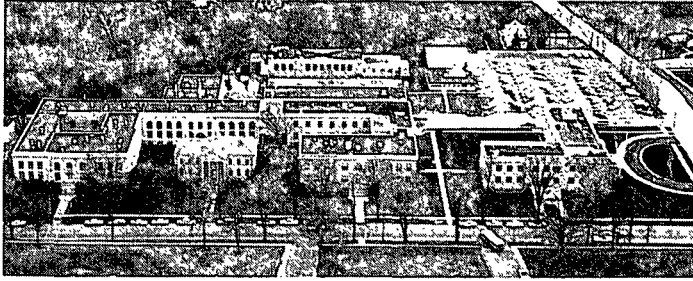


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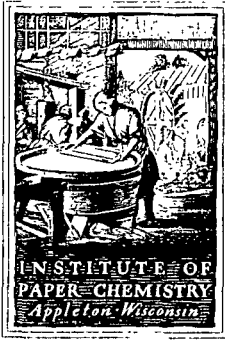


THE INSTITUTE OF PAPER CHEMISTRY, APPLETON, WISCONSIN

STATUS REPORTS

To The
Engineering Project Advisory Committee

April 3-4, 1985
The Institute of Paper Chemistry
Continuing Education Center
Appleton, Wisconsin



THE INSTITUTE OF PAPER CHEMISTRY
Post Office Box 1039
Appleton, Wisconsin 54912
Phone: 414/734-9251
Telex: 469289

March 5, 1985

TO: Members of the Engineering Project Advisory Committee

Enclosed is advance reading material for the April 3-4 meeting of the Engineering Project Advisory Committee. Included are brief status reports for active projects (in accordance with the new reporting policy mailed to you earlier), a revised agenda, and a current membership list.

Rooms have been reserved in the Continuing Education Center, and meals will be provided as stated on the agenda. If you haven't already indicated your attendance, please do so at your earliest convenience by calling Evonne Ludwig at (414) 738-3320.

We look forward to meeting with you on April 3-4.

Sincerely,

A handwritten signature in cursive script, appearing to read 'Clyde'.

Clyde H. Sprague, Director
Engineering Division

CHS/el
Enclosures

TABLE OF CONTENTS

	<u>Page</u>
TABLE OF CONTENTS	i
AGENDA	ii
COMMITTEE LIST	iii
Project 3470: Fundamentals of Drying	1
Project 3480: Process Fundamentals of Wet Pressing	5
Project 3556: Fundamentals of Kraft Liquor Corrosivity	9
Project 3309: Fundamentals of Corrosion Control in Paper Mills	14
Project 3479: Higher Consistency Processing	19
Project 3384: Refining of Chemical Pulps for Improved Properties	24

* * * PRELIMINARY AGENDA * * *

ENGINEERING
PROJECT ADVISORY COMMITTEE

April 3-4, 1985

Continuing Education Center (CEC)
The Institute of Paper Chemistry
Appleton, Wisconsin

Wednesday, April 3, 1985

- 10:00am -- INTRODUCTION Sprague/White
- PROJECT REVIEWS
- Fundamentals of Drying Sprague
 - Mathematical Model of Impulse Drying Pounder (student)
 - Dynamics of Densification in Impulse Drying Burton (student)
- 12:00pm -- LUNCH
- 1:00pm -- PROJECT REVIEWS - continued
- Process Fundamentals of Wet Pressing Sprague
 - Fundamentals of Kraft Liquor Corrosivity Yeske
 - Fundamentals of Corrosion Control in Paper Mills Yeske
- 3:15pm -- BREAK
- 3:30pm -- PROJECT REVIEWS - continued
- Higher Consistency Processing Sinkey
 - Refining of Chemical Pulps for Improved Properties Sinkey
- 5:30pm -- COCKTAILS
- 6:00pm -- DINNER - CEC Dining Room

Thursday, April 4, 1985

- 7:15am -- BREAKFAST -- CEC Dining Room
- 8:00am -- Discussion of Projects Committee & Research Staff
- 9:30am -- BREAK
- 9:45am -- Continued Discussion of Projects
- 10:30am -- Report Preparation Committee
- 11:30am -- Adjourn
- LUNCH - CEC Dining Room

NOTE: The fall Engineering PAC Meeting is scheduled for October 23-24, 1985.

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THE INSTITUTE OF PAPER CHEMISTRY
Appleton, Wisconsin

Status Report
to the
ENGINEERING PROJECT ADVISORY COMMITTEE

Project 3470
FUNDAMENTALS OF DRYING

February 20, 1985

PROJECT SUMMARY FORM

DATE: February 20, 1985

PROJECT NO. 3470 - Fundamentals of Drying

PROJECT LEADER: C. H. Sprague

IPC GOAL:

Reduction of the "necessary minimum" complexity (number and/or sophistication) of process steps.

OBJECTIVE:

To develop an understanding and a data base sufficient for commercialization of advanced water removal systems, based on high-intensity drying principles, that will result in reduced capital cost/increased machine productivity, reduced quantity and/or quality of energy use, and a favorable impact on paper properties.

CURRENT FISCAL BUDGET: \$150,000

SUMMARY OF RESULTS SINCE LAST REPORT: (October, 1984 - February, 1985)

For the past year or so, work on 3470 has been concentrated primarily on impulse drying with the objective of obtaining data to encourage and support commercial application of the process. Impulse drying involves the short term, simultaneous application of high temperatures and high pressures to a previously well-pressed sheet to effect extremely high drying rates. Much smaller dryers, improved energy efficiency, and better product properties and property control are all expected benefits.

Over this reporting period, some additional exploratory work has been carried out, but preparation for a detailed technical performance evaluation has been the main task. When completed, this evaluation will provide information on drying rates, energy utilization, property development and other issues, all for six selected furnishes/grades which, collectively, represent about 70-80% of total production. In turn, these data will be used to assess the potential applications of the process and for followup calculations on the engineering and economic aspects of impulse drying for each applicable grade. Laboratory pilot scale demonstrations will follow, if warranted or necessary to penetrate the commercial market.

Impulse drying is much more like pressing than conventional drying so the question of appropriate felt design becomes important. Limited evaluation of a number of pressing and drying felts showed little influence on impulse drying results, thus suggesting that there is considerable latitude in felt design. One of the new, high contact dryer felts will be evaluated shortly. In contrast, impulse drying tends to improve with felt moisture content, possibly because the pre-moistened felt is easier to wet and the resident moisture serves as an effective heat sink for condensation of the vapor expressed from the drying sheet. Improvement continues up to at least 35% moisture in the felt and may add 2-3 percentage points of dryness out of the impulse dryer. Press felts may offer a slight advantage over dryer felts when operating moist.

The key tool in the technical performance evaluation is an electro-hydraulic press system designed to provide electronic control over the pressing profile, including nip residence time. Much work has been required to complete construction and check out of this system, but it is now operating in a productive mode. This system can deliver pressure pulses of up to 18,000 pounds with durations from 10 milliseconds on up. This permits the use of 20 in.² handsheets, large enough for proper property evaluation.

Other work, related to this evaluation and now virtually completed, includes the development of procedures for making and handling sheets. A special sheet mold for making 5" sheets has been worked out. A roll press and the related procedures for pre-pressing to the desired moisture ratio are now available. Press impulses typical of real machines are used for this purpose (to avoid unreasonable densification in the pre-pressing step). Finally, a post drying technique using "normal" dryer temperatures and pressures, has been worked out to take each sheet to a predetermined final moisture content. All of these issues were mentioned at the last meeting, but the details, so critical to success of the evaluation, had not been worked out.

Preliminary screening tests, in accordance with the test plan, are now underway. Some performance data, including properties, should be available by meeting time.

Work related to Project 3470, being carried out by three students, will be reported in part at the meeting. Matt Nightingale is studying the engineering issues relative to a gas flame-heated impulse dryer; Steve Burton is studying the dynamics of the densification processes that take place during impulse drying; and, Joe Pounder is developing a mathematical model that describes many aspects of impulse drying.

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

Status Report

to the

ENGINEERING PROJECT ADVISORY COMMITTEE

Project 3480

PROCESS FUNDAMENTALS OF WET PRESSING

February 20, 1985

PROJECT SUMMARY FORM

DATE: February 20, 1985

PROJECT NO. 3480 - Process Fundamentals of Wet Pressing

PROJECT LEADER: C. H. Sprague

IPC GOAL:

Fundamentally increase the potential capacity of processes.

OBJECTIVE:

1. To increase press effectiveness through improving the water receiving system.
2. To determine the feasibility and performance of displacement pressing in achieving high dryness, press effectiveness, and property control.

CURRENT FISCAL BUDGET: \$140,000

SUMMARY OF RESULTS SINCE LAST REPORT: (October, 1984 - February, 1985)

This project has two objectives: (1) to determine the feasibility of displacement pressing for achieving much higher dryness levels for well pre-pressed sheets or density-dryness decoupling when pressing much wetter sheets; and, (2) examining the merits of incompressible but porous materials as water receivers for current pressing regimes. Both objectives are exploratory in nature and require the development of new equipment and techniques.

Previous work has shown that dryness levels of 65% or higher can be achieved by displacement methods, but require nip residence times that are marginal to long. Impulse drying results suggest better performance is possible and steps are being taken to improve the system in line with both displacement pressing and impulse drying experience. Changes include more uniform mechanical pressure application and more impulse-like application of the air pressure. Because of the limitations mentioned in the cover letter, having data from this system in time for the meeting seems doubtful.

Decoupling density and dryness can be achieved by pressing wet sheets at relatively low mechanical pressures and displacing the water with air. For this type of operation, density development depends primarily on mechanical pressures and displacing the water with air. For this type of operation, density development depends primarily on mechanical pressure and hot displacement. Dewatering, on the other hand, is only a weak function of mechanical pressure, thus affording good density control. Exploratory work of this type with a tissue furnish is planned.

Use of incompressible porous plates as water receivers was prompted by water removal data from the UMO wet pressing study which greatly favored plates over felts. It is now believed - confirmation is hopefully on the way from UMO - that these data reflect water removal based on minimum sheet thickness and neglect the uptake of water that occurs during expansion and rewetting. Consequently, actual net water removal should be much less than they reported.

As a first step in evaluating porous plates, it was deemed advisable to compare them with felts using common equipment - the UMO report presents data from a pilot press for felts and from a laboratory platen press for porous plates.

Accordingly, felts and porous plates are now being compared on a common hammer and anvil press simulator. Considerable effort has been required to work out repeatable procedures to provide a reliable, fair comparison. These new procedures are now nearly completed and preliminary data are coming in. It appears that these data will agree reasonably well with the pilot press data for felts and that water removal for at least one porous plate will be close to that for felts.

If the approximate equality of performance between porous plates and felts holds up under further testing, then incompressible, fine porous structures may have merit as commercial water receivers. Accordingly, we are currently making plans to do a more comprehensive evaluation of porous materials in this application. The first step is to devise ways to appropriately characterize porous plates for wet pressing. This step is just now beginning.

THE INSTITUTE OF PAPER CHEMISTRY
Appleton, Wisconsin

Status Report
to the
ENGINEERING PROJECT ADVISORY COMMITTEE

Project 3556
FUNDAMENTALS OF KRAFT LIQUOR CORROSIVITY

February 28, 1985

PROJECT SUMMARY FORM

DATE: February 28, 1985

PROJECT NO. 3556 - Fundamentals of Kraft Liquor Corrosivity

PROJECT LEADER: R. A. Yeske

IPC GOAL:

Increase the useful life of equipment by proper selection of materials of construction and by identifying suitable process conditions.

OBJECTIVE:

To understand the causes of corrosion and corrosion-assisted cracking of carbon steels exposed to kraft liquor, as the basis for developing methods for reducing corrosion damage in the recaustizing plants. When this project is successfully completed, mills will be aware of the conditions that promote costly corrosion damage in recausticizing plants and will be informed of practical measures that can be taken to reduce the damage.

CURRENT FISCAL BUDGET: \$130,000

SUMMARY OF RESULTS SINCE LAST REPORT: (October, 1984 - February, 1985)

Approach. Corrosion monitoring methods are being developed to provide an early warning when corrosion of carbon steel is severe — in time to take remedial measures before corrosion damage is extensive. Liquor conditions that accelerate corrosion are being determined to provide guidance regarding changes that can be made by the mill to reduce liquor corrosivity. Tests are also being conducted in actual mill equipment to insure relevance to actual liquors.

Progress. In previous work, two methods of on-line monitoring of corrosion damage — linear polarization (LP) and electrical resistance (ER) — were evaluated for use in monitoring corrosion of carbon steel in simulated

white liquor. Both methods were effective in measuring the corrosion rate provided simple precautions were taken. In particular, the LP method required the use of a calibration factor to bring the average corrosion rate into agreement with long-term weight loss measurements.

On-line corrosion monitoring has been performed in white liquor at three different kraft mills, to assess whether these methods are equally effective in actual liquor. In two mills, the LP method was evaluated and in the third mill, the ER method was studied. Comparisons were made of the average corrosion rates, determined by the LP and ER methods, and the actual corrosion rates found with weight loss coupons exposed at the same time. Recently, simultaneous tests of the ER, LP, and weight loss type were initiated at the third mill.

Linear polarization tests provided accurate measurements of the corrosion rates in both mills, even though the corrosion rates differed by a factor of two at the different sites. The calibration factor determined in laboratory tests on simulated liquors was found to be appropriate for use in both of the actual liquors. The corrosion rates of different grades of carbon steel did not differ appreciably, and the LP method was equally predictive for all four carbon steels tested.

The on-line measurements indicated much greater volatility in the corrosion rate at the first mill (where the average corrosion rates were higher by a factor of two). Furthermore, each individual probe exposed to this liquor corroded independently of the others, — i.e., individual probes would experience occasional periods of high corrosion while other probes exposed nearby did not. This independent behavior of individual electrodes casts some doubt on the

hypothesis that small changes in corrosion rates are caused by corresponding changes in liquor composition.

Analyses of liquor extracted at each mill also failed to reveal changes in liquor composition that would explain differences in corrosion rates. Although the corrosion rate at mill #1 was nearly twice that of mill #2, the compositions of the two liquors were quite similar. Furthermore, analyses of liquors extracted during periods of high corrosion of a selected electrode did not reveal differences in liquor composition at those times, compared to the average liquor composition when corrosion rates were lower. These analyses also raised questions regarding the role of liquor composition on corrosivity toward carbon steel in actual mill environments.

Nonetheless, laboratory tests in simulated liquors continue to show that liquor composition can affect the rate of corrosion of carbon steel. The test sequence involving polysulfide addition has now been completed and a new sequence of tests to examine the effects of thiosulfate is under way. Polysulfides at moderate concentrations — less than 2.5 g/L — were shown to cause a short-lived increase in corrosion rates of carbon steel. Initial results of tests in liquors containing thiosulfate show that ten-fold increases in corrosion rates occur when thiosulfates are present in appropriate concentrations.

Liquor velocity also affects the rate of corrosion, with extraordinary corrosion rates — as high as 150 mils/yr — measured under turbulent flow conditions. Previous corrosion tests in a flow loop had revealed these high corrosion rates, but problems were encountered in the reproducibility of flow conditions. The flow loop has been redesigned to provide better control over hydrodynamic conditions. An alternative laboratory test to determine velocity

effect, employing a rotating cylinder of carbon steel immersed in white liquor, is being installed for use in the next reporting period.

Also under development is a microprocessor-based data acquisition system that will conduct remote linear polarization tests in mills and report the data to computers at the Institute via telephone line. The hardware for two systems has been purchased, and hardware assembly and software development are underway.

Plans for 1985

1) Validation of corrosion monitoring methods via in-mill testing at additional mill sites.

2) Evaluation of the effect of liquor composition on corrosivity of white liquor in laboratory (thiosulfate effects) and in-mill testing.

3) Characterization of effects of liquor velocity on corrosion rates using flow loop and rotating cylinder tests.

4) Installation of microprocessor controlled, linear polarization test equipment.

Significance to the Industry

On-line corrosion monitoring now appears to be validated for use by kraft mills in studies of corrosion by white liquor. The effect of liquor composition on corrosivity of white liquor is known in simulated liquors, but the effect in actual liquors remains uncertain awaiting continued in-mill testing.

THE INSTITUTE OF PAPER CHEMISTRY
Appleton, Wisconsin

Status Report
to the
ENGINEERING PROJECT ADVISORY COMMITTEE

Project 3309
FUNDAMENTALS OF CORROSION CONTROL IN PAPER MILLS

February 28, 1985

PROJECT SUMMARY FORM

DATE: February 28, 1985

PROJECT NO. 3309 - Fundamentals of Corrosion Control in Paper Mills

PROJECT LEADER: Ronald A. Yeske

IPC GOAL:

Increase the useful life of equipment by proper selection of materials of construction and by identifying suitable process conditions.

OBJECTIVE:

Improve the useful life of paper machine suction rolls by conducting corrosion and corrosion fatigue studies to establish the mechanisms of failure as the basis for developing approaches for prolonging roll lifetime.

CURRENT FISCAL BUDGET: \$130,000

SUMMARY OF RESULTS SINCE LAST REPORT: (October, 1984 - February, 1985)

Approach. Currently, tests used in the industry to evaluate candidate suction roll alloys do not accurately predict service performance as measured by failure rate statistics. Alloys with impressive resistance to corrosion and corrosion fatigue in laboratory tests have not performed well in the field as alloys with inferior corrosion and corrosion fatigue characteristics. A more predictive test is needed if improved alloys are to be developed in a more rational fashion.

Consequently, the current effort in this project is focused on identifying laboratory tests that correlate with performance of suction roll alloys in the field. In this search, various corrosion and corrosion fatigue tests will be performed on stainless alloys with either superior or inferior records

of performance as suction roll materials. Tests that discriminate between desirable and undesirable roll alloys will be rationalized in terms of cracking mechanisms and subsequently used to evaluate new alloys with promise as improved suction roll materials.

The effort to identify a more predictive test will be supplemented by an effort to normalize results of different corrosion fatigue tests used by roll vendors to support selection of roll materials. Different tests are used by different vendors and mills have difficulty in comparing alloys in the absence of such a normalization study.

Progress: The MTS system for fatigue testing has been modified to allow fatigue crack propagation studies on compact tension specimens of suction roll alloys. Modifications include: 1) installation of a titanium metal cage and grip assembly on the upper loading platen, 2) incorporation of a heated test solution chamber, and 3) installation of a traveling telemicroscope and lighting system for crack length monitoring. This system is now in readiness for fatigue crack growth studies to be conducted in the search for a predictive test of suction roll alloy performance.

Initial fatigue crack growth tests are under way on specimens of Alloy 63 exposed to the first of two simulated white waters propagated by the Tappi Corrosion and Materials Engineering Subcommittee on Suction Rolls. (Alloy 63 is a duplex stainless steel that experiences an early failure rate above 50% and is no longer offered as a suction roll material.) The simulated white water for this test is held at 50°C, contains 1000 ppm/Cl⁻, and has a pH of 4.5 maintained by HCl and NaOH addition. Measurements are being made of the rate of crack growth versus applied stress intensity range, ΔK , where ΔK is the usual measure of mechanical driving force for crack growth.

A similar installation of a test chamber for use on the R.R. Moore rotating bending fatigue machine is nearing completion. This chamber will be used in the determination of the fatigue lifetime of suction roll alloys, plotted as the (logarithm of) number of cycles to fatigue failure versus the magnitude of the alternating stress applied to the specimen — i.e., the S-N curve. The S-N curve is a measure of resistance to fatigue crack initiation rather than crack propagation. Test specimens have also been prepared from Alloy 63 material and initial tests will be conducted to determine the S-N curve for Alloy 63 exposed to the Tappi simulated white water described above.

A report to the membership on suction roll materials has been issued in this reporting period. The report was prepared by Dr. Bowers before his departure from the Institute. The report describes tests of corrosion resistance of conventional suction roll alloys exposed to various simulated paper machine white waters. Additional topics include alloy metallurgical structure, effects of surface finish, and feasibility of shot peening to increase resistance to cracking. A detailed review of the published literature of suction roll failures and testing methods is also presented as an appendix.

Alloys 63 and 75 have been obtained in sufficient quantities and with appropriate heat treatment from Beloit/Sandusky, as examples of stainless suction roll alloys with high and non-existent rates of failure, respectively. Other alloys are being solicited from other suction roll vendors.

Plans for 1985

1) Continue search for a predictive test that correlates with suction roll performance. Initial tests will involve near-threshold fatigue crack growth studies and tests to determine mean stress effects on crack initiation.

2) Begin tests to normalize the S-N curve produced with different test methods.

Significance to the Industry

Facilities are now in place for corrosion fatigue testing to characterize suction roll alloys and their performance in simulated white water systems.

THE INSTITUTE OF PAPER CHEMISTRY
Appleton, Wisconsin

Status Report
to the
ENGINEERING PROJECT ADVISORY COMMITTEE

Project 3479
HIGHER CONSISTENCY PROCESSING

February 25, 1985

PROJECT SUMMARY FORM

DATE: February 25, 1985

PROJECT NO. 3479 - Higher Consistency Processing

PROJECT LEADER: John D. Sinkey

IPC GOAL:

Reduction of the complexity of screening, cleaning, and forming systems.

OBJECTIVE:

To identify or develop methods and principles for applying forces of controlled magnitude to various particles in 2-6% consistency slurries, so as to enable practical separation and forming processes to be carried out at these levels.

CURRENT FISCAL BUDGET: \$130,000

SUMMARY OF RESULTS SINCE LAST REPORT: (October, 1984 - February, 1985)

In considering the separation of contaminants from HC pulp slurries, we have reasoned that interfiber interactions would best be reduced by physically getting some distance between the fibers at the time of applying the separation forces. Two ways we considered to accomplish this involved (1) spraying, and (2) spreading the slurry into a film thin enough that particles would contact each other in relatively few places. Fiber orientation would be important in the latter. Separating forces could then be applied to such a system to physically move particles of undesirable characteristics from acceptable fiber.

Accordingly, an apparatus embodying the thin film principle was constructed to establish if separation could be achieved in this way, and if so,

to study fundamentals of HC phenomena in such a system. The experimental apparatus consists of a rapidly moving cylinder with several alternative means for applying a film of slurry to the roll face. The options included (among others) passing a well-dispersed slurry through the nip with a counter-rotating roll (as discussed previously), or alternatively, distributing the slurry onto a stationary blade which contacts the roll face at a nearly tangential position. In the latter configuration, the blade eliminates the disruption caused by the air layer following the roll, allowing much greater film stability to be realized. In both cases, coarse particles escape from the film under centrifugal force, while finer particles which remain in the film follow the roll to be doctored off.

This second option features a shear and rapid acceleration of the dispersed fibers which would be expected to align them in the flow direction. In fact, this system has intriguing similarities with the early forming zone: a film of slurry between a solid moving surface and free air. Hence, a study of fiber orientation and flocculation in this system may elucidate some fundamental concepts which not only relate to HC separation, but may also find potential application to HC forming systems.

Operating in the twin-roll configuration, a 50/50 mixture of TMP and kraft pulps (440 CSF, 1.6-1.9% 6-cut rejects) was processed under various conditions. The total reject rate (percent of feed ejected from the rolls) ranged from 20 to 60%, depending on feed rate. Material doctored off was in the 300-425 CSF range but contained as little as 0.3% 6-cut rejects, representing a removed rate of up to 82% for these contaminants. Operating in the second configuration, the improved film stability afforded much better shive removal at lower reject rates. The very coarsest shives and chop were ejected immediately

after the film contacted the roll, in a relatively dewatered state. Depending on the nature of the contaminant, this mode of operation affords clean accepted pulps at reject rates potentially below 10%.

The size and speeds of the apparatus design were chosen on the assumption that separation would occur as a result of only two major forces: centrifugal and surface tension. Hence, a balance of force/unit mass on a particle of dimensions l , w , and t yields:

$$\frac{v^2}{2\gamma R} = \frac{\cos \theta}{\rho w t},$$

where v is particle velocity, R the roll radius, γ the surface tension, θ the contact angle, and ρ the particle density. If μ is the particle coarseness, then the right-hand term becomes $\cos \theta/\mu$. Substitution of appropriate numerical values predicts that a particle with a size near the 6-cut screen slot width would be ejected when it attained a speed of about 2500 cm/s. Given the coarseness of a typical "acceptable" softwood pulp fiber, however, one would predict an order-of-magnitude higher rejection velocity, or a centrifugal force per unit mass of 100 times that of the 6-cut shive. This is indeed consistent with the nature of the separation observed. In addition, the dependence on contact angle predicts an effective novel way for removing "stickies" from pulp.

Plans for future work include:

1. qualitative testing of the mechanistic separation theory by systematic variation of particle coarseness, length, contact angle, etc.;
2. quantitative testing of the theory by measurement of particle velocities in the film using double-exposure, high-speed photography;
3. determination of optimal conditions for practical separations of shives, dirt, and stickies (consistency, speed effects, etc.);

4. phenomenological study, by high-speed photography, of the nature of the separation mechanism and of the degree of flocculation and fiber orientation seen in well-dispersed slurry films under such shear and acceleration; and
5. fundamental studies of the nature of the dispersion required at HC to enable fibers to become oriented and move independently under the extreme acceleration and shear of such a system.

THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

Status Report

to the

ENGINEERING PROJECT ADVISORY COMMITTEE

Project 3384

REFINING OF CHEMICAL PULPS FOR IMPROVED PROPERTIES

February 25, 1985

PROJECT SUMMARY FORM

DATE: February 25, 1985

PROJECT NO. 3384 - Refining of Chemical Pulps for Improved Properties

PROJECT LEADER: John D. Sinkey

IPC GOAL: Develop ways to measure and control manufacturing processes.

OBJECTIVE:

To identify or develop ways of measuring and controlling refining intensity, so that the operation can be carried out at the appropriate level of severity without detrimental fiber shortening and fines generation, as a function of fiber type (hardwood vs. softwood, e.g.) pulp end-use requirements, and refiner design and operation. Increased understanding of the factors which influence the stresses encountered by an individual fiber, and the fiber response, would assist us in maintaining stresses below levels which lead to undesirable fiber damage. Such knowledge may impact refiner design and operation, as well as our ability to utilize cheaper but more sensitive pulps, such as hardwoods.

CURRENT FISCAL BUDGET: \$105,000

SUMMARY OF RESULTS SINCE LAST REPORT: (October, 1984 - February, 1985)

Theoretical consideration of the stress on a single fiber element led to a new expression for refining severity, which takes into account several of the factors not addressed in classical specific edge load theory. An experimental plan was previously outlined to test the predicted correlations between fiber length and distribution, and fiber response to refining severity. A key

variable relating refining parameters to fiber damage is seen to be the local normal pressure on a bar segment, P_N . Suitable measurement of this parameter may provide the means to maintain fiber stresses within the window of optimum fiber development.

Accordingly, plans were developed for measuring P_N in a Valley beater. A beater was first equipped with the capability of measuring coefficient of friction and specific energy. Base-line experiments with a bleached softwood sulfite pulp showed a response to beating severity similar to that reported for hardwoods: low-intensity refining affords significant property improvements, and significant net specific energy savings (unlike softwood kraft). This sulfite pulp will be used for the first phase of studies relating measured P_N to fiber damage.

The means for measuring local normal and tangential forces on a 1/8-inch square bar segment have been devised and put in place. The bar segment within the bedplate is attached to a flat beam beneath the bedplate knives. Eight strain gages are attached to the beam, and connected into two Wheatstone bridge circuits. The placement of the gages and their connection in the bridges allows a voltage output from one bridge to be calibrated against force on the bar segment in the normal direction; the other bridge output is calibrated against tangential force on the bar segment leading edge. The calibration procedure, performed on the instrumented bedplate assembly outside the beater, also yields cross-talk corrections between normal and tangential signals.

During operation, the normal and tangential signals are processed through amplifiers and fed to a Tracor-Northern data acquisition system. A triggering mechanism on the beater shaft initiates one data collection sweep per

revolution. The normal and tangential voltage outputs as functions of time can be viewed on an oscilloscope screen, and dumped to an Apple computer for manipulation. Good resolution is obtained at a data acquisition rate of 22 μ s per point, giving up to six impacts per sweep. Software has been written for the Apple to receive the data, convert voltage to force per the calibration information (including cross-talk corrections), and then convert normal force to P_N by dividing by the calculated time-dependent bar segment crossing area.

The typical normal force-time curve has the expected peak, which starts when the leading edges of the rotor bar and the instrumented bar segment meet, and ends when the leading edge of the rotor bar passes the trailing edge of the bar segment. An unanticipated but often prevalent feature, however, is a second normal force peak immediately following the first. This is apparently associated with forces exerted on the wood filling trailing the bar segment, since it is normally accompanied by a negative tangential deflection. Calculated values of P_N , obtained at standard beating conditions, tend to be in the range of 30-100 psi, but with large variability, and occasional impacts over 200 psi. By far the greatest variability is observed in early beating.

A number of instrumentation and other problems have been successfully addressed, including signal noise, thermally-induced drift, and techniques for proper strain gage attachment and bar potting. Plans for the near-term future include:

1. Determination of effects of bedplate load, consistency, and additives on specific energy, friction coefficient, and magnitude and variability of P_N . These effects will be correlated with fiber response.
2. Continue work with dyed fibers to test hypothesized effects of fiber length and distribution on cutting and fines generation,

Longer term future activities are seen to include similar studies with hardwood pulp, and instrumentation of a larger refiner for similar data acquisition.