

---

**Lightweight, High-Opacity Bible Paper by Fiber Loading™**

- (1) Klaus Doelle, Manager R&D Engineering
- (2) Oliver Heise, Director Technology Center

**Voith Sulzer Paper Technology**  
**North America inc.**  
**Stock Preparation**  
**2620 E. Glendale Ave.**  
**Appleton, WI 54912-2337**

**Co-authors:**

- (1) John H. Klungness, Research Chemical Engineer
- (2) Said M. AbuBakr, Supervisory Chemical Engineer

**USDA Forest Service**  
**Forest Products Laboratory**  
**One Gifford Pinchot Drive**  
**Madison, WI 53705-2396**

**Prepared for presentation at:**

**Specialty & Technical Papers Europe 2000**  
**21-23 June 2000**  
**Grand Hyatt Berling Hotel**  
**Berlin, Germany**

---

## **Abstract**

This paper has been prepared in order to discuss Fiber Loading™ for lightweight, high-opacity bible paper. Incorporating fillers within pulp fibers has been subject to research since 1960 (Green et al. 1962, Scallan et al. 1985, Allen et al. 1992). Fiber Loading™ is a method for manufacturing precipitated calcium carbonate (PCC) directly within the pulp processing system. The Fiber Loading™ process results in fiber loaded precipitated calcium carbonate (FLPCC™) being partly deposited both within the fiber on the fiber walls and in between the fibers, targeting replacement of cellulose fibers, due to the fact that fillers are normally cheaper than the cellulose fibers. The Fiber Loading™ process results in potential raw material and energy savings for the papermaker. In addition, there are potential increases in both the physical and optical paper properties, as well as increasing the environmental savings by reducing free solids in the paparmaking process water stream.

A major drawback of using commercial, PCC filler in making paper is that a high proportion of filler-to-fiber in the sheet impairs the strength of paper. Therefore, papermakers utilize relatively low maximum filler-to-fiber ratio to maintain sheet properties.

Fiber Loading™ bonds some of the FLPCC™ directly to the fiber and other is contained within the fiber. This allows the maximum filler-to-fiber ratio to be increased without sacrificing sheet properties. Fiber Loading™ is particularly suited

for Bible paper applications where high physical and optical paper properties are needed by applying high filler levels at the same time.

### **Light Weight High-Opacity Bible Paper by Fiber Loading™**

This paper has been prepared in order to discuss Lightweight, High-Opacity Bible Paper by Fiber Loading™ from the standpoint of filler morphology, reduction in basis weight grammage, and increase in filler level, as well as reduction in drying and the associated engineering costs.

Presently, US paper industry uses 3.9 million tons of kaolin day, the largest category of filler consumed. The next largest filler type used is precipitated calcium carbonate (PCC), which is used as paper filler at about half the rate of kaolin in the US paper industry. The demand of PCC use is expected to grow as in the past decades due to increased filler levels in paper produced in the US. Therefore, neutral or alkaline papermaking is becoming more and more attractive to papermakers in the US from a process standpoint, allowing the use of calcium carbonate as paper filler as well as a paper coating pigment. Therefore, in the last 30 years, neutral and alkaline papermaking utilizing calcium carbonate as filler has changed the face of papermaking.

In Europe, the technological paper machine runability challenge of switching from acid to a neutral/alkaline paper-making process has been solved since the 1980s. Globally, this conversion has been successfully repeated hundreds of

times. Unfortunately, compared to the European papermakers, the North America papermaking pH conversion started with a 10-year delay.

The phenomenal, increased global usage rate of calcium carbonate, especially in North America (20-40% annually), is driven by the printing industry's need for higher brightness and improved printability. The availability of multicolor offset printing machines made it possible to economically print even smaller paper tonnage with a high quality print image. In turn, the paper industry's answer to these printing needs is to increase filler content in the paper and utilize calcium carbonate as a coating pigment. The two highest user applications of calcium carbonate in the US are coated (wood-free 135 g/m<sup>2</sup>) and copy and office papers (75-80 g/m<sup>2</sup>).

Bible paper has its niche in the production of uncoated fine paper. Different grades for lightweight printing and low weight offset papers can be either surface-sized or pigmented. The basis weight can range between 25-40 g/m<sup>2</sup> and the filler content can be from 10 to 25%.

For office and copy papers, the potential of increasing filler levels further with a new generation of fiber loaded, precipitated calcium carbonate (FLPCC™), was demonstrated successfully a lab scale setting, allowing replacement of expensive fibers with a more economical FLPCC™.

Besides the potential high use of FLPCC™ filler in office and printing paper, using the FLPCC™ is also envisioned in other markets such as specialty lightweight printing papers like Bible paper grades.

---

Fillers are normally incorporated in the paper web during formation on the papermaking wire. This is achieved by having the filler present in suspension in the papermaking pulp. This pulp is drained on the wire while suspended filler particles are retained in the formed fibrous web. A common problem with such a system is that a relatively high portion of the filler particles is entrained in the water draining through the wire, rather than being retained in the fibrous web, and is, therefore, potentially lost. This problem is particularly serious with relatively lightweight papers, as well as copy and printing papers.

As the cost of pulp, fillers and energy has increased, much effort has been devoted to the development of techniques which facilitate higher loading levels without unacceptable deterioration on paper properties. Strength properties, stiffness, and/or increased retention during the forming process on the paper machine are of particular interest.

The most efficient present practice for manufacturing PCC as a papermaking filler is to produce it in a satellite plant adjacent to a paper mill. Using tower reactors in a batch process scheme at a satellite plant traditionally carries out the production of precipitated calcium carbonate in various forms and shapes like scalenohedral and rombohedral shape, to name the most common ones, with mean particle diameters between 0.97  $\mu\text{m}$  and 1.26  $\mu\text{m}$ . This process includes two steps. First, calcium oxides is added to water to produce calcium hydroxide. This mixture is then pumped into a second tank. The second step is to bubble carbon dioxide through the mixture to precipitate calcium carbonate.

Satellite plants for producing PCC exist near large-scale paper mills, which produce virgin printing and writing papers grades. Only paper mills producing 700 tons per day have sufficient demand to justify the capital investment of over \$20 million for a satellite plant.

Besides the satellite plant operation, wet and dry ground, precipitated calcium carbonate (GCC), with an mean particle diameter of 0.47  $\mu\text{m}$  for wet ground and 1.64  $\mu\text{m}$  for dry ground, are used to achieve the same effect as with PCC. A common problem with both filler types is that a high portion of the filler particles is not retained in the fibrous web, creating wire wear and lower retention.

The Fiber Loading™ process (US Patent 5,223,090 and RE 35,460) adopts the PCC manufacturing technology used in a satellite plant to the pulp processing operation in a paper mill. Calcium hydroxide is added to the moist pulp and then reacted with carbon dioxide in a pressurized reactor to form PCC. The so-called Fiber Loaded™ Precipitated Calcium Carbonate (FLPCC™), which is partly deposited within the fiber on the fiber walls and in between the fibers, has a mean particle diameter of 1.42  $\mu\text{m}$ .

In comparison to the existing satellite plant technology, Fiber Loading™ can be more efficient than the conventional method due to its high consistency online reactor operation, which eliminates the need for a satellite plant to manufacture PCC slurry.

Laboratory research by Forest Products Laboratory (FPL) and Voith Sulzer has proven this technology suitable for commercialization (Klungness et al. 1998,

Heise et al. 1996), due to the fact that mechanical and optical properties of paper are improved and or maintained at same or lower basis weight, meaning reduction in grammage by increasing filler level.

Due to reduced drying on the paper machine, estimated savings are based on the assumption that FLPCCTM substitution for fibers will result in higher solids entering the dryer section of a paper machine. Savings range from \$20,000.00 to \$66,000.00 per year with or without basis weight reduction of 2 g/m<sup>2</sup> to 6 g/m<sup>2</sup> and incorporating filler content from 4% to 8% at the same time.

The return of investment (ROI) estimation was based on a hypothetical bible paper mill producing 150 metric tons per year with a basis weight of 35 g/m<sup>2</sup> and a filler content of 16% commercial PCC. The economical analysis covers savings for reduced drying as well as savings due to reduced fiber needs. Substitution of low cost FLPCCTM for higher cost fiber was evaluated by comparing cost savings aspects with the cost of purchasing, installing and operating Fiber Loading™ equipment. As an example, this leads to an ROI of 35% for a typical 150 t/d Fiber Loading™ installation having 6% filler increase by reducing the basis weight at 4g/m<sup>2</sup>.

Further results show that total return on capital investment ranges from 20% up to 70%, based on incorporated filler level and basis weight reduction. These ROI's are significantly higher than the typical reported ROI's of 10 to 15% for papermaking capital investments.

## **Conclusion**

In comparison to the existing satellite plant technology, Fiber Loading™ can be more efficient than the conventional method due to its high consistency on-line reactor operation, which could eliminate the need for a satellite plant to manufacture PCC slurry. The Fiber Loading™ process results in potential raw material savings for the papermaker. In addition, there are potential increases in both the physical and optical paper properties, as well as increasing the environmental savings by reducing free solids in the papermaking process water stream.

Fiber Loading™ is particularly suited for applications on printing and writing papers where high physical and chemical paper properties are needed by applying high filler levels at the same time, but can also be applied to other types of paper as well.

## Literature

**Allen, G.G., and Ritzenthaler, P. (1992):** The microporosity of pulp, *Tappi J.*, 75(3), 239.

**Green, H.V., Fox, T.J., and Scallan, A.M. (1982):** Lumen-loaded pulp, *Pulp and Paper Canada*, 83(7): T203.

**Heise, O. Fineran, W., Klungness, J., Tan, F., Sykes, M., AbuBakr, S., and Eisenwasser, J. (1996):** Industrial scale-up of fiber loading on deinked wastepaper, In 1996 Tappi Pulping Conference Proceedings, Oct. 27-31, Nashville, TN, Atlanta, GA, TAPPI Press. pp. 895-900.

**Klungness, J., Caulfield, D., Sachs, I., Sykes, M., Tan, F., and Shilts, R. (1993):** U.S. Patent 5,223,090, (1997) RE 35,460.

**Scallan, A.M., and Middleton, S.R. (1985):** In "Papermaking Raw Materials," Vol. 2, Edited V. Punton, Transactions of the symposium held at Oxford, Sept., Mechanical Engineering Publications, London pp. 613-630.

**Sykes, M.S., Klungness, J.H., Tan, F., and AbuBakr, S.M.. (1998):** Value added mechanical pulps for lightweight, high-opacity paper, In: 1998 Tappi Pulping Conference proceedings, Oct. 25-29, Montreal, Canada, Atlanta, GA TAPPI Press, pp. 539-544.

# Lightweight, High-Opacity Bible Paper by Fiber Loading™

Presented by: *Mr. Klaus Decker, Manager of  
Voith Sulzer Paper Technology  
Appleton, WI USA*

VOITH SULZER  
PAPER TECHNOLOGY

## CO-AUTHORS

*Voith Sulzer Paper Technology  
Appleton, Wisconsin*

*Oliver U. Heise*



*USDA Forest Product Laboratory,  
Madison, Wisconsin*

*John H. Klungness*

*Said AbuBakr*

VOITH SULZER  
PAPER TECHNOLOGY

**VOITH SULZER PAPER TECHNOLOGY  
FIBER LOADING™ PATENTS**



US Patent  
5,223,090

European  
Patent  
0690938

**VOITH SULZER**  
PAPER TECHNOLOGY

**TOPICS OF DISCUSSION**

- **Introduction**
- **Objectives**
- **Calcium Carbonate Filler Morphology**
- **Fiber Loading™ Process**
- **Reduction in Drying**
- **Engineering Analysis**
- **Conclusion**

**VOITH SULZER**  
PAPER TECHNOLOGY

# Introduction

VOITH SULZER

## Chemical Pulp Dominating Paper Grades Uncoated Fine Papers

→ *Lightweight printing paper  
or low weight offset papers  
Either surface sized or pigmented*

### Specialty Grade: Bible Paper Specifications

**Basis weight:** 25 to 40 g/m<sup>2</sup>

**Filler level:** 10 to 25% PCF

VOITH SULZER

# Objectives

VOITH SULZER

PAPER TECHNOLOGY

## FIBER LOADING™ OBJECTIVES

- *Maintains Strength and Optical Properties at Higher Filler Levels.*
- *Alkaline Paper Mills Currently Purchasing Merchant PCC Can Use Fiber Loading™ as an Alternate Source of PCC.*
- *Maintains Strength and Optical Properties at Low Basis Weight.*

VOITH SULZER

PAPER TECHNOLOGY

# Calcium Carbonate Filler Morphology

VOITH SULZER

## PROCESS - TRANSITION FROM ACID TO NEUTRAL (Pseudo Neutral) / Alkaline Papermaking



VOITH SULZER

## Biography

**Klaus Doelle has worked for Voith Sulzer Paper Technology, in both Germany and the US, for 15 years, primarily in the areas of design, start-up, and research and development engineering of stock preparation equipment.**

**He began as an apprentice with Voith Sulzer and received his mechanical engineering degree from University Aalen, Germany in 1990. Since 1997, he has held the position of Manager of Research and Development at Voith Sulzer Paper Technology inc., Appleton, Wisconsin, USA**

Doelle, Klaus; Heise, Oliver; Klungness, John H.; Abubakr, Said M. 2000. Lightweight, high-opacity bible paper by fiber loading. In: Proceedings of the specialty and technical papers Europe 2000 conference: 2000 JUNE 21-23; Berlin, Germany. Portland, ME: Intertech: 15 pp.