SAVINGS FOR 1980

	<u>1975 Unit Cost</u>	<u>1980 Unit Cost</u>	<u>Annual Cost Savings for 1980</u>
Energy	\$2.50/MMBTU	\$6.00/MMBTU	215,250
Water	\$0.60/1000 gal	\$0.60/1000 gal	155,000
Sewer	\$0.15/1000 gal	\$0.21/1000 gal	54,300
TOTAL ANNUAL SAVINGS			\$424,550

Although the savings from the system are substantial, there are several drawbacks that should be evaluated when considering the installation of a water chlorination and reuse system. The returned water contains chemical fragments of unknown composition that, although colorless, can contribute to dyeing problems that could be difficult to solve. Dyes and chemicals in the water are destroyed by the process, and therefore no chemical savings are possible. In addition, recent research has shown that under certain conditions polychlorinated biphenyls (PCB's) can be formed by bubbling chlorine gas through aqueous solutions containing biphenyl and related aromatic carriers commonly used in dyeing polyester.

Summary

In analyzing this investment, Salem's management chose the simple pay-back technique. At 1975 costs, the initial investment of the system was paid back in only 1.8 years. Although this payback period was longer than the normal one year payback sought by the company, the economics were

greatly enhanced by the fact that total plant production was constrained by the available water supply, and the effects of this potential lost revenue were taken into consideration.

From an overall viewpoint, Salem's water recycling system provides several benefits. From the standpoint of energy, it provides a facility that is more energy efficient than comparable operations, while allowing the plant to achieve otherwise unobtainable production levels. Another benefit offered by the system is the conservation of water, an increasingly scarce resource.

-for further information contact

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Ringgold, Georgia

Appendix G

CASE STUDY REPORT
OVEN EXHAUST AIR COUNTERFLOW

TEXTILE ENERGY CONSERVATION CASE STUDY:

OVEN EXHAUST AIR COUNTERFLOW

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

William B. Himes, Jr.

September 30, 1981

OVEN EXHAUST AIR COUNTERFLOW

- Dan River, Inc.
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- Mr. B.C. Haraway
Technical Superintendent, Finishing
804-799-4961
- The primary product at Dan River is a shirting weight composed of a 65/35 blend of polyester and cotton.
- Dan River, Inc. has modified 10 tenter frame ovens and predryers with a system that ducts the predryer exhaust into the tenter and counterflows the tenter exhaust. These changes reduce the total exhaust from the predryer and tenter by approximately 47%.
- For the year prior to the installation the price of natural gas averaged \$1.94 per MMBTU. For 1980, the natural gas cost averaged \$3.60 per MMBTU.
- Since the modifications, Dan River has had an average annual energy savings of 24,250 MMBTU, and a cost savings of \$87,302 based on 1980 natural gas prices.
- The average payback period of Dan River energy conservation projects is one year or less, however, programs with a payback period of five years or less are still considered.

OVEN EXHAUST AIR COUNTERFLOW

Introduction

One of the major energy consuming industries in the United States is the textile industry. In an effort to reduce the industry's energy requirement of over 67 million barrels of oil equivalent annually, much work is being done to determine ways to conserve energy in textiles. A major textile processing area that shows promise for energy conservation is the drying/curing/heat setting operation.

The major method for removing water from textile materials, curing finishes, and heat setting fabrics is convective drying using tenter frames and predryers. This operation consumes roughly 25% of the energy required to produce finished textile goods. Most of the ovens and dryers used in textile operations today were designed and built during the time when energy costs did not make a significant impact on the cost of finished goods. Consequently, from an energy standpoint, the efficiency of most textile ovens is low. The energy efficiency of older textile ovens can be improved through some relatively inexpensive modifications.

The thermal energy consumed in a convective heating operation arises from the following four requirements:

- Thermal energy is needed to heat water in the textile material to the evaporation temperature, evaporate it, and then raise the vaporized water from the vaporization temperature to the exhaust temperature.
- Thermal energy is required to raise the textile material from the entrance temperature to the exit temperature.
- Thermal energy is required to replace the heat lost by radiation and convection from the oven housing.
- Thermal energy is required to replace the heat lost when the hot air in the oven is exhausted.

Traditional Operation

Dan River Inc., in Danville, Virginia, has been successful in substantially reducing the quantity of gas consumed in the drying/curing/heat setting operation without significantly affecting product quality or production rates. Their primary product is a 65/35 percent blend of polyester and cotton in dress goods and shirting weight material. Polyester and cotton fiber is brought into the plant in bales. The fiber is processed into yarn, which is woven or knitted into fabric. Depending on the type of material, it is either prepared, dyed, or finished.

Before modifications were made to the tenter frames at Dan River, the drying/curing/heat setting process began in the gas fired infrared predryer (see Figure 1). Ten gas fired burners divided into three banks provided the initial drying, reducing the moisture content of the fabric to around 35%.

The tenter frame dryer was the next step in the process. The tenter frame was divided into three zones, each of which had exhaust ducts. Burners in each zone were separately controlled to vary the operating temperature in each zone. The first two zones were used for drying and curing, and the last zone was used for heatsetting.

Air was exhausted from the tenter frame to remove vaporized water, smoke, solvents, and particulate matter from the dryer housing. Prior to any modification, Dan River was only exhausting air from the first and third zones of the tenter. The exhaust air left the tenter housing at the average temperature inside each zone. Fresh make-up air, usually at room temperature, was taken into the tenter to replace the exhausted air and was heated to the tenter operating temperature. The energy required to heat this large volume of air constitutes approximately 50% of the energy used in the process.

Modification

It is in the area of hot air exhaust reduction that Dan River found the potential for significant savings. The modification implemented on the tenter frames involved the counterflow of the tenter exhaust air and the ducting of the predryer exhaust into the tenter housing instead of to the atmosphere (see Figure 2).

G-15

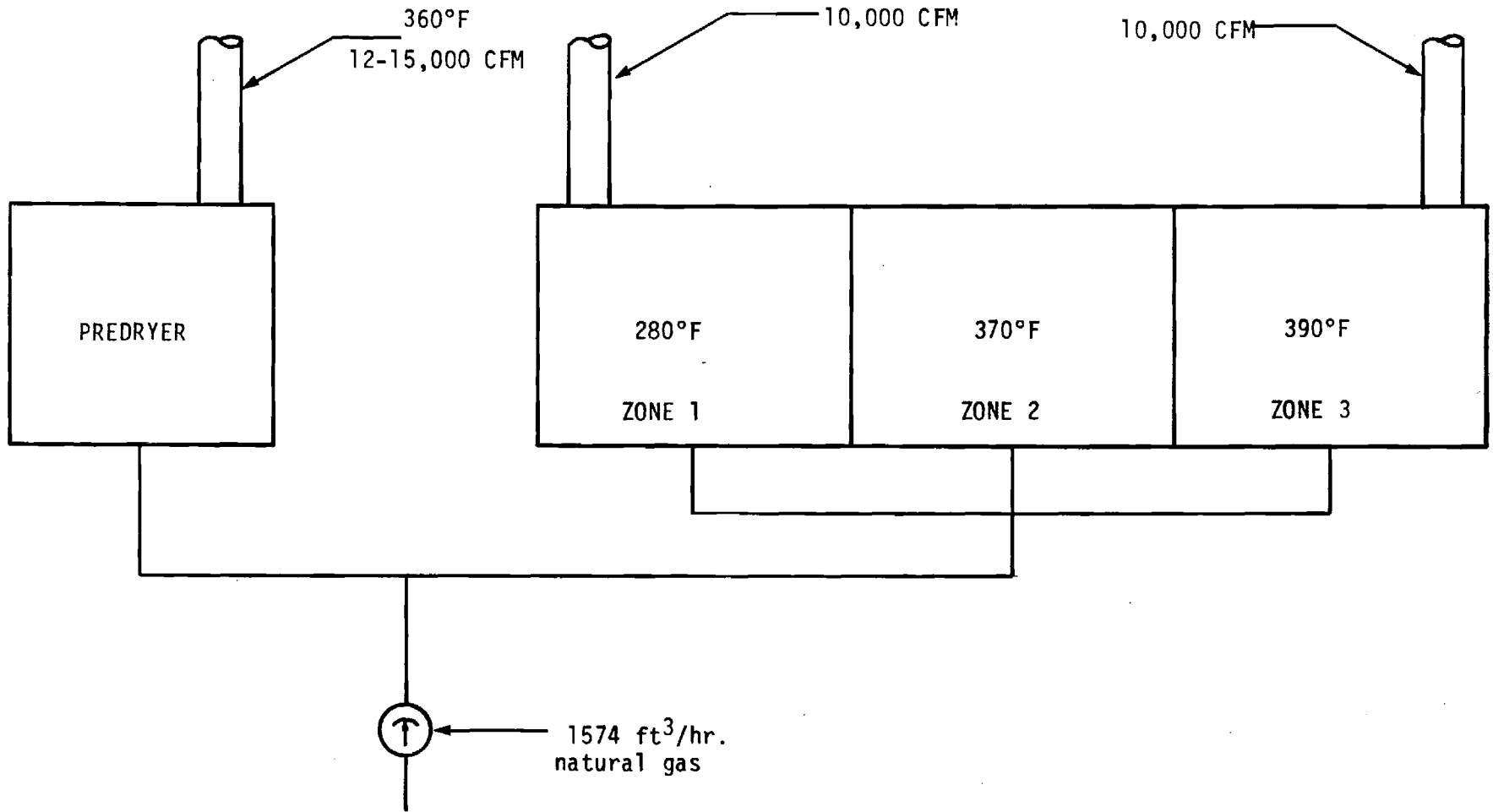


FIGURE 1.
TYPICAL UNMODIFIED CONVECTIVE DRYING ARRANGEMENT

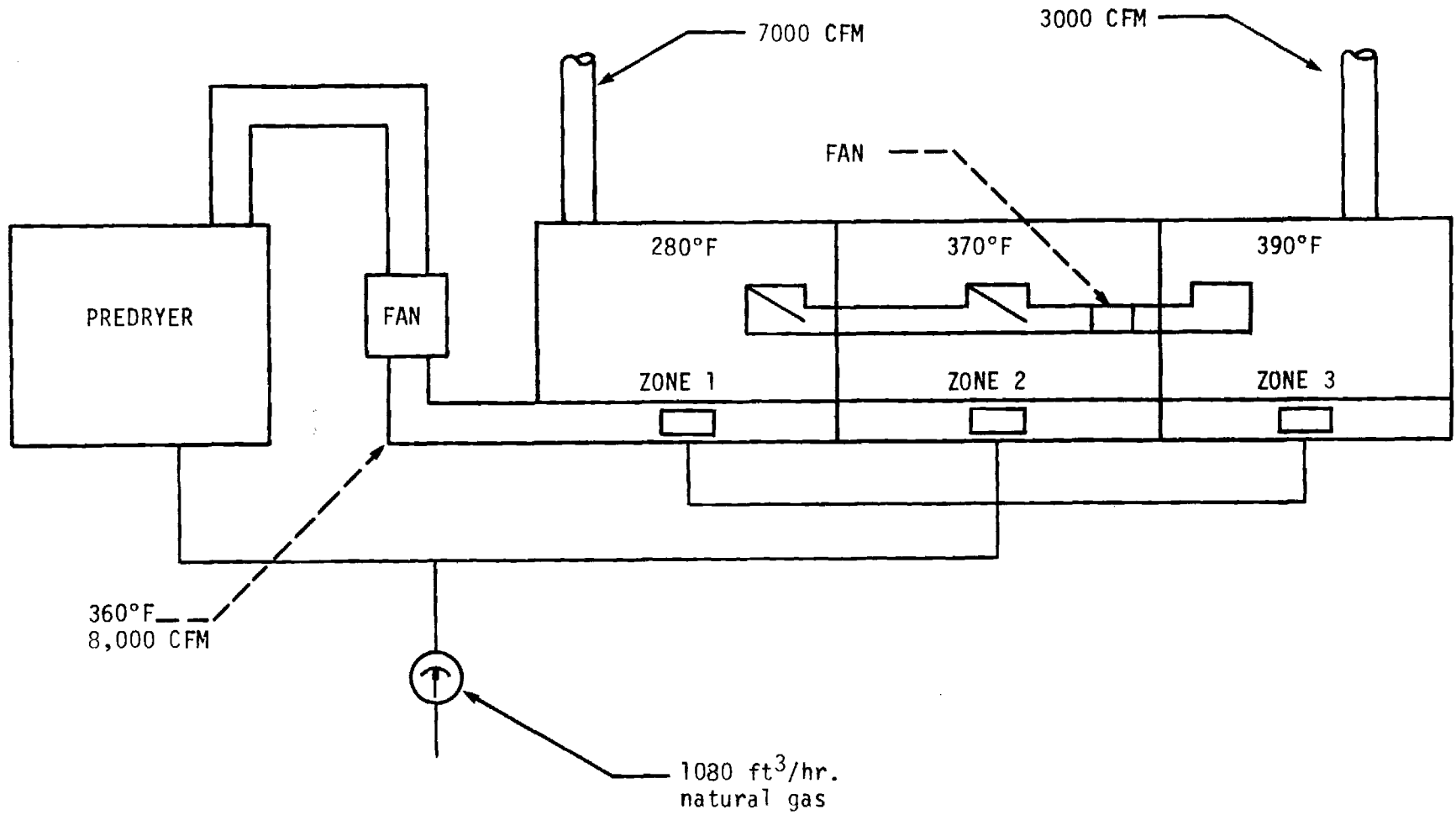


FIGURE 2.
TYPICAL COUNTERFLOW CONVERSION

Prior to modification, the exhaust from the predryer averaged approximately 12,000 to 15,000 CFM at 360°F. This air had a low moisture content and was very clean and was thus able to be ducted into the tenter. After the change, the volume of air through the predryer was reduced to an average of 7,000 to 8,000 CFM and the entire exhaust was ducted into the tenter housing, with a portion entering each of the three tenter zones.

To counterflow the air inside the tenter, a duct with a fan inside was constructed on the side of the tenter housing. This duct carried air from the third zone back into the first and second zones.

The volume of air exhausted prior to conversion was equally divided between the first and third zones, and was approximately 10,000 CFM from each zone. After the changes, the exhaust from the first zone was reduced to 7,000 CFM and the exhaust from the third zone was reduced to 3,000 CFM. Table I shows the results of the first complete tenter modification, at a cost of \$17,920.

Table I
EFFECTS OF COUNTERFLOW MODIFICATIONS

	<u>Before</u>	<u>After</u>	<u>Reduction</u>
Exhaust Volume	33,500 CFM	17,500 CFM	47%
Natural Gas Consumption	1,575 CFH	1,080 CFH	31%

Based on the reductions shown above, the decision was made to convert nine more tenter frames in early 1977 at a total cost of \$150,061 or \$16,673 per tenter.

Savings

The exact amount of exhaust reduction possible will vary from tenter to tenter based on initial operating conditions and several other factors,

such as the amount of oils and resins that are evaporated along with water that can cause smoke. Reducing the amount exhaust air increases the tendency of this smoke to blow out the entrance and exit slots. Insurance companies also have regulations that must be strictly adhered to when combustibles are being evaporated. Each of these factors has an effect on the amount of reduction possible. The results of Dan River's modification are shown for the first year of operation and for 1980 in Table II.

Table II
ENERGY AND COST SAVINGS AFTER MODIFICATION

<u>Year</u>	<u>Natural Gas Cost</u>	<u>Energy Savings</u>	<u>Cost Savings</u>
1977	\$1.94/MMBTU	24,250 MMBTU	\$47,046
1980	\$3.60/MMBTU	24,250 MMBTU	\$87,302

The payback period in 1977 was 3.6 years. However, at 1981 natural gas prices the conversions return their investment in less than two years.

Summary

Dan River's management is conservative in cost considerations, yet at the same time is imaginative and innovative and always seeking new opportunities to provide a better product at a competitive price. Each plant annually submits to corporate management an estimate of capital needs for energy improvements. The average return that is accepted is approximately one year or less; however, a five year return is still attractive.

-for further information contact

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Dan River, Inc.
Danville, Virginia

Appendix H
CASE STUDY REPORT
BOILER ECONOMIZER

TEXTILE ENERGY CONSERVATION CASE STUDY:

BOILER ECONOMIZER

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

LuAnn T. Rockett

September 4, 1981

BOILER ECONOMIZER

- Collins and Aikman Corporation
1803 North Main Street
Roxboro, North Carolina 27573
- Mr. Ernest F. Godshall
Environmental and Utilities Engineer
704-596-8500
- Collins and Aikman produces woven and knitted pile upholstery and apparel fabric at its Roxboro plant.
- Collins and Aikman has installed an economizer on the exhaust stack of an 80,000 pound per hour boiler. The hot flue gases pass over a set of coils in the stack through which feedwater for the boiler is passed. The feedwater is preheated and the amount of energy used to produce steam is reduced.
- Before the economizer was installed, an average of 60,000 pounds per hour of steam was produced, and 624,725 MMBTU was consumed annually by the boiler.
After the economizer was installed, an average of 32,600 pounds per hour of steam was produced, and 315,765 MMBTU was consumed annually by the boiler.
- Before the economizer was installed, No. 6 fuel oil costs averaged \$2.20 per MMBTU.
After the economizer was installed, No. 6 fuel oil costs averaged \$5.30 per MMBTU.
- Based on the output of the boiler being 32,600 pounds per hour, an energy savings of 14,057 MMBTU and a cost savings of \$74,971 resulted from the installation of the economizer.
- The decision to invest in the boiler economizer was based on pilot plant feasibility studies and a projected payback of 3 years. Collins and Aikman requires a payback of 3 years or less.

BOILER ECONOMIZER

Introduction

Faced with rising energy costs and the decreasing availability of fossil fuels, the textile industry has been forced to conserve energy in as many ways as are economically feasible. Because 80% of all energy consumed is in the form of fossil fuels and boilers consume more fuel to generate steam than any other process, many textile companies have concentrated a large energy conservation effort toward improving boiler and steam system efficiency.

Improvements in boiler efficiency result primarily from reductions in waste heat energy losses in the stack gases and expelled water. Maximum efficiency results when combustion of the fuel is complete and the heat losses are minimized. Excess air for combustion must be held to a minimum in order to optimize boiler efficiency. Because most boilers are designed to operate with more air flow than is needed for complete combustion, regular tune-ups must be made to ensure that the excess air level is optimized. Other boiler losses result from radiation and convection from equipment surfaces, and are especially critical in older, less well insulated systems.

On the average, for manufacturing facilities, boilers use from 50% to 70% of the total energy requirements of a plant. The savings potential for a steam system can be up to 50% with a good energy conservation program that focuses on steam line insulation, combustion efficiency tune-ups, condensate return, wastewater heat recovery, and proper feedwater treatment. The addition of a boiler economizer is an example where these savings can be increased even further.

Traditional Operation

Collins and Aikman Corporation is a large diversified textile, paper, and wallcovering manufacturer with 29 plants in North America. They are involved in all phases of textile manufacturing from spinning yarn to dyeing and finishing textile products. One of the largest divisions is located in Roxboro, North Carolina. The plant produces woven and knitted pile

upholstery and apparel such as velvets, velours, and artificial furs.

The boiler at the Collins and Aikman Roxboro plant is tuned up on a regular basis. The plant normally runs 24 hours a day, 7 days a week; however for calculation purposes, a 7000 hour per year operating schedule is assumed to be average. The boiler operation is detailed in Figure 1. The boiler has an 80,000 pound per hour steam capacity, and at an average projected load of 60,000 pounds per hour operates at an efficiency of 80.4%. The system presently burns No. 6 fuel oil and, without an economizer, burned 1.71 million gallons per year at a price of \$0.33 per gallon.

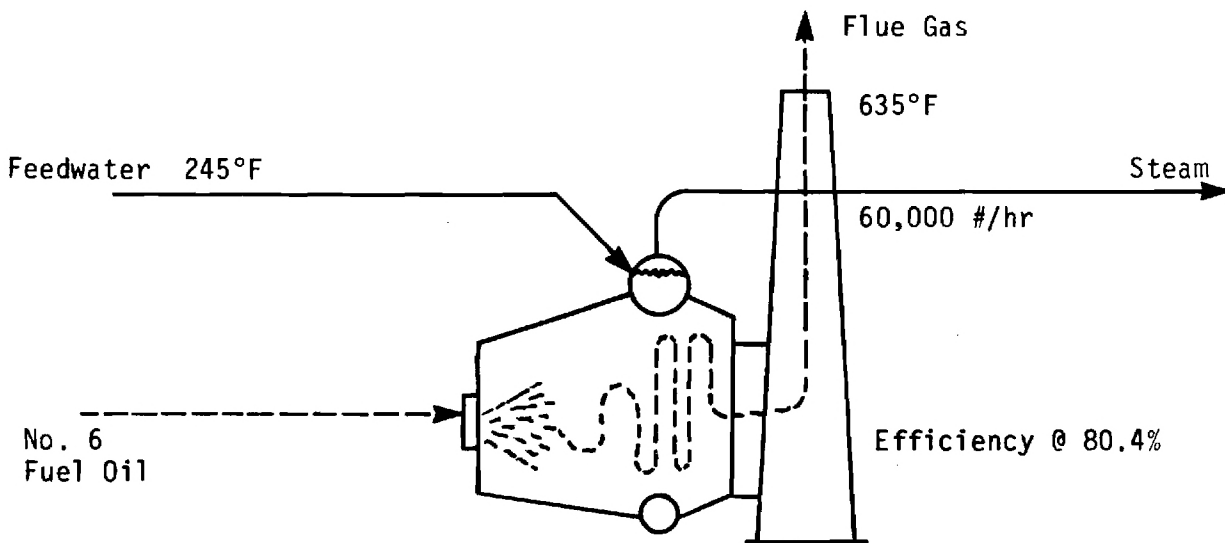
Modifications

A boiler economizer is a heat exchanger located in the boiler stack which is designed to recover some of the waste heat from the products of combustion. A substantial amount of waste heat from a boiler can escape in exhaust gases. The economizer consists of a series of tubes through which feedwater flows on the way to the boiler. Water enters at one end of the economizer and is directed through a series of bends and headers before returning to the steam drum. The feedwater is thus preheated by waste heat and less oil is required to generate an equal amount of steam.

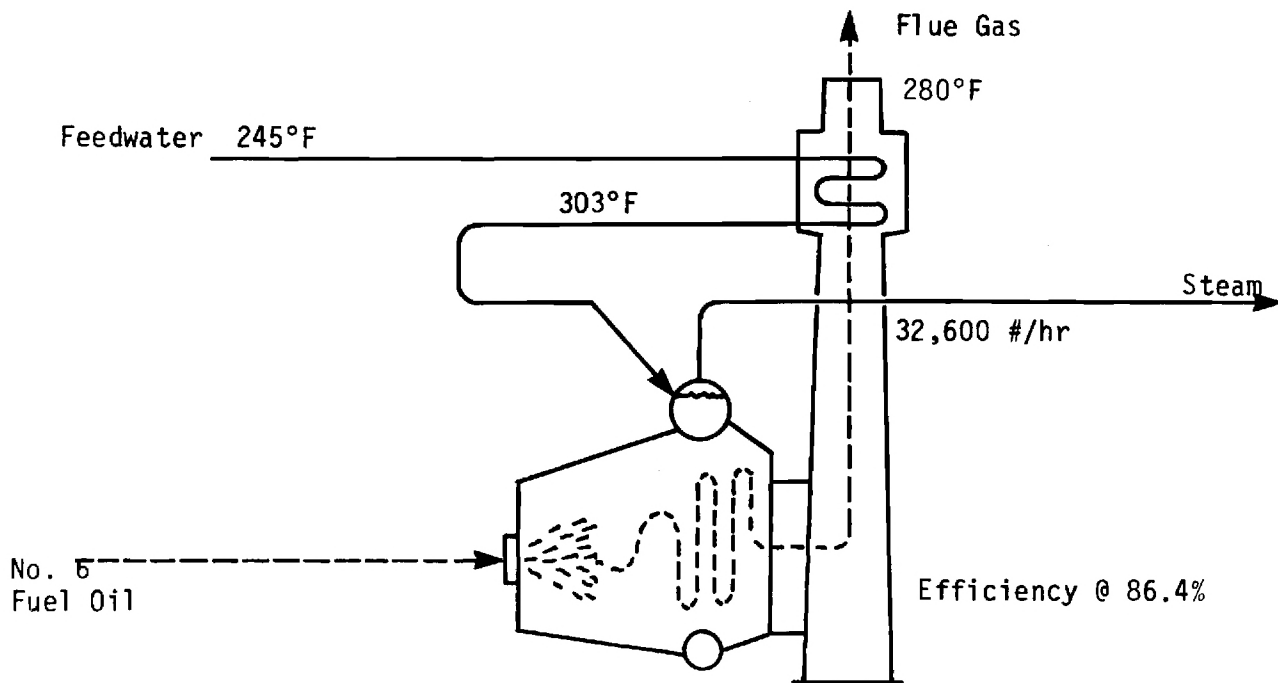
Collins and Aikman Corporation's Decorative Fabrics Division at Roxboro, North Carolina, successfully installed an economizer on their 80,000 pound per hour oil/gas boiler. The system was installed in May 1979 and has been operating without any problems since that time. The economizer at Roxboro was based on the successful implementation of another economizer at a pilot plant site in Albemarle, North Carolina.

The economizer was installed in a bypass arrangement with the boiler. This arrangement has three advantages:

- The feedwater flows upward, preventing recirculation and steaming in the feedwater line.
- The economizer can be shut down completely for general maintenance while the boiler remains in operation.
- Greater energy recovery is possible since the system may be "over designed" to absorb too much heat and the damper adjusted to optimize overall efficiency.



Boiler Operation Before Adding Economizer
Figure 1.



Boiler Operation After Adding Economizer
Figure 2.

Installation was based on the boiler operating at 60,000 pounds per hour for 7000 hours per year, and was designed to increase boiler efficiency from 80.4% to 86.4%. (See Figures 1 and 2.)

The only modifications made to the system involved operational criteria. Before the system was installed, the boiler operated at a steam load of 60,000 pounds per hour. During May 1979, while installation was accomplished, the boiler load was still 60,000 pounds per hour. Once the economizer was successfully running, a general slowdown in the economy affected plant production to a point that during 1980, the system averaged a steam load of 32,600 pounds per hour, well below the forecast load. The steam loads are summarized in Table I.

Table I
PROJECTED AND ACTUAL BOILER
STEAM LOADS

	<u>Avg. Steam Load</u>	<u>Steam Generated</u>
Forecast	60,000 pounds per hour	4.20×10^8 pounds
Actual	32,600 pounds per hour	2.28×10^8 pounds

Savings

Savings resulting from using the economizer at the forecast load of 60,000 pounds per hour are shown in Table II.

Table II
ECONOMIZER SAVINGS
AT 60,000 PPH

<u>Energy Savings</u> <u>MMBTU/yr</u>	<u>Fuel Savings</u> <u>gal/yr</u>	<u>Cost Savings</u> <u>\$/yr</u>
33,998	226,573	74,769

1978 Fuel Cost 33¢/gal

Although the system only operated at an average load of 32,600 pounds per hour, significant savings were achieved in fuel cost and consumption. The decrease in system load is due to the fact that the recessed economy has led to an overall decline in goods produced. In spite of this decreased load, the dollar savings exceeded the original forecast. This was due, however, to the tremendous increase in fuel costs. No. 6 fuel oil increased in price from 33¢ per gallon to 80¢ per gallon during the time of the study. The savings are summarized in Table III.

Table III
ECONOMIZER SAVINGS
AT 32,600 PPH

Energy Savings MMBTU/yr	Fuel Savings gal/yr	Cost Savings \$/yr
14,057	93,714	74,971

1980 Fuel Cost 80¢/gal

The Roxboro economizer has operated without any down-time due to problems of fouling. Regular cleaning and maintenance is performed, as are general tune-ups on the boiler. Down-time is defined as any period of time when the boiler is not operating due to anything other than regular maintenance. Down-time can occur due to any number of factors, including tube fouling or scaling.

Summary

The decision to invest in the economizer was based on:

- Feasibility studies based on the Albemarle pilot site.
- A projected payback of approximately 3.4 years.

The actual total cost of the system was \$148,230 installed. Based on dollar savings of \$74,971 per year, the system will have a payback of 1.98 years. Again, this savings is directly attributable to the ever increasing cost of No. 6 fuel oil.

Because of the success of the economizers at both Roxboro and Albemarle, the company is planning to install as many as three more at existing plant sites.

-for further information contact

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Charlotte, North Carolina

Appendix I

CASE STUDY REPORT
WOOD-FIRED BOILER

TEXTILE ENERGY CONSERVATION CASE STUDY:

WOOD-FIRED BOILER

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

William B. Himes, Jr.

August 28, 1981

WOOD-FIRED BOILER

- Integrated Products, Inc.
P. O. Box 1791
Rome, Georgia 30161
- Mr. Mike Brown
Research Engineer
Georgia Tech
404-894-3636
- Integrated Products produces nylon carpet yarn.
- Integrated Products has installed a 400 HP boiler fired by wood fuel, which is capable of supporting all plant manufacturing operations and plant heating requirements.
- From May 1978 to April 1979, Integrated Products consumed 59,419 MMBTU of natural gas and No. 2 fuel oil to fire a 200 HP boiler and a 350 HP boiler.
From February 1981 to July 1981, the wood-fired boiler has required 35,415 MMBTU of wood fuel to fire the 400 HP boiler.
- From May 1978 to April 1979, natural gas costs averaged \$3.00 per million BTU and No. 2 fuel oil averaged \$6.14 per MMBTU.
From January 1981 to August 1981, wood fuel costs have averaged \$1.00 per MMBTU. Integrated Products has not consumed any natural gas or fuel oil in this time period; however, current prices in the Rome area are \$3.25 per MMBTU for natural gas and \$6.38 per MMBTU for No. 2 fuel oil.
- The use of the wood-fired boiler at Integrated Products has virtually eliminated the need for fossil fuels, and resulted in a fuel cost savings of \$60,000 per year even though it has not reduced the amount of energy needed to produce steam.

WOOD-FIRED BOILER

Introduction

The textile industry is one of the major fossil fuel consuming industries in the United States and is dependent upon petroleum products and natural gas for process energy. Total energy requirements for the industry are approximately 67 million barrels of oil equivalent annually. In an effort to reduce this fossil fuel demand, the conversion to renewable energy sources is being carefully considered by the textile industry.

One major application for the use of alternate energy sources is in the production of process steam. An average of 50% to 70% of the fossil fuel energy consumed by the textile industry goes into the production of steam. Thus using alternate energy sources such as wood or solar energy to produce steam can reduce the textile industry's heavy dependence on fossil fuels. As part of a state demonstration of wood energy utilization for nonforest products industries, the U.S. Department of Energy provided matching funds to install a wood-fired boiler at a textile plant in northern Georgia.

Traditional Operation

Integrated Products, located in Aragon, Georgia, is a textile manufacturing firm that produces nylon yarn for the carpet industry. The manufacturing process involves spinning nylon fibers into yarn. A twist in the yarn is heat set in large autoclaves using steam. The yarn is then dried in steam-heated dryers to complete the process. During the winter months steam is also used for space heating.

Prior to conversion to wood fuel, the plant operated one 350 HP boiler and one 200 HP boiler on natural gas or No. 2 fuel oil. Approximately 85% of the energy consumed was provided by natural gas and the remaining 15% was No. 2 fuel oil. The plant is operated 24 hours per day, 6 days per week, 50 weeks per year. Average annual consumption of each fuel is shown in Table I.

Table I
FOSSIL FUEL CONSUMPTION PRIOR TO WOOD CONVERSION
May 1978 - April 1979

<u>Fuel</u>	<u>Quantity</u>	<u>MMBTU</u>
Natural Gas	519,348 therms	51,934
No. 2 Fuel Oil	53,464 gallons	7,485
Total		59,419

Modifications

In order to use wood fuel to produce steam, a completely new boiler system had to be designed. The new wood system was required to supply all of the process and space heating requirements. No backup by the fossil fuel boilers was to be employed except in emergencies.

Sizing of the boiler was based on the existing energy consumption, size and utilization of existing boilers, and plans for future expansion. Based on these considerations, a 400 HP boiler was installed to replace a 200 HP and a 350 HP gas/oil fired boiler.

The boiler chosen was a horizontal return tube firetube boiler designed to produce 13,200 pounds per hour of saturated steam at 130 psig from feedwater supplied to the unit at 220°F. Wood with a 50% moisture content (wet basis) such as sawdust, bark, and chips was to be burned as fuel.

After determining the boiler size, fuel requirements for the chosen boiler were used to determine the volume and area necessary to store an adequate fuel supply for reliable operation of the system. At rated capacity, a 400 HP boiler consumes fuel at the rates shown in Table II.

Table II
FUEL REQUIREMENTS FOR 400 HP SYSTEM

<u>Wood Consumption</u>	<u>100% Capacity</u>	<u>70% Capacity</u>
tons/hr	2.6	1.8
ft ³ /hr	221	155
truckloads/day	3	2
tons/year	19,100	13,300

A poured concrete silo, 48 feet high by 24 feet in diameter, is used to store fuel for the automatic fuel feeding system. The usable storage capacity of the silo is 14,464 cubic feet and is sufficient to store wood fuel for approximately 72 hours when the boiler is operating at 70% load. For long term storage, an open area with a 6,000 square foot concrete floor provides sufficient space to store wood for approximately 15 days.

A simple wood handling system is most economical for a plant of this size. Self-unloading trailers bring the wood chip fuel to the plant. They can unload the fuel in the open storage area or in the fuel staging area, located close to the storage silo. The wood fuel in the staging area is moved to the receiving hopper by means of a front-end loader. From the hopper, a screw conveyor delivers the fuel to a bucket elevator, which raises it into the storage silo. Screw conveyors transfer the fuel from the silo first to the metering bin and then to the air sweep feeders where it enters the combustion area. Figure 1 shows the layout of the system.

Results

The energy savings analysis shown below includes the operating cost associated with the new wood system and the old oil and gas system, the

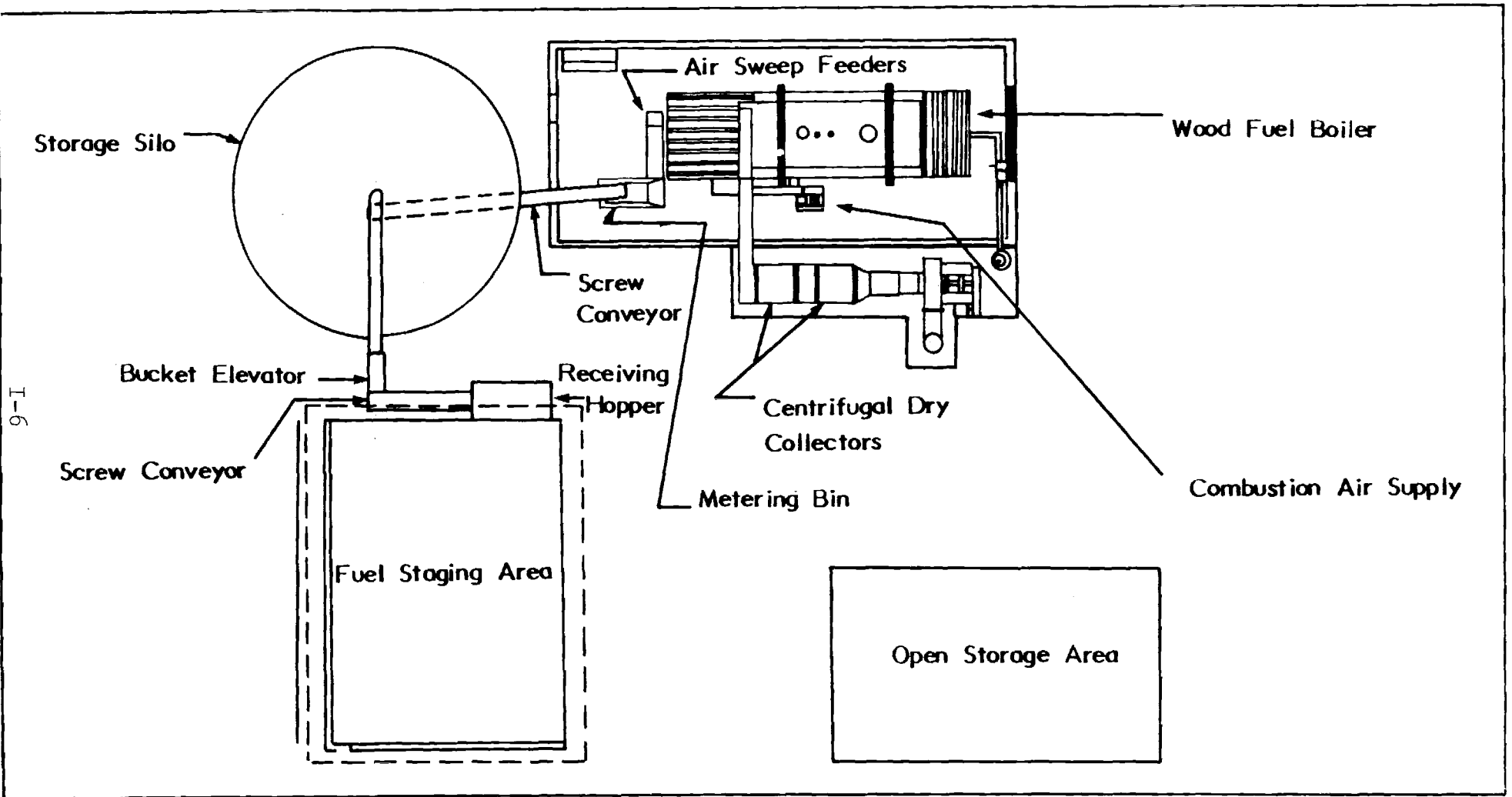


Figure 1. Wood Fired Boiler System at Integrated Products

first year savings, and the simple payback period. The installed cost of the system was \$460,000. First year federal tax credits of \$92,000 resulted in an adjusted capital investment of \$368,000. Based on the financial analysis, an annual cost savings of \$59,071 should result. The simple payback calculated for this system before taxes was 6 years.

SYSTEM FINANCIAL ANALYSIS

Cost Component	Wood System	Existing System
Annual Cost of Capital	\$ 49,268	\$ 0
Amortization (20 years @ 12%)		
Operating Costs	\$ 40,552	\$ 20,744
Electricity, labor, front end loader, maintenance		
Insurance and Property Tax	\$ 4,500	\$ 4,000
Fuel Costs		
Wood fuel @ \$8/ton	\$ 73,136	---
Gas @ \$3/MCF		\$155,804
Oil @ \$0.86/gal		\$ 45,979
	\$167,456	\$226,527
Total Cost Per Year	\$167,456	\$226,527
	SAVINGS \$59,071	

Two additional factors have a bearing on the economic analysis and actual payback period of the system at Integrated Products. The first is a \$146,000 United States Department of Energy demonstration grant that reduced the actual adjusted capital investment to \$222,000 and the projected payback period to 2.8 years. The second factor was the slow economy in the first half of 1980 that forced the plant to operate at a greatly reduced capacity. This lengthened the payback period since the annual cost of capital, operating costs, insurance and property taxes remained relatively constant and the fuel savings decreased.

Overall operation of the new system has been nearly flawless. With the exception of a defective feedwater pump there have been no problems with the new system supplying steam for the plant. The existing boilers were retained for use as an emergency backup system; however, the wood-fired unit is so reliable the gas-fired system has been completely shut down since initial tests were completed on the wood system.

Operating labor is higher for the wood system than for the gas boilers since fuel must be manually loaded into the receiving hopper. Routine maintenance is also necessary for the materials handling equipment that makes up the automatic feed system. The additional labor cost is more than offset by the savings in the cost of fuel.

Summary

The demonstration grant from the United States Department of Energy was an important factor in the decision to invest in wood energy for Integrated Products; however, several other factors also made the conversion attractive. Adequate local supplies of waste fuel at economical prices, combined with a desire to move away from dependence on fossil fuels influenced the decision. Integrated Products also has a competent technical staff that was interested in designing and operating an innovative cost savings system.

Despite the reduced plant output, the new system is performing well and corporate management is very pleased. Exact cost savings are difficult to define because fuel is being inventoried and production is approximately 20% below capacity; however, the cost savings are still approximately \$5,000 per month or \$60,000 annually. With the grant taken into consideration, the simple payback period is less than 3 years.

The benefits of the project reach farther than just Integrated Products. The installation of the wood energy system at Aragon demonstrates the feasibility of using wood fuel in nonforest industries. Conversions to renewable energy systems also reduce dependence on foreign energy supplies.

-for further information contact

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Appendix J

CASE STUDY REPORT
SOLAR INDUSTRIAL PROCESS HEAT

TEXTILE ENERGY CONSERVATION CASE STUDY:

SOLAR INDUSTRIAL PROCESS HEAT

-performed by

Engineering Experiment Station
Georgia Institute of Technology

-sponsored by

Battelle, Pacific Northwest Laboratories

by

James L. Clark

September 29, 1981

SOLAR INDUSTRIAL PROCESS HEAT

- Johnson and Johnson
U.S. Highway 75 South
Sherman, Texas 75090
- Mr. Don C. Whetzle
Staff Engineer
214-892-2191
- Johnson and Johnson produces a variety of sterile pharmaceutical products.
- The U.S. Department of Energy has sponsored the installation at the Johnson and Johnson plant of a solar energy system to produce steam to augment that provided by conventional boilers. The system incorporates an 11,520 square foot array of tracking parabolic trough concentrators as the solar collector and a 5000 gallon flash boiler. Treated water is delivered from boiler feed pumps to the flash boiler. It is circulated at high pressure through the collectors where it is heated. The pressure is reduced as the water is throttled back to the boiler, and a portion is flashed to steam. As pressure builds in the boiler, steam is released into a 110 psig plant steam header for the process areas.
- The solar energy system does not serve an individual process for which energy consumption, costs, and savings may be identified. The estimated total energy provided to the plant during the first year of the system's operation was 632 million BTU. This includes steam metered into the plant header plus steam leaked to the condensate line by faulty traps and later recovered. The current cost of conventional fuel is \$3.00 per million BTU with future price increases already announced.
- Johnson and Johnson's investment criteria include a required 15% after tax internal rate of return and a maximum simple payback period of eight years. An added benefit of the solar system was the plant's reduced dependence on fossil fuels.

SOLAR INDUSTRIAL PROCESS HEAT

Introduction

Most industrial energy conservation efforts are directed at procedures and equipment that will reduce total energy consumption. In recent years, however, there has been increased emphasis on the use of renewable energy resources rather than conventional fuels. Many devices have been designed to capture energy from the sun, the wind, ocean currents and tides, inland waterways, and biomass systems.

The suitability of some of these designs to provide industrial process heat from the sun has been investigated through a series of field tests sponsored by the U.S. Department of Energy. One of these tests was conducted at the Johnson and Johnson plant in Sherman, Texas. This test program has demonstrated the technical feasibility of providing a portion of a plant's thermal energy needs with solar energy by means of a steam generating system interfaced with a conventional steam plant.

The economic viability of the technique is still under evaluation because of the high development costs associated with the system, the low current price for conventional fuel, and the current economic environment that stresses near-term benefits over future benefits. The company has developed plans for the expansion of the system, which will be implemented when financial investment criteria are met.

Conventional Operation

The Johnson and Johnson plant processes a variety of sanitary pharmaceutical products. The plant uses several processes requiring heat including gauze bleaching, cotton bleaching, sterilization, and space heating. These needs are served by a central steam plant that operates at 110 psig. The solar energy system interfaces with the central steam plant at a main steam header, rather than directly operating a manufacturing process. Thus, the manufacturing processes are not measurably affected by the source of the energy used.

Solar Energy System

The solar energy system installed at the Johnson and Johnson plant is illustrated in Figure 1. Pressurized water is circulated from a flash boiler, through an array of tracking parabolic trough solar collectors and back to the boiler. Water in the collector loop may reach a temperature of 395°F. A control valve in the return line maintains the water pressure in the collector at 165 psi higher than the pressure in the boiler. As the water is throttled back to the lower pressure in the boiler, a portion of the water is flashed to steam. As steam is produced and the pressure in the boiler increases above that in the plant steam main, a control valve releases the steam to the main to be used in the process areas.

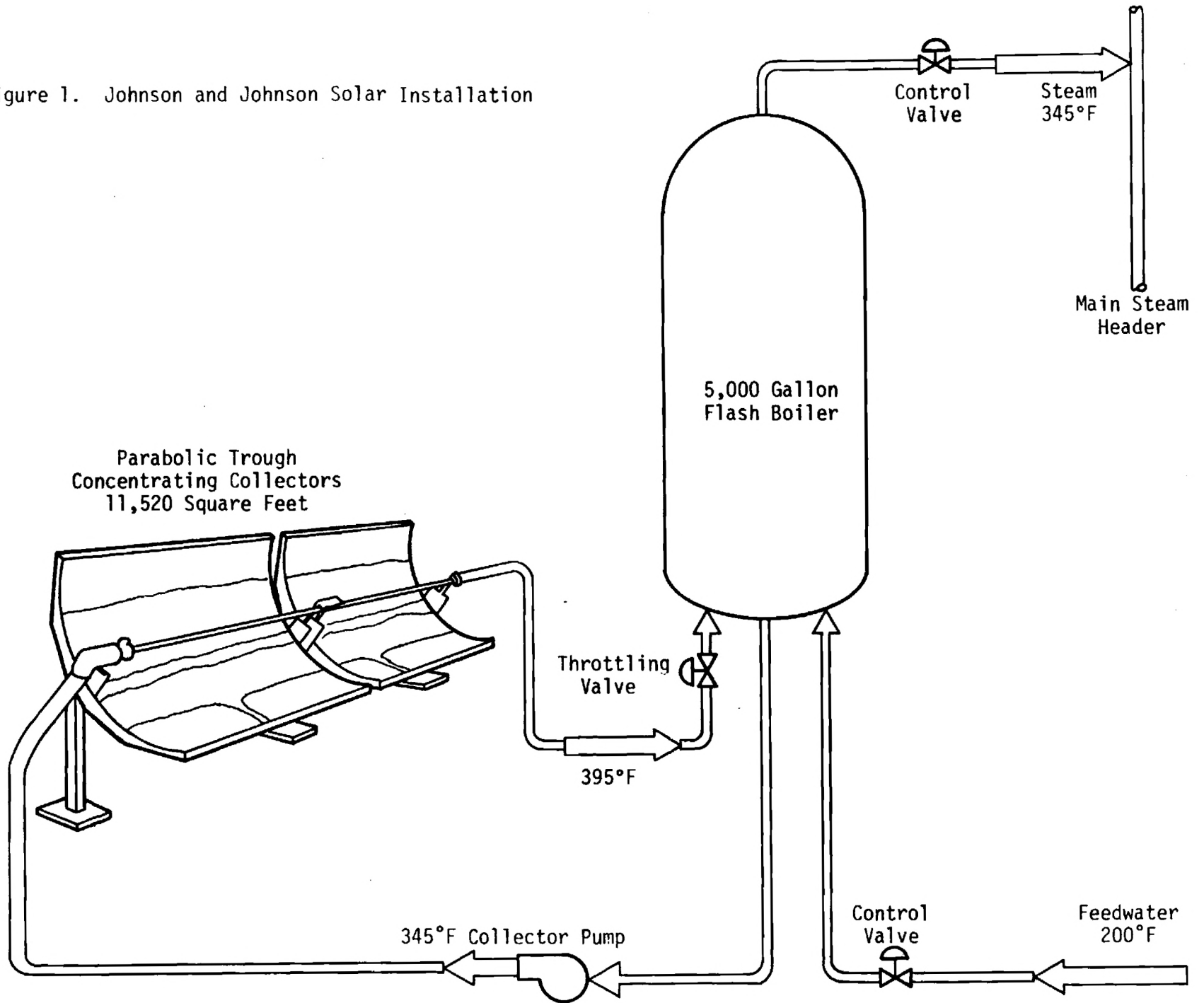
The collector fluid is pure water, obtained from the existing treatment plant for boiler feedwater. Because the collector fluid is eventually flashed and used as process steam, no antifreeze additives are used. Make-up water is pumped into the flash boiler vessel by the plant's boiler feed pumps.

The solar collector array is composed of 192 modules of Acurex Model 3001 parabolic trough for a total collection area of 11,520 square feet. Each module has an aperture of 6 feet and a length of 10 feet. Each drive unit operates a section of eight modules, four on each side of the drive. Tracking of each section is controlled by a sensor located at the drive unit.

The array configuration is eight rows with three drive sections (24 modules) in each row. The array is divided into four parallel flow loops with six sections of troughs per loop. Performance of the collector array is slightly dependent on orientation. Rather than the desired north-south axis, the installation uses a northeast-southwest axis. This was chosen for aesthetic considerations related to the orientation of the plant building and the public visibility of the array site. This non-optimum orientation results in a minor performance deterioration.

Several design variations for the collector modules have been developed and marketed by Acurex. Reflective surfaces have included 3M FEK film, silvered glass, and polished metal. The array installed at the

Figure 1. Johnson and Johnson Solar Installation



Johnson and Johnson plant uses a polished aluminum reflector surface. The module design currently being marketed has an increased collection area with an aperture of 7 feet and a length of 20 feet. The larger area provides proportionately increased energy output with only a minor cost increase.

A central control system monitors solar insolation and determines when the array should begin tracking. In the event of high winds (above 35 mph) or a loss of sunlight for more than 20 minutes, the control system will return the collectors to their stowed (face down) position. The system also controls the operation of the circulation pump in both the operating and freeze protection modes.

The flash boiler is an ASME pressure vessel rated for 160 psig at 370^oF; however, it is only required to operate at pressures less than 125 psig. Pressure in the steam main is 110 psig, and only a 5 psi differential pressure is required for release of steam from the flash boiler.

The boiler has a capacity of 5,000 gallons that provides a limited energy storage capability. In addition to offering a smoothing effect on energy output, the storage capacity provides the energy required for freeze protection. At times when the ambient temperature is below 35^oF, the circulation pump operates at low speed even if there is inadequate solar insolation for the system to provide energy. By the circulation of hot water from the boiler through the collector array, freezing and damage to the collectors and piping are avoided.

The two-speed pump is driven by a 25 horsepower motor and operates at 3500 rpm (68 gpm) in the operating mode and 1120 rpm in the freeze protection mode.

System Performance

The solar energy system was installed during the latter half of 1979 and began operation in January 1980. Operation responsibilities were turned over to Johnson and Johnson from Acurex in April 1980. During the first year of operation, the system was available for operation 97% of the days and actually delivered energy 70% of the days. The remainder of the time there was either insufficient solar insolation or the plant was not operating.

The number of days the system operated does not give a good indication of its contribution to the plant's energy requirements. On many days the system delivered energy to the flash boiler without generating adequate pressure for steam to be released to the plant steam header.

During the first year 472,350 pounds of steam were delivered to the steam main. This figure is significantly below that expected, and analysis revealed that a substantial amount of energy was being released from the boiler to the condensate line by faulty steam traps. Since all condensate was recovered, most of the energy was eventually available to the plant, though at a lower temperature.

It was estimated that the total energy delivered to the plant during the first year of operation was 632 MMBtu. Delivery of solar energy to the boiler was at an average efficiency of 25.4%, while delivery of energy from the boiler to the plant (including the steam leaked to the condensate line) was estimated to be at 76% efficiency.

Table I
PROCESS ENERGY SAVINGS

Annual Steam Production	472,350 lb
Annual Energy Savings from Steam Produced	562.6 MMBtu
Estimated Total Annual Energy Savings	632 MMBtu
Annual Cost Savings from Steam Produced	\$2,250
Estimated Total Annual Cost Savings	\$2,530

Even by the initial design projections, the system provides only 2% of the plant's total energy needs. Thus, the system is mainly a field test of equipment rather than a major energy-producing installation. Nevertheless, the design provides for possible expansion of the collector array.

Johnson and Johnson has already been notified of a 33% increase in natural gas prices to take place in the next year. The opportunity for an investment in additional solar energy equipment will be evaluated in light of the anticipated financial environment and established corporate decision criteria.

Summary

A potential barrier to the implementation of solar energy technology exists in the disparity between actual and claimed performance levels of early systems. Nevertheless, the solar industrial process heat field test installation at the Johnson and Johnson plant has demonstrated the technical feasibility of providing process steam with solar energy and has identified several implementation problems which have since been addressed.

In order for such an installation to be economically attractive to the industrial sector, capital costs must be reduced substantially and/or conventional fuel prices must be significantly higher. As fuel prices escalate more rapidly than the general cost of manufactured goods and as solar energy system costs are reduced through mass production and modular design, such installations will become more viable as industrial alternatives.

-for further information contact

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Appendix K

SUMMARY OF OTHER ENERGY
CONSERVING TECHNOLOGIES IMPLEMENTED
BY THE TEXTILE INDUSTRY

Appendix K
SUMMARY OF OTHER ENERGY CONSERVING
TECHNOLOGIES IMPLEMENTED BY THE TEXTILE INDUSTRY

The following section includes a discussion on several energy conserving technologies that have been successfully implemented by the textile industry, but were not studied under this project because the companies chose not to participate. Further information on these technologies can be obtained from Georgia Tech project team members at the following address:

Technology Applications Laboratory
Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia 30332

Mechanical Predrying

The removal of water by mechanical processes consumes up to 40% less energy than thermal processes. Therefore, whenever product construction or process conditions permit, mechanical water removal should always precede thermal drying in the interest of fuel economy. Not all the water contained in the textile material can be removed by mechanical means, therefore mechanical drying cannot be relied upon alone. Loose water, adherent water, and sometimes capillary water can be removed mechanically. Thermal drying is needed to remove the chemically bound swelling water.

The most common forms of mechanical drying are suction and mangling. Whenever conditions permit, squeeze rolls followed by a vacuum slot should be utilized before thermal drying. The major concern for squeeze rolls is the capital investment, because the operating cost is negligible as compared to other forms of mechanical drying. The energy consumption of a vacuum slot is approximately 300 BTU per pound of water removed, which is considerably less than thermal drying. Generally, the moisture content after mechanical predrying is from 30% to 70% of the dry weight of the material.

A new device known as the machnozzle uses sonic and supersonic steam flow (acoustic transport) to literally blow the water molecules from the cloth or other textile items. This device is presently being tested and should be evaluated fully in the near future.

Dryer Controls

Air is exhausted from a dryer to remove vaporized water and sometimes smoke, solvents, or particulate matter from the dryer housing. The exhaust air leaves the housing at the average temperature inside the dryer containing moisture and particulate matter. To replace the exhausted air, fresh make-up air, usually at room temperature, is taken into the dryer and heated to dryer temperature. The mass flow of the incoming air must equal the mass flow of the air exhausted in order to maintain steady operation. Therefore, a reduction in exhaust flow rate or dryer operating temperature will result in a net energy savings.

There are several means by which the exhaust rate can be reduced and dryer air humidity increased. A simple method of reducing exhaust air flow is to close the exhaust dampers back or reduce the speed of the exhaust fans. This can be performed manually but might prove troublesome due to the wide variety of product constructions with different entering moisture levels and drying characteristics. Therefore, the most effective means of control is to have the output of a product moisture monitor and an exhaust humidity monitor feed back to the exhaust dampers or fans and adjust the levels accordingly.

In theory there is no limit to the humidity level that can be tolerated while still maintaining efficient drying. However, a very important factor limiting the exhaust flow rate is safety and insurance regulations. In the drying of materials that might lead to the buildup of combustible particulate matter, explosive oils or solvents, or potentially toxic materials in the dryer housing, the insurance formula and safety considerations will always take precedence over any reduction in exhaust for the sake of energy savings.

As a result of studies on the drying of textile materials, the recommended humidity level for air leaving the dryer is from 0.08 to 0.12 pounds of water per pound of dry air. In-plant trials are necessary to determine the optimum level for each dryer based on the types of fabrics dried.

Dryer Heat Recovery

Recovery of heat from the dryer exhaust air should be considered when the exhaust air humidity has been adjusted to the maximum level, based on guidelines

stated in the previous section. The heat that is recovered from the exhaust air can be used to preheat make-up air or process water.

Two major barriers to the implementation of heat recovery from textile ovens and dryers are the buildup of lint and the condensation of finishes inside the heat exchanger. These two factors can cause severe maintenance problems and can literally render the heat exchanger useless. Therefore, conventional fin-tube heat exchangers are not well suited for use in textile dryer applications. Maintenance problems have also been noted in other more conventional heat exchanger types.

There are, however, several new heat exchanger designs which offer solutions to these problems. One type utilizes glass rather than metal for the tube portion of the heat exchange surface. The smooth, nonporous surface is more effective in resisting finish and lint deposits. Another new type of heat exchanger uses regenerator units that attach to the dryer sides. Each regenerator unit consists of two heat storage sets through which flow alternately hot dryer exhaust and cool make-up air. The lint and finish problems are minimized because lint builds up at the hot end of the heat storage set but does not adhere to the surface because the finishes do not condense until they reach the cool end. Thus, the lint can be easily removed by blowing the units off with air.

Batch Processing Equipment Modifications

Control of direct sparge heating is usually achieved by temperature feedback to a pneumatically actuated proportional steam control valve. The different accuracies in temperature controllers require different command settings to control at a desired temperature. Obviously, the higher the command set point above the maximum signal for control, the greater the resulting error signal that determines how much steam is added to the bath. Since the sparge steam has been throttled from supply pressure to just above atmospheric pressure, it is superheated. Therefore, the steam has a tendency to pass through the bath without yielding its latent heat, remaining in a vapor phase that is exhausted to the atmosphere.

In many textile plants, the command is set much higher than the control temperature in order to satisfy the operators' subjective desire for "more" temperature and agitation. However, liquids boil at constant temperature if pressure is constant so that higher temperatures are in fact not achieved. If agitation is required above that provided with the machine, speeding up or changing the design of the mechanical agitation device is much less expensive than using live steam. Thus, the controller set point should be placed on the lowest possible setting to still obtain the desired operating temperature.

Sparging efficiency refers to the mixing efficiency of the sparge steam and processing liquor and is always an important energy consumption consideration for heating of liquids by live steam injection. The superheat in the sparge steam inhibits the tendency for the steam to mix with the processing liquor and give up latent heat. Steam sparge tubes in general are under-designed and usually consist of a tube with uniform holes drilled on a uniform spacing. The placement of the sparge tube in the processing equipment is usually such that live steam injection directly on the textile material is prevented. This placement usually results in the lowest level of steam-to-liquor mixing with a low pressure escape route provided directly above the sparging device. The mixing of sparge steam and processing liquor may be enhanced by any device that causes the break-up of sparge steam bubbles or results in longer retention time for the sparge steam within the processing bath. Devices of this type include sparge area covers, baffles or screens, and wire braid or screen fitted around the sparge tube.

It has been estimated that 50% or more of the energy used in typical batch processing is lost through evaporation. The reduction of evaporative losses is an easy problem to attack. Pressure equipment has been developed to reduce energy consumption by reducing evaporation losses. When modifying atmospheric batch processing equipment to reduce evaporative losses, it is desirable to approach as closely as possible the operation of pressure equipment without violating any pressure vessel codes. Therefore, changes should be made in atmospheric equipment to eliminate almost all of the vapor escape routes, such as using doors and reducing the use of large exhaust fans.

Indirect Steam Heating

Once the above modifications have been evaluated and implemented, if economically attractive, an alternative to improving steam sparging efficiency should be considered. The indirect steam heating of dye becks through heat transfer surfaces and coils is becoming economically feasible as energy costs rise.

The major advantages of indirect steam heating over direct sparging are the ability to return condensate to the boiler and the elimination of steam that passes through the dyebath without condensing. Since the condensate can be returned to the boiler, the temperature of the feedwater is increased thus improving the boiler efficiency. Chemical treatment of feedwater can be reduced since the returned condensate does not have to be retreated. Boiler capacity is freed for other uses due to the reduced steam demand from the dye becks. The condensed steam is not present to dilute the dyebath and increase the water volume.

An inherent characteristic of indirect heating is that the temperature control must be very precise in order to prevent overheating. If the set point of the controller is set above the dyeing temperature, especially when dyeing at the boil, steam will continue to be added even after the dyeing temperature is reached while trying to reach the set point temperature. This results in supplying unneeded steam to the beck at a high flow rate. The problem is not as critical for direct sparging since the heat transfer area is much smaller, and thus flows are lower. The problem can be solved by fine tuning of the controller mechanism and careful supervision of the set point temperature, as well as optimum placement of the temperature probe in the dye beck.

Differential Pressure Control of Steamers

The steaming process is commonly used as a part of continuous dyeing operations to set the dyes onto the material. The process requires that the material be subjected to elevated temperatures and an oxygen-free atmosphere. To assure that these conditions are met, the traditional practice is to provide a sufficient steam flow for a maximum production run. The steam flow rate is set by the operator who manually opens the steam valve or by a pneumatically operated

temperature controller that adjusts the steam valve to maintain a desired temperature. Neither method compensates the steam flow for changes in production rates, thus resulting in a very high steam flow into the steamer. This requires steam to be continuously exhausted from the steamer to prevent condensation.

An alternate means of controlling the steaming process is by maintaining a set pressure inside the steamer. The problem with the temperature controller is that the steam temperature may be the same no matter what the steam flow rate might be. A differential pressure controller, however, regulates the steam flow rate by maintaining a slight positive pressure inside the steamer. The pressure controller works in conjunction with a temperature controller to maintain the desired degree of superheat. The positive internal pressure prevents air from entering the steamer and is maintained by compensating for changes in atmospheric pressure in the process room or for changes in production rate. The differential pressure controller regulates the steam flow valve to allow only the amount of steam necessary to make up for losses of heat through the steamer walls and for losses due to condensation on the fabric. This reduces or eliminates the exhaust, thereby minimizing the stack losses. Measurements taken on a vertical steamer on a carpet dye range before and after a differential pressure controller had been added indicated that the steam flow could be halved by using the device.