PAPER KAYAKS TEST ENGINEERING THEORIES

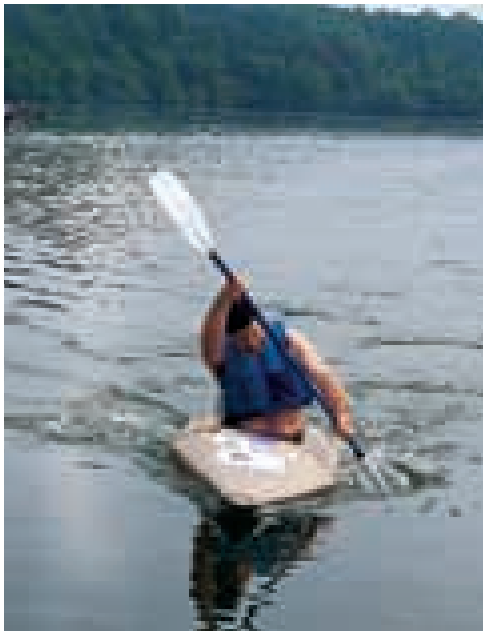
DONALD G. MEADOWS

CONTEST ENCOURAGES ENERGY-EFFICIENT USE OF PAPER MATERIALS

SOMETIMES A GREAT IDEA DOESN'T HOLD WATER. Or, for those students who endeavored to build paper kayaks as part of the 1999 Energy Challenge, the great idea may not float—at least not for very long.

In several cases, however, the designs worked exceptionally well.

On a pleasant Saturday morning in May, students representing seven universities met at Sweetwater Creek on the outskirts of Atlanta, GA, the final round of competiton for a US$ 15,000 grand prize.



This year's participants included teams from Georgia Institute of Technology, Miami University of Ohio, Mississippi State University, University of Maine, University of Colorado at Denver, University of Minnesota at St. Paul, and State University of New York College of Environmental Science and Forestry (ESF) at Syracuse.

This was the latest competition sponsored by the U.S. Department of Energy and the Institute of Pulp and Paper Science. For the DOE, Valri Robinson served as vision team leader/forest products. Emmie Cochran served as design competition coordinator from IPST.

The basic assignment was to build a one-person kayak using wood-based fibers and commonly used paper chemicals. Duct tape and thermoset resins could also be used as joining materials. The kayak had to weigh less than 35 lb and measure no more than 9 ft long by 30 in. wide and 20 in. high.

More specifically, the paper kayak project emphasized "a fundamental understanding of fiber-to-fiber bonding, liquid penetration resistance, wet strength, the structural mechanics of paper products, the minimization of waste in product design, the liquid penetration resistance of paper and the environmental impact of paper design considerations."

Judging focused in part on:

- the dry weight of the kayak
- the weight percentage of secondary materials in the kayak
- the economics and cost effectiveness of the design
- puncture test (TAPPI T-803)
- tensile test (TAPPI T-494)
- performance of the kayak during a race in the water.

Based on scores for the various criteria, the race wouldn't necessarily go to the fastest kayak—though in this instance it did. In timed races on Sweetwater Creek, the University of Maine's Jaime Morin paddled the 300 m course in 3.06 minutes, a good half minute faster than the next best time.

Before setting out on the water, each team was given 5 min to describe it's kayak design concept.

For Georgia Tech, the idea was to keep it simple: two layers of single wall corrugated on the inside sandwiched with beverage containers and held together with duct tape. The hope was that the design would be water resistant enough to complete one or even two courses of the race. It did—barely.

The team from the University of Maine included a mechanical engineering student who helped with the structural design. The team used paperboard for the internal frame and a covering of paper from recycled cardboard (100% softwood kraft). An AKD size, wet-strength resin and a starch with some covalent wet-strength bonding were used following a variety of studies.

The ESF team also tested various additives and recy-

The team from the University of Maine took first place in the Energy Challenge '99 competition for a prize of US$ 15,000.

Models of the internal structure (above) demonstrated the design work that went into building the full-scale kayak (below).

cled cardboard to make their own paper. Various aspects of the compartmentalized design were tested using models. The intent was to develop water-tight materials that would allow the kayak to be used many times. (Even after soaking in water for six weeks, the paper developed by the team retained about 80% tensile strength.)

The team from Mississippi State used corrugated board that they creased, glued, and taped together to form an open boat. The design floated high in the water, but proved to be highly unstable until water was added as ballast.

The team from the University of Minnesota consulted a number of sources for design ideas. They used a CAD program to develop the hull design, focusing on the internal structure. Materials used included linerboard, corrugated and honey-comb board, plus a commercially made moisture barrier paper. In trying to find the right balance between stability vs. speed, the team opted for a cigar shape they thought would be especially fast. (Unfortunately, it kept rolling over and they were unable to complete the race.)

The team from Miami University, which placed third in the competition for a US$ 2000 prize, researched proven kayak designs they could adapt. They used a CAD program to refine the design. They also built it to last using internal bulkheads and I-beams for structural rigidity. The bottom section was built using three layers of triple-wall corrugating medium, with the flute going in opposite directions, and a penetraing epoxy applied between layers.

The team from the University of Colorado took the approach that they were shipwrecked and had to build a kayak from available materials, "sort of a grass roots approach." They used newspaper for the keel, laminated with starch and formed in a plywood mold. Corrugated board was used for the internal bulkheads and cockpit. They used hot-melt glue to bind the materials and parafin wax for water-proofing.

The students from Colorado are all majoring in mechanical engineering and had to learn about paper science as they were working on the project. The kayak they brough to Atlanta was the fifth evolution of their original design and proved good enough to earn them second place (just 1.9 points behind the University of Maine) and a US$ 3000 prize. **TJ**

Meadows is editor of TAPPI JOURNAL; email: dmeadows@tappi.org

A DAY AT THE RACES