**BENEFITS**

- Produces pulps with high brightness and strength
- Increases pulp yields
- Enhances bleaching uniformity
- Decreases use of energy and chemicals
- Reduces costs for delignification
- Lowers capital costs

**APPLICATIONS**

There are 30 U.S. pulp bleaching plants that use oxygen or ozone for delignification and 100 plants that use oxygen for alkaline extraction. The retrofit technology will be introduced commercially about 2003. It is estimated that 60 percent of plants using oxygen or ozone for delignification would use the retrofit and 50 percent of the plants using oxygen in alkaline extraction would adopt it. It would take 10 years for total market saturation.

**Retrofits to Existing Systems Will Improve Low- and Medium-Consistency Bleaching Operations**

If gaseous chemicals such as oxygen and ozone are used to delignify and bleach pulp, they must be transferred efficiently to the liquid phase, where they normally have a low solubility. By dispersing oxygen or ozone in the pulp as small gas bubbles, the bubbles provide enough surface area to achieve efficient mass transfer of gas to liquid. This ensures that all of the pulp is exposed uniformly to oxygen and that good bleaching activity can take place. The same method can be used to transfer gas to liquid in ozone delignification and in the oxygen-reinforced, alkali-extraction steps of the pulping process.

While it is essential to control the size and flow of gas bubbles in pulp-bleaching operations, it is difficult to measure gas-flow characteristics in an opaque fibrous system. Researchers will use advanced radiation techniques to visualize the size and flow characteristics of the bubbles in low-and medium-consistency systems, correlating the information with the amount of bleaching achieved. Based on this data, new technology will be developed that can be added as a retrofit to existing bleaching systems to achieve the proper conditions for optimal oxygen and ozone bleaching.

Enhanced bleaching efficiency will allow the elimination of one bleaching stage in a five-stage mill and significantly reduce the use of energy and chlorine dioxide in these operations.

![Figure 1. Flash X-ray radiography (FXR) will be used in this project to visualize gas flows in fiber suspensions typical of bleaching operations. This figure shows previous FXR images where the gas flow rate was fixed while the fiber consistency was increased. The dark regions represent the air bubbles. As shown, fiber consistency has a large effect on the gas flow characteristics. The goal in the current project is to be able to quantify this in bleaching operations.](image-url)
PROJECT DESCRIPTION

Goal: To identify the conditions for treating kraft pulp with gaseous chemicals that result in selective, uniform bleaching, increased delignification, and reduced costs for energy, chemicals, and capital goods.

This three-year effort will be carried out in the laboratories of the Institute of Paper Science and Technology. The research objectives are to 1) measure gas bubble size distributions and flow characteristics in fiber suspensions typically used in bleaching with gaseous chemicals, using the advanced technologies of flash X-ray radiography and gamma-ray densitometry; 2) correlate these results with the amount of delignification and cellulose degradation observed; 3) identify detrimental flow regimes such as channeling and slug flow conditions in the suspensions; and 4) develop methods to control bubble size and bubble flow conditions through retrofits that will maximize bleaching performance.

PROGRESS & MILESTONES
The following milestones have been identified for reaching the objectives of this research:

- Experimental equipment is fabricated and used to determine the effects of air flow rate, stock flow rate, and consistency on the air bubble size distribution and flow conditions.
- The effects of replacing air with oxygen are determined, and gas consumption and delignification are monitored as a function of reaction conditions.
- Retrofits are developed to enhance flow conditions for optimal oxygen bleaching.
- The effects of replacing oxygen with ozone are determined, and gas consumption and delignification are monitored as a function of reaction conditions.
- Retrofits are developed to enhance flow conditions for optimal ozone bleaching.
- Researchers have designed, constructed, and are in the process of completing instrumentation on a low-consistency (up to 3%) bubble column that can operate in vertical and horizontal configurations.
- Work on the medium consistency (10% or more) test cell for all the oxygen and ozone bleaching tests has been initiated.