Laser-Ultrasonic Web Stiffness Sensor

Benefits

- Ability to monitor papermaking processes on the dry end of the paper machine
- Optimal use of pulp feedstock
- Reduced refining and remanufacturing
- Reduced energy use and cost
- Improved quality and consistency
- Simplified development of full-sheet systems
- Increased use of recycled fiber
- Minimized waste, including “hidden waste” of lost fiber quality during drying and rewetting

Applications

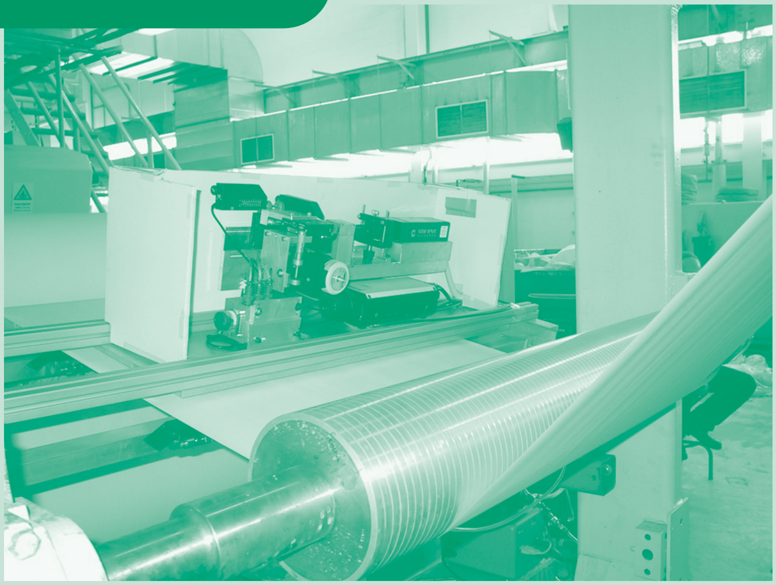
A non-contact method for measuring paper stiffness, which determines the ability of the material to hold its shape, would provide benefits in the production of paper grades ranging from copy paper to folding carton, cup and plate stock, and milk carton stock.

A Noncontact Sensor for Monitoring the Mechanical Behavior of Paper During Production Would Improve Manufacturing Processes

Every year, paper manufacturers repulp and remanufacture as much as 5 percent of the paper they produce to account for substandard mechanical properties and strength. Current methods to measure the mechanical properties of paper, which is one of the most important parameters for process and quality control during production, use off-line samples cut from the reel after the paper has already been manufactured. The measurements are done manually, are very slow, and don’t allow any feedback for the control during manufacture. Also, the measured properties relate to paper stiffness only remotely and can be quite unreliable.

An innovative, non-contact technique that employs laser ultrasonics would allow monitoring of paper-stiffness properties on a moving web without damage to the web (Figure 1). Using a semi-empirical model to interpret data, manufacturers could translate paper stiffness properties to manufacturing techniques. They could refocus the manufacturing process onto stiffness targets rather than basis weight targets and adjust machines accordingly during production. Real-time control of paper machines would enable more efficient use of materials, including a higher percentage of recycled fiber, which could result in less repulping and remanufacturing. Manufacturers could optimize their use of raw materials by using less fibers, conserving energy, and producing higher quality, more uniform paper products.

Figure 1.



Partial view of the system for noncontact laser ultrasonic generation and detection on a moving paper web.

Project Description

Goal: Demonstrate a robust industrial laser ultrasonic sensor for on-line measurement of paper mechanical properties, leading ultimately to commercialization.

The project is a combined effort of organizations with complementary expertise in paper physics and laser ultrasonics. Tasks include optimizing ultrasound generation on moving paper, developing interferometric detection schemes for on-line operation, and constructing a prototype for single-point application on a paper machine. Researchers will develop a sensor that uses laser ultrasonics to excite and detect Lamb waves propagating in the paper plane. Once a sensor measures wave velocity, the velocity will be used to determine real-time paper stiffness, which is the most important factor determining paper end-product properties. Sensors installed on commercial papermaking machines will provide manufacturers with real-time paper stiffness information. Manufacturers can use this information to determine short- and long-term trends and adjust their paper-making processes to ensure the utmost efficiency and quality.

Progress & Milestones

- This project is the continuation of a project titled Contactless Real-Time Monitoring of Paper Mechanical Behavior During Papermaking, which began in September 1997. In the first year of that project, researchers focused on laboratory evaluations of five different laser ultrasonic methods suitable for testing rough moving surfaces.
- In the second year of the project, researchers developed a prototype sensor for simultaneous on-machine detection of paper stiffness and fiber orientation distributions.
- In August 2001, researchers successfully demonstrated a prototype sensor on a Mead-Westvaco pilot coater that generated clear Ao signals at all machine speeds (including the 5,000-feet-per-minute maximum) for five out of six paper grades of basis weights ranging from 38-280 grams per square meter.
- Future research includes: optimizing conditions for generating larger signals without damage; extending LUS techniques to the detection of So waves for measuring in-plane shear and normal stiffness; preparing and hardening the LUS assembly; and conducting a mill trial on a production machine.

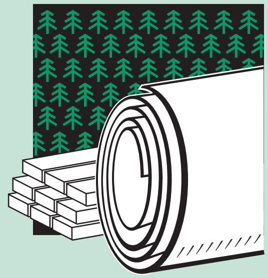
Awards, Patents, and Invention Records

U.S. patent number 6,115,127: "Non-contact measurements of ultrasonic waves on paper webs using a photorefractive interferometer."

U.S. patent number 6,356,846: "System and method of reducing motion-induced noise in the optical detection of an ultrasound signal in a moving body of material."

Commercialization

Commercialization of a laser ultrasonic device would begin following the completion of this project. ABB Industrial Systems, Inc., which currently markets CD instrument scanners worldwide, would include the device in some of their scanners as part of a device package. The commercialization of the device would require approximately two years following project completion.



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