**21st Century Pulp
& Paper, LLC**

INL

Idaho National Laboratory

Final Technical Report

Project Title:

Steam Cycle Washer For Unbleached Pulp

Submitted to: DOE Office of Energy Efficiency and
Renewable Energy

Recipient Organization:

**Port Townsend Paper Corporation
100 Mill Road
Port Townsend, WA 98368**

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EXECUTIVE SUMMARY

When completed, the patented SC Washer will provide an innovative, energy efficient demonstration project to wash unbleached pulp using a pressure vessel charged with steam. The feasibility of the concept has been demonstrated through extensive pilot plant evaluations and the commercial design has been nearly completed using funding from this DOE-EERE project. Proprietary, unpublished results confirm that a SC Washer will allow pulp mills to: 1) substantially reduce energy consumption, 2) exceed environmental compliance requirements, 3) increase fiber quality, and 4) achieve 28-32% washing and discharge consistency.

In addition the SC Washer has the potential to increase profitability by producing a superior fiber product when compared to current available technologies. SC Washer fiber: Is stronger and has superior absorbent qualities as fiber morphology changes during the exit from the SC Washer; Needs less digesting, resulting in a 1.9% higher unbleached yield and 4.1% production increase, without increase in wood raw material consumption because the new washing process provides a refining action during the exit from the SC Washer.

The Port Townsend Paper Corporation's pulp mill in Port Townsend, WA was initially selected as the host site for conducting the demonstration of the SCW because the technology could be installed with minimal downtime and production impact to the mill by installing it in parallel to the existing brown stock washers. Due to 2006 and 2007 delays in the project caused by issues with 21st Century Pulp & Paper, the developer of the SCW, and the 2007 bankruptcy proceedings and subsequent restructuring at Port Townsend Paper, the mill can no longer serve as a host site. An alternate host site is now being sought to complete the commercial demonstration of the Steam Cycle Washer for Unbleached Pulp. It is estimated that startup and initial testing of the SCW could now take place late in 2009 or early 2010.

Additionally, estimated costs to complete the project have more than doubled since the initial estimates for the project were completed in 2002. It was determined that without additional funds from DOE to match the additional spending required of the recipients the completion of the SCW demonstration project could not happen. Additional grant funding from DOE was sought and in July, 2008 the additional DOE funds were procured under a new DOE award, DE-PS36-08GO98014 issued to INL.

Using recipient matching funds and the initial DOE grant award DE-FC36-04GO14304 most of the SCW engineering design and drawing were completed. Materials were procured and fabrication was started on the SCW internal components.

21st Century P&P is not now involved in the washer project. An investor, Steam Filter LLC, is willing to contribute \$2,000,000 toward the completion of the washer project now that additional DOE funding is procured. The commitment of Steam Filter LLC together with the approval of DOE Award Number DE-PS36-08GO98014 assures that the project can get moving again from a financial standpoint.

Once the new host site is secured the completion of the project will begin under the management of INL. Immediate work that can get started includes: design of the SCW installation at the host site; contracting with a new vendor to complete refinement of the SCW P&ID's, E&I design, and programming; continue with fabrication and machining of the SCW internal components; and complete final design, drawings, contractor selection, and fabrication of the washer shell.

Future progress reports and milestone tracking will be completed under requirements of new DOE Award Number DE-PS36-08GO98014.

PROJECT DISCUSSION

Introduction

The objective of this project is to provide a commercial scale demonstration of the Steam Cycle Washer (SCW) for Unbleached Pulp. When completed the project will demonstrate that the SCW can provide an innovative, energy efficient means to wash unbleached pulp using a pressure vessel charged with steam. The benefits of the SCW are that it will enhance mill profitability by significantly reducing energy costs, increasing product quality, and ensure environmental compliance exceeding current regulations.

The feasibility of the concept has been demonstrated through extensive pilot plant evaluations and the commercial design has been nearly completed using funding from this DOE-EERE project. Proprietary, unpublished pilot research results confirm that a SC Washer will allow pulp mills to: 1) substantially reduce energy consumption (up to 21% reduction in electrical power consumption for unbleached pulp production; up to 50% reduction in evaporator load, which translates to a potential 40% overall reduction in fuel/steam consumption for unbleached pulp production); 2) exceed environmental compliance requirements (up to 45% reduction in plant effluent and fresh water usage, reducing environmental impact to water resources); 3) increase fiber quality, and 4) achieve 28-32% washing and discharge consistency.

In addition the SC Washer has the potential to increase profitability by producing a superior fiber product when compared to current available technologies. SC Washer fiber: Is stronger and has superior absorbent qualities as fiber morphology changes during the exit from the SC Washer; Needs less digesting, resulting in a 1.9% higher unbleached yield and 4.1% production increase, without increase in wood raw material consumption because the new washing process provides a refining action during the exit from the SC Washer.

The SC Washer commercial demonstration project meets the needs outlined in the program announcement under the *Advanced Water Removal* Technical Area of Interest (see page 6, Forest Products Technologies, and page 8, Energy Intensive Processes of the announcement). Specifically, the SC Washer is a technology that would “reduce water requirements for washing steps, and energy consumed in the steam-driven evaporation process of the washer filtrate.”

Technology Description

The SC Washer is designed to de-water and wash wood pulp using counter current washing, steam, and high differential pressure. The SC Washer can be briefly described as a horizontal wire-belt type de-watering mechanism enclosed in a pressure vessel ASME coded for 8-bar operating pressure. The pressure is maintained using 8-bar steam supplied from mill sources. The entire washing operation takes place within the pressure vessel. The washing consistency is 28-32%, and the dilution factor is 0-0.5 tons of water per ton of oven dry pulp. The amount of wash water required is between 2.5 and 3 tons per ton of oven dry pulp.

This design uses 70-75% less water than conventional washers because it allows a pulp mat to be washed at a high consistency of 28-32%. The result is less energy used for heating and pumping and evaporation.

A detailed description of the SC Washer technology and operating cycle can be found in the original grant awarded for the SC Washer demonstration project started initially under Award Number: DE-FC36-04GO14304. A brief description of this technology and operating cycle follows:

Within the pressure vessel there is a Fourdrinier type de-watering mechanism consisting of a wire table, perimeter frame, pressure plate, blow-out funnel for dewatered stock, 4 wash-liquid headers over the wire table, and six longitudinal perforated tubes under the wire table for wash filtrate discharge.

Outside, above the main pressure vessel and at the same pressure, there are two head-boxes for the pulp slurry, one on each side. Each head-box is connected with pipes and pulp inlet valves spaced four meters apart through the main pressure vessel wall.

The SC Washer operating cycle consists of 7 steps.

1. Head Box Discharge (5 seconds): The operating cycle begins with the discharge of the pulp slurry at about 2.5% consistency into the perimeter frame on top of the wire belt.

2. De-watering (11-13 seconds): After the perimeter frame has been filled with pulp slurry, the process computer opens a liquor outlet valve causing two wire table tubes to discharge liquor into the black liquor tank that is used for digester filling, and for dilution from digester and blow tank. This begins the de-watering phase of the washing operation. A second valve opens two seconds later causing another pair of wire table tubes to discharge liquor into the black liquor tank that feeds the evaporators.

3. First Wash (2 seconds): When a desired consistency, for example 20%, is reached, the computer calls for the first wash filtrate to be discharged onto the pressure plate. When the de-watering has progressed to the desired washing consistency, 28%, the first wash filtrate has penetrated into the pulp mat and displaced the black liquor.

4. Second Wash (3 seconds): The second wash filtrate is then discharged onto the pressure plate, and one of the remaining two tubes in the wire table opens to discharge into the first filtrate tank, which accumulates filtrate displaced by this second wash filtrate.

5. Third Wash (3-5 seconds): The fresh wash water (followed by the alkaline or acid wash liquor) is then discharged onto the pressure plate. When the liquid level in the second filtrate tank has reached its upper level, the sixth discharge tube of the wire table is closed and the washed pulp mat discharge procedure is initiated.

6. Washed Pulp Discharge (6-8 seconds): After the perimeter frame and pressure plate are raised, the blow valve is opened. This signals the start of the wire drive-roll and the wire feeds the pulp mat to the blowout funnel. When the wire has moved the length of the pulp mat, it stops and the blowout valve closes.

7. When the wire stops, the perimeter frame is lowered down to the wire surface and the next washing cycle begins. The two head-boxes are connected to the main pressure vessel with vent piping to maintain the same 8 bar operating pressure in both of them.

Figure 1. Three-dimensional view of SC Washer.

Technical Objectives

The SC Washer will provide substantial energy and environmental-related benefits to the United States and its pulp and paper industry. In addition to being a major energy consumer of 268 trillion BTUs per year based on 2000 data, this industry is the largest user of fresh water for industrial processes in the U.S. It also uses a number of regulated chemicals that create toxic effluent. Also, the chemical pulp industry generates approximately 1,550 billion gallons of wastewater annually.

The project objectives are to build a commercial scale, 450 ADTPD, Steam Cycle Washer directed at washing brown stock with the specific technical objectives; Wash pulp at 28 to 30% consistency; Use only 3 tons of wash water per ton of pulp; Reduce the soda loss below 20 lbs per ton of pulp; Enable bleaching stages to be processed at this higher 28 -30% consistency.

The demonstration SC Washer installation is a brown stock washer demonstration project; however, it can also be applied to bleaching processes. We anticipate that additional energy savings and increased yields may be realized in the bleaching processes based on: Chlorine dioxide bleaching stages can be reduced and in some mills eliminated^a; Other bleaching stages can be run at lower pressures, temperatures, chemical charges, and reaction times; Fewer bleaching stages will be needed for pulp that has been washed with an SC Washer.

This extends the potential benefits of the SC Washer technology by further increasing the yield and strength characteristics of the bleached pulp and paper while saving energy, fresh water, and chemicals and reducing the amount of effluent.

All the above objectives will: Improve the pulp mill's environmental safety margins; Improve basic pulp manufacturing process, and reduce the energy intensity of Kraft chemical pulping process by 30%; Lead to development of a new bleach process that will result in 2/3 reduction in energy, 1/4 reduction in chemicals, and significant reduction in capital equipment needed to bleach pulp.

Background

Over the past 100 years, the pulp and paper machinery manufacturing industry has developed new technologies, built the first commercial-scale units, and then given them to a pulp or paper mill for operational testing. However, all major pulp and paper machinery manufacturers are and have been experiencing financial conditions that preclude significant research and development investment. None of the pulp and paper machinery manufacturers can currently afford the investment necessary to develop a technology such as the innovative SC Washer.

Drum filter washing is the most common installation in pulp mills today. A drum covered with wire cloth rotates in a vat. Pulp, at 1-2 % consistency in the vat, forms a 10 % consistency mat on the rotating wire cloth, due to the pressure differential between the inside and outside of the drum causing some of the free liquid to drain through the wire. The dilution factor is 3-4 tons of water per ton of oven dry pulp, and the amount of wash water required is about 12-13 tons per ton of oven dry pulp.

The SC Washer can significantly improve pulp washing. Compared to the drum washer the SCW can be briefly described as a horizontal wire-belt type de-watering mechanism enclosed in a pressure vessel ASME coded for 8-bar operating pressure. The pressure is maintained with 8-bar steam. The washing consistency is 28-32%, and the dilution factor is 0-0.5 tons of water per ton of oven dry pulp. The amount of wash water required is between 2.5 and 3 tons per ton of oven dry pulp.

Using a steam pressure vessel to wash chemical pulp after the digesting process is an innovative approach that realizes significant energy savings, provides a 10% stronger fiber, and exceeds environmental compliance regulatory requirements.

a. As stated in *Alliance For Environmental Technology (AET)*, "Trends in World Bleached Pulp Production: 1990-2002"

ACTUAL ACCOMPLISHMENTS VS GOALS

The initial award for the commercial scale demonstration of the Steam Cycle Washer (SCW) for Unbleached Pulp (Award Number DE-FC36-04GO14304) was approved for funding from 10/01/2004 through 11/30/2006. A no-cost time extension was granted to continue the project through 6/30/2008.

During that time the project encountered several significant roadblocks that prevented the project from being completed under the initial grant Award Number DE-FC36-04GO14304. These included:

- In the design review process between Port Townsend Paper, 21st Century Pulp & Paper (a member of the original project team and owner of the SC Washer patent), and Idaho National Laboratory (INL) maintenance related design issues were identified. These changes required modification of the original design specifications, and caused considerable added time to the final design. These engineering changes and added drafting time resulted in an accelerated expenditure rate of the DOE portion of the budget.
- During 2006/2007 21st Century Pulp & Paper began a long process of resolving internal organizational and matching-funding procurement issues. Although engineering continued during this time, these issues delayed the start of SCW fabrication well over 2 years.
- Estimated costs to complete the project more than doubled since the initial estimates for the project were completed in 2002.
- Port Townsend Paper went through bankruptcy proceedings in 2007. As a result of these proceedings and with new ownership of Port Townsend Paper in July 2008 it became necessary for Port Townsend Paper to withdraw as the host site for the commercial demonstration of the Steam Cycle Washer for Unbleached Pulp.

The net result is that there was no way that the Steam Cycle washer project could be completed by June 30th, 2008, the end of the project authorization period with the original planned funding. While the roadblocks were being addressed, work on the project continued with recipient matching funds and the initial DOE grant award DE-FC36-04GO14304 used to complete most of the SCW engineering design and drawing. Materials were also procured and fabrication was started on the SCW internal components.

Wire Table Fabrication in Progress

The SCW project has not been completed. Since the original award funding has been expended and the project authorization period has ended DOE has suggested that the final report for Award Number DE-FC36-04GO14304 be prepared and the SCW project be continued under a new project award and time schedule. Presently the efforts by Port Townsend Paper/21st Century Pulp & Paper to complete the fabrication and installation of the SCW under Award Number DE-FC36-04GO14304 have ended. Additional grant funding from DOE was applied for and in July, 2008 additional DOE funds were

procured under a new DOE award, DE-PS36-08GO98014 issued to INL. Once the new host site is secured the completion of the SCW project will begin under the management of INL.

Milestone Status Table:

Project: Steam Cycle Washer for Unbleached Pulp				
			Status	Comments
Task 1				
	Design and Specifications			
		Washer Design and Specs	90% complete	
		Algorithms and P&ID Development	75% complete	
		Design Field Piping	80% complete at Port Townsend	Must be redone for new host site.
Task 2				
	Fabrication and Shop Testing			
		Fabrication	20% complete	
		Shop Testing	0%	
Task 3				
	Delivery and Field Installation			
		Delivery	0%	
		Field Installation	25% complete at Port Townsend	Must be redone for new host site.
Task 4				
	Complete Field Validation		0%	

Major Task 1: Design and Specifications for the SCW:

Subtask 1: Design and Specifications: Most of the specifications and design for the SCW are complete. Remaining to complete are final fabrication and design drawings for the washer shell, ancillary tanks, and piping. Alaskan Copper will perform this work. As these drawings are completed they can be delivered to fabricators for construction. Preliminary bids for pressure vessel fabrication have already been received. Hypower has completed the preliminary design of the hydraulic system required for the SCW. Yet to be contracted is to convert their design sketches into final drawing for bid. This can be contracted as soon as the project is started with a new host site.

Subtask 2: Algorithms and P&IDs Development: Much of the instrumentation design, process control software programming, development of algorithms, and P&ID development for operation of the washer have been completed by Checkmate Control Systems (CCSi). Because of the delays in the project, it is expected that a new contractor will have to be hired for continuing the engineering for the Electrical, Instrumentation, and Programming portion of the project with respect to the new host site.

Subtask 3: Design Field Piping: Port Townsend Paper has completed the tie-ins, valve and piping relocations, and design of many field piping runs for installation of the SCW at the mill site. Unfortunately these efforts will have to be repeated for installation of the SCW at a new host site.

Major Task: 2: Fabrication and shop testing.

Subtask 1: Fabrication: Fabrication on the SCW interior components (e.g. wire table, perimeter frame, pressure plate, and wash header assemblies) was started at Jesse Engineering in 4Q05. During 4Q06 complex machining of the pressure plate was completed and delivered to Jesse Engineering. Their work on the project was suspended in 1Q07. Budget pricing has been solicited and received for the fabrication of the pressure vessel. Once the project is restarted final design of the pressure vessel can be completed and a contract can be awarded for completion of the pressure vessel. When fabrication of the SCW pressure vessel is completed it will be delivered to Jesse Engineering for final assembly and shop testing. Presently all fabrication on the SCW has been suspended.

Subtask 2: Shop Testing: It is planned that shop testing of the assembled washer will occur at Jesse engineering before delivery to the new host site.

Major Task: 3: Delivery and Field Installation

Sub Task 1: Delivery: Port Townsend Paper had identified the pumps, motors, valves, instruments, and piping required for the new SCW installation at the mill. Long delivery items such as pumps, motors, and low voltage electrical switchgear were delivered to Port Townsend. During 4Q07 the last of the medium voltage switchgear needed for the pump drives was delivered to Port Townsend. As previously stated, these efforts will have to be repeated for installation of the SCW at a new host site.

Sub Task 2: Field Installation: Port Townsend Paper has completed most of the engineering and bidding for installation of the SCW at the Port Townsend mill. These efforts will also have to be repeated for installation of the SCW at a new host site.

Publications:

None

Inventions/Patents:

None

Existing Status of Project Spending

Recipient Matching Funds: Port Townsend Paper and 21st Century Pulp & Paper have spent \$1,543,910 in matching funds for engineering, design, material procurement, field construction, and in-kind costs toward the completion of the SCW project.

During 2006/2007 21st Century Pulp & Paper began a long process of resolving internal organizational and matching-funding procurement issues. Although engineering continued during this time, these issues delayed the start of SCW fabrication well over 2 years. In addition, estimated costs to complete the project more than doubled since the initial estimates for the project were completed in 2002. Finally, Port Townsend Paper went through bankruptcy proceedings in 2007. As a result of these proceedings and with new ownership of Port Townsend Paper in July 2008 it became necessary for Port Townsend Paper to withdraw as the host site for the commercial demonstration of the Steam Cycle Washer for Unbleached Pulp.

The net result is that there was no way that the Steam Cycle washer project could be completed by June 30th, 2008, the end of the project authorization period. Since the original award funding has been expended and the project authorization period has ended DOE has suggested that the final report for Award Number DE-FC36-04GO14304 be prepared and the SCW project be continued under a new project award and time schedule. Presently the efforts by Port Townsend Paper to complete the fabrication and installation of the SCW under Award Number DE-FC36-04GO14304 are on hold.

21st Century P&P is not now involved in the washer project. An investor, Steam Filter LLC, is willing to contribute \$2,000,000 toward the completion of the washer project now that additional DOE funding is procured. A new host site is being sought and it is expected that a new host site for the installation of the commercial demonstration of the SCW will be identified by the end of October, 2008.

DOE Matching Funds: All of the matching (\$1,770,000) funds identified for the Steam Cycle Washer have been received from DOE. All of these funds have been distributed to 21st Century Pulp & Paper for engineering, design, drawing preparation, material procurement, and beginning of fabrication of the Steam Cycle Washer components.

To address the requirement for additional DOE funds, both INL and PTPC applied for separate DOE grants to provide an additional \$2,000,000 in DOE matching funds to complete the SCW project. At this time the DOE has approved INL's response to a DOE Lab Call and approved funding for completion of the SCW project (Award DE-PS36-08GO98014). The new grant will provide an additional \$1.999 million in matching funds from DOE to assist in completing the fabrication of the washer.

When the initial SCW project award (DE-FC36-04GO14304) spending is combined with the projected spending under the new SCW project award (DE-PS36-08GO98014), the Recipient matching funds spending will more than exceed the 50% requirement per the terms of the awards. The projected total costs to complete the commercial demonstration project for the Steam Cycle Washer for Unbleached Pulp would be:

DOE Matching Funds:

Award Number DE-FC36-04GO14304	= \$2,170,000
(\$400k to INL and \$1,770k to PTPC/21 st Century P&P)	
Award Number DE-PS36-08GO98014	= \$1,999,000
(\$650k to INL and \$1,349k to new host recipient.	
Total DOE awards	= \$4,169,000

Recipient Matching Funds:

Award Number DE-FC36-04GO14304	= \$1,543,910
(spending by PTPC/21 st Century P&P)	
Award Number DE-PS36-08GO98014	= est. \$3,500,000
(\$2,000k by Steam Filter LLC and \$1,500k by new host site).	
Total estimated Recipient matching spending	= \$5,043,910

Ratio of DOE/Recipient Matching Funds = \$4,169k: \$5,033 = 45:55

Future Plans

The commitment of Steam Filter LLC together with the approval of DOE Award Number DE-PS36-08GO98014 assures that the project can get moving again from a financial standpoint. Once the new host site is secured the completion of the project will begin under the management of INL. Immediate work that can get started includes: design of the SCW installation at the host site; contracting with a new vendor to complete refinement of the SCW P&ID's, E&I design, and programming; Jesse Engineering will continue with fabrication and machining of the SCW internal components; Alaskan Copper will be contracted to complete final design and completion of fabrication drawings for the washer shell; and a fabrication contractor for the SCW shell will be selected. INL's efforts in drafting performance auditing test procedures will start with the new host site personnel.

Future progress reports and milestone tracking will be completed under requirements of new DOE Award Number DE-PS36-08GO98014.