Fibre loading has many advantages for conventional precipitated calcium carbonate direct loading, such as improved environmental aspects of papermaking, energy savings, and economic competitiveness.

Precipitating calcium carbonate within the stock preparation process

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Fibre loading is an environmentally friendly, energy-efficient, and economical method of manufacturing precipitated calcium carbonate (PCC) partially within pulp fibres and as part of the pulp processing system. A method to incorporate fillers within pulp fibres has been the subject of extensive research. The basic idea for this research is to incorporate low-cost filler to extend high-cost fibre. The first studies of these phenomena were reported as lumen loading. These experiments focused on the use of titanium dioxide as filler. An excess of titanium dioxide was mechanically mixed with a pulp slurry, depositing titanium dioxide within the fibre lumen. However, limitations of this method are that a large excess of titanium dioxide is required for lumen loading and a process to recycle this excess titanium dioxide is needed.

More recent studies on cell wall loading focused on saturating pulp fibres with, for example, sodium carbonate, and reacting the resulting pulp mixture with a salt-containing calcium, such as calcium chloride. The resulting pulp mixture could contain high levels of calcium carbonate. However, additional processing was required to remove counter salts remaining in the mixture.

The fibre loading process developed in USDA's laboratory is a two-step process. First, calcium hydroxide is mixed into pulp fibres. Then the pulp mixture is reacted using a high-consistency pressurised refiner under carbon dioxide pressure to precipitate calcium carbonate. This process uses conventional process equipment and has no by-products.

Figure 1. Control de-inked pulp.
Figure 2. De-inked pulp with directly added commercial scalenohedral PCC.

There are three general areas of potential benefit to fibre loading:

- Improvements in mill operation costs including energy needs
- Improvements in product quality
- Reduction in raw material and capital costs for manufacturing PCC

Recycling recovered paper

Recycling mills produce up to two to four times as much sludge as virgin fibre mills, in excess of 200 kg/tonne of paper produced. Recycling mills in the USA alone generate an estimated 4.1 million tonnes (dry basis) of sludge annually. At the USDA Forest Products Library, retention of PCC was measured for fibre loading and conventional loading. Pulp obtained by both processes was recycled several times using a recirculating handsheet mould to evaluate the relative impact on process water, and ultimately, sludge production. Process water from fibre loading indicates that fibre loading can reduce PCC loss by up to 50 per cent less than conventional processing. Reduction in sludge can be proportionately reduced for paper manufacturing using recovered papers.

Because of the elevated pH and consistency used in the fibre loading process, the benefits of increased swelling and high-consistency refining were noted. Strength properties were restored using fibre loading. This is in addition to the benefit of being able to use more low-cost PCC to replace higher cost fibre when a portion of PCC is deposited within the fibres.

In the same recycling study, solids content was measured on pressed handsheets as an indicator of the solids of the paper entering the drying section of the paper machine. Handsheets compared at approximately the same ash content (about 7 per cent) showed an advantage for fibre loading. The never-dried control gave solids of 34.5 per cent after pressing. After recycling, the control handsheet gave solids of 38.6 per cent. After two recycles, the fibre-loaded handsheets gave 41.8 per cent solids compared with 36.4 per cent for the direct-loaded handsheets after two recycles.

Energy savings were estimated for fibre loading compared with direct loading (including hot dispersion). Four operations for energy savings were calculated - electrical savings from reduced sludge dewatering needs, natural gas savings from reduced sludge dewatering needs, natural gas savings from eliminating steam from dispersion, and natural gas savings from reduced paper drying requirements.

Energy requirements from a conventionally recycled unit in kJ/year/unit (unit equals 500 tonnes of de-inked pulp per day, dry basis) are 2.34 x 10^{11} sludge dewatering, 1.1 x 10^{11} steam for dispersing, and 12.2 x 10^{11} steam for drying. For a similar unit of fibre-loaded pulp, the energy requirements are 1.76 x 10^{11} sludge dewatering and 11.51 x 10^{11} steam for drying. Net saving for fibre loading compared with direct loading are estimated to be 2.38 x 10^{11} kJ/year/unit.

Reduced capital costs, reduced loss of papermaking materials, and, to a somewhat lesser degree, reduced energy costs for fibre loading make it a process that improves the efficiency of recycling de-inked pulp for printing and writing grades. USDA estimates the cost of installed equipment is $3,000,000 if producing 500 tonnes (dry basis) de-inked pulp per day. Compared with an estimated $9,000,000 for current satellite capital costs, fibre loading saves an estimated $6,000,000 per unit.

As a result of loss of papermaking materials, costs are reduced from $1,080,000 to $270,000 per year, for a net saving of $810,000 per year. Somewhat lower savings are estimated for energy reductions. Assuming a seven-year depreciation, these estimates give an annual cost of $5,122,000 for the dispersion process compared with $2,994,000 for fibre loading. The net annual costs are $3,128,000. The payback time for the investment is estimated at 1.9 years.

References are available from the author.

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John H. Klungness is a research chemical engineer in the Fibre Processes and Products Research Group of the USDA Forest Service, Forest Products Laboratory, in Madison, Wisconsin. He has published and presented more than 75 technical papers at conferences, mainly on overcoming technical problems associated with recycling pulps from recovered papers.
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