

1991 International Paper Physics Conference: an exciting meeting in an exotic location

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The Paper Physics Committee of the TAPPI Research and Development Division has been responsible for organizing many conferences, workshops, and seminars since its inception in the fall of 1963. The International Paper Physics Conference recently held in Kailua Kona, HI, is the sixth such meeting in a series whose venue alternates every four years between the United States and Canada. This year's meeting included 137 delegates (plus a few walk-ins) from 14 countries. During the four-day meeting, a total of 65 papers were presented in nine sessions.

In spite of the location and an unfavorable economic climate, attendance was not adversely affected, although it is tempting to speculate that had the meeting been held on the mainland, attendance records might have been broken. Part of the rationale for the meeting being held in Hawaii was to encourage more international cooperation from Pacific Rim countries. Although this was largely accomplished, it did not appear to be at the expense of European and Scandinavian participation.

Rajinder Seth, Paprican, Conference Chairman, and Richard Mark, ESPRI, Program Chairman, worked tirelessly to ensure the success of this meeting, which had a number of innovations including scientific field trips and poster sessions. The efforts of TAPPI staff members, in particular Michelle Skrmetta, Donna Woodhall, and Ed Robie, are gratefully acknowledged.

At Wednesday evening's banquet, the Research and Development Division Award and Aiken Prize were presented to Douglas Wahren, vice president of Stora Technology in Falun, Sweden, in recognition of his outstanding contributions to the scientific and technological advancement of the pulp and paper industry. The presentation was made by Gary Baum who was also representing the TAPPI Board of Directors. The poetic leanings of our indefatigable Program Chairman Richard Mark, during his after dinner comments, were expressed in this limerick:

*A physicist (paper) named Xavier
Defended his cocksure behavior;
"From nice deformations,
And orientations,
I'll soon be the industry's savior."*

This brief report is no substitute for actual participation in the conference, where coffee break discussions and spontaneous contributions from the floor can sometimes be more enlightening and informative than the actual presentation of the paper. Space does not allow a review of all the papers. Readers are encouraged to seek further details from the two-volume *1991 International Paper Physics Conference Proceedings*, which can be ordered from TAPPI PRESS. Under the leadership of Richard Mark, the nine-member program committee selected a final program of 65 papers from about three times that number of abstracts submitted. In general, the quality of the papers and their presentation was very high, although there is always room for improvement.

Session 1: Statistics of fiber networks

The formidable task of determining how sheet formation is developed from the headbox to the reel was the essence of a presentation by Christopher T. Dodson, University of Toronto. Comparing the uniformity of random handsheets with a fourdrinier made sheet, Dodson estimates that a 50% increase in the variability of the machine-made paper could be ascribed as follows: dynamics (turbulence and drainage), 18%; statics (pulp and headbox), 18%; and fiber orientation, 14%.

Dodson's model seems to indicate that consolidation processes, e.g., refining and wet pressing, should lead to an improvement in mass density distribution—a result found by Waterhouse and presented in Session 2.

Bonding is central to strength and the development of a number of paper properties, and yet its measurement is not a straightforward task. Z-D tensile, Z-D elastic constant, and delamination energy were measures of bond strength examined by Robert A. Stratton, Institute of Paper Science and Technology. Fines, strength additives, and combinations of refining and wet pressing, were used to change bond strength. It was found that Z-toughness, and Z-direction tensile were sensitive indicators of bond-strength enhancement.

Other excellent papers in session dealt with fiber properties, and the impact of medium consistency processing on fiber and paper properties.

Session 2: Mechanical properties I

Simultaneous measurements of acoustic emission and light scattering were made when samples of paper were subjected to tensile loading. The increase in scattering coefficient is mainly attributed to the separation of surfaces in optical contact, but not necessarily bonded. According to T. Yamauchi and K. Murakami, Kyoto University, acoustic emission arises from fiber straining (i.e., release of microcompressions), and beyond the yield point rises very rapidly. As refining increased, so did the increase in scattering coefficient; on the other hand, the acoustic emission level dropped.

J. Astrom and K. Niskanen, Finnish Pulp and Paper Research Institute, undertook a supercomputer simulation of network fracture which, of necessity, focused on the area of low grammage and low-density networks. Failure in the network of elastic elements in which network density, bond, and segment strength could be varied was by segment or bond failure. Modulus was linearly dependent on density, and increased with fiber width. When bond breaking predominates, tensile strength is equal to the product of the modulus and shear strain. For segment breaking, the strength-to-modulus ratio increases with network densification.

Ultimate strength, fracture, and the energy involved in breaking fiber-to-fiber bonds were other important topics dealt within Session 2.

Session 3: Mechanical properties II

The Z-direction compressibility of paper is of considerable significance in a number of converting and end-use performance areas. Through a model which accounts for both the internal and surface structure of the paper, H. J. Schaffrath and L. Gottsching of the Institut für Papierfabrikation attempted to relate single compressibility to multiple-sheet compressibility.

The nondestructive measurement of out-of-plane elastic constants is particularly challenging; however, Pierre Brodeur and Maclin S. Hall, Institute of Paper Science and Technology, demonstrated the potential of the fluid-filled wheel approach. With this technique, both caliper and pulse delay time are measured ultrasonically.

An accurate noncontacting method for measuring the 3-D deformation behavior of a variety of structures including a fracture toughness specimen, and a paperboard container, was demonstrated by Stephen McNeil, who presented the paper authored by Y. J. Chao, M. A. Sutton, and P. F. Luo, University of South Carolina. The basic system involves the utilization of a digital-image correlation technique already used to accurately determine in-plane displacements and strains. Out-of-plane displacements and strains are measured using a stereo pair of CCD cameras.

The influence of moisture on the nonlinear constitutive behavior of paper, and creep, and the effects of drying

stress on surface properties were other important contributions in this session.

Session 4: Structure analysis

Small-scale grammage, fiber anisotropy, and fiber misalignment distributions from a single-optical measurement employing a far infrared or submillimeter laser (wavelength 70 μm) was the main theme of the paper presented by P. Bernard and A. Charlebois, National Optics Institute. Spectral density distributions and correlations between each of these measurements were examined.

Some elegant studies exploring the possibilities of the confocal microscope for fiber characterization were presented by Rajinder S. Seth in a paper coauthored with H. F. Jang and A. Gordon Robertson. When used in conjunction with image analysis, it is clearly a powerful tool for measuring the coarseness and cell wall thickness distribution of a pulp. [See also *Tappi Journal* 74(10): 217(1991).]

The work presented by Hiroki Nanko, S. Asano, and J. Ohsawa, Japan Pulp and Paper Research Institute is the first study of cell wall shrinkage behavior during drying since the pioneering work of Page and Tydeman published in 1963. The study involved the use of the laser scanning microscope to measure changes in cell wall dimensions during drying. The results were quite controversial, since the main findings were that significant changes in cell wall dimensions did not occur until a consistency of 85–88% had been reached, i.e., well beyond the fiber collapse point!

Comparing the deformation behavior of isolated single fibers with those removed from a sheet of paper, i.e., meso-elements was the formidable task undertaken by Fuushern Wu and Richard E. Mark. These comparisons included the effects of recycling and orientation of the fiber within the sheet. The latter effects, however, were overshadowed by the differences between the single-fiber properties and those of the meso-element. On average, the modulus and strength of the meso-elements was less than one third that of the single fibers, while the stretch of the meso-elements was just over one and one half times as great.

Papers on fiber curvature measurements in a network, and the effects of recycling on the surface properties of paper, were also presented in this session.

Session 5: Performance criteria

A wide variety of topics were evident in this session, including refining, fillers, friction, moisture effects, and strain measurements on corrugated containers.

Results of efforts to improve our knowledge of the failure behavior of corrugated containers were presented by J. Claude Pommier, Joel Poustis, E. Fourcade, and P. Morlier, Bordeaux I University, who used a finite element method (SYSTUS code). The early findings of this investi-

gation are promising, and good agreement, at least for a square container, was obtained between prediction and measurement of failure load.

Measurement of the compressive load-deformation curve to failure of corrugated board test specimens designed to avoid end failure, was presented by B. Westerlind and L. A. Carlson, SCA Research AB and Florida Atlantic University, respectively. It was shown that these load-deformation curves were closely approximated by a superposition of the long span load-deformation curves of its components. When local buckling occurs, this increases deformation and slightly reduces compressive strength. Prediction of ultimate strength from short-span compressive strength measurements is reconciled through the use of a simple scaling law based on Weibull statistics.

Session 6: Physical properties I

Pigment projected area appears to be a unifying variable when considering the effectiveness of TiO_2 in the presence of retention aids, according to S. I'Anson and A. Eghterafi, UMIST. It was demonstrated

that, even when the TiO_2 is uniformly distributed, classical predictions of scattering coefficient and opacity differ quite considerably from measured values. By contrast, calculations based on the Z-distribution of projected area are in better agreement.

Isko Kajanto, Finnish Pulp and Paper Research Institute, found a good correlation between print unevenness and formation for uncoated papers made on an experimental paper machine, and a much weaker correlation for production-made papers. The latter requires that formation-induced effects on other properties, e.g., surface topography and porosity, have to be reduced. Kajanto also found that soft-nip calendering is more forgiving of poorer formation than hard-nip calendering.

The University of Oulu's M. Leskela's stated objective was to develop a model to relate the reflectance of a sheet to the optical properties of all particles making up the sheet and how they are packed, since the well known Kubelka-Munk model is unable to do so. Furthermore, since paper is optically a closed-packed material, more rigorous theories involving multiple scattering and radiative transfer theories are generally not applicable. In Leskela's contribution, however, a simplified model of radiative transfer theory and simple single scattering were used together with a Monte Carlo simulation program to predict optical properties. Using image analysis techniques to measure the number of voids, Leskela found good agreement with measured values.

Small scale variations in properties other than grammage are now being measured. O. Schultz-Eklund, Christer N. Fellers, and P. A. Johansson, STFI, combined small-scale grammage and caliper variations to demonstrate their interaction with calendering and watermark quality. With regard to the latter, it is clearly a grammage

variation and not a density variation which is responsible for the clarity of the watermark image.

The session also included a contribution on plasma etching presented by Tetsu Uesaka.

Session 7: Physical properties II

Moisture-induced effects was the dominant theme of this session, although there were interesting contributions in the areas of paper conductivity, ink transfer, and resin absorption.

A new hygroexpansimeter used to measure dimensional changes under cyclic humidity conditions as a function of moisture content rather than relative humidity was presented by T. Uesaka, C. Moss, and Y. Nanri, Paprican. Uesaka proposed that the hygroexpansion of paper is characterized by two effects: the inherent hygroexpansive effect and the viscoelastic deformation due to drying stresses.

Elegant creep experiments on corrugated board were performed by Christer Soremark and Fellers, ASSI Kraftliner and STFI, respectively. In order to separate the contributions from tension and compression, steel bands were used to replace the top and bottom liners of a corrugated beam. In the paper presented by Soremark, compression stresses were found to increase hygroexpansion, whereas tension stresses were found to decrease hygroexpansion. This dominant effect is called stress-induced hygroexpansion, and a model was proposed to explain these effects.

Z. V. Padanyi, Amcor Ltd., proposed in his presentation that accelerated compressive creep, a mechano-sorptive effect, is equivalent to physical aging. Physical aging of an amorphous polymer is associated with a reduction in free volume and molecular mobility as it approaches equilibrium below its glass transition temperature. Dynamic mechanical thermal analysis and creep measurements were used to demonstrate the effects of aging. De-aging by subjecting kraft linerboard samples to 100% RH for 2 h had a significant impact on creep behavior even three days after the treatment, in spite of the fact that moisture equilibration only took 30 min to reach 99% of its final value.

Session 8: Physics of defiberization

This session included papers on deformation measurements in small wood specimens, sulfur distribution in sulfonated southern pine latewood fibers, performance of mechanical pulps, and properties of chemical and mechanical pulp blends.

The paper by J. R. Wood and Alkis Karnis, Paprican, concerning the characterization of mechanical pulp fines from turbidity measurements was given on behalf of the authors by Derek H. Page (Paprican). The method, which depends on large particle light scattering, appears to be quite promising, particularly for measuring the effects of

recycling. An 80–90% loss in surface area was found with drying.

An increase in apparent density with an increase in fiber orientation was theoretically predicted and then measured for four mechanical pulps by Reza Amiri, Wood, and Karnis, Paprican, and G. Gorres, University of Rhode Island. Predicted sheet densities were, however, considerably lower than those measured, and the role of fines requires further clarification. The paper was presented by Uesaka.

Session 9: Poster sessions

The poster sessions received mixed comments, ranging from “the program is busy enough,” “there was not enough room” and, on a more positive note, “some of the better papers were in the poster session.” The posters were of high quality, and the sessions were well attended. More

unusual topics for a paper physics conference included Paper Anisotropy and Web Tension Profiles, Strengths of Interactions Between Papermaking Polymers and Particles, Wet End Control and Paper Microstructure, and Improving Coated Papers Surface Properties by Optimization of the Bent Blade Process. All of the poster session papers are contained in the two-volume *Proceedings*.

Hawaii attracted both new and well-known scientists involved in paper physics research; however, it was a great pleasure to have Johannes A. Van den Akker and his wife drop in on their way back from their vacation trip to Alaska. Van den Akker is a charter member of the Paper Physics Committee, and on the final scientific field trip joined with a number of us to the summit of Mauna Kea and tour of the observatories there. An excellent conclusion to a most enjoyable and professionally rewarding conference. □