REDUCTION OF GREENHOUSE GASES BY FIBER-LOADED LIGHTWEIGHT, HIGH-OPACITY NEWSPRINT PRODUCTION

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ABSTRACT

We estimated the effectiveness of fiber loading in reducing greenhouse gas emissions for producing lightweight high-opacity newsprint. Fiber loading enhances fiber bonding at increased precipitated calcium carbonate levels without significant loss in Canadian Standard Freeness or additional energy use. We investigated the reduction of greenhouse gas emissions for a hypothetical 600 metric ton/day newsprint mill. The energy reductions responsible for the reduction in greenhouse gases were due to substituting more readily dewatered fiber-loaded precipitated calcium carbonate (FLPCC) for fiber, reducing grammage, and reducing the energy needed for processing fiber. This was offset by the energy needed for operating the fiber loading equipment. Assuming that a 4-g/m^2 reduction in grammage and a 6% increase in ash as a result of FLPCC are reasonable, greenhouse gas emissions can be reduced. If all newsprint currently manufactured in the United States were fiber loaded, 341,000 metric tons/year of CO_2, 127.1 metric tons/year of N_2O, and 8.7 metric tons/year of CH_4 could be prevented from entering the atmosphere. Given the high reductions in greenhouse gases possible with FLPCC lightweight high-opacity newsprint, the environmental benefits for producing FPLCC lightweight high-opacity mottled and white-top linerboard and printing and writing grades need to be assessed.

INTRODUCTION

Fiber-loaded precipitated calcium carbonate can be a key factor in producing lightweight, high-opacity newsprint. An attractive return on investment has been estimated for lightweight, high-opacity newsprint (1), and fiber loading can significantly reduce newsprint manufacturing energy and the associated greenhouse gas emissions.

Fiber loading, which was developed at the Forest Products Laboratory (FPL), consists of at least two steps (2). First. calcium hydroxide is mixed into pulp fibers with water. Then, the pulp and calcium hydroxide mixture is reacted using a high consistency pressurized reactor (refiner or disk disperser) under carbon dioxide pressure to precipitate calcium carbonate. The fiber-loaded precipitated calcium carbonate (FLPCC) is deposited within. on the surface, and outside the pulp fibers. As a result of fiber loading, fiber bonding is increased. as shown by increased handsheet strength Fiber-loaded pulps are stronger than similar direct-loaded pulps at the same precipitated calcium carbonate levels as a result of three independent mechanisms: (a) deposit of FLPCC within the fiber wall and lumen (3), (b) gentle refining at high pH (4), and (c) gentle refining at high consistency (4,5). The low energy (approximately 6.84×10^4 kJ/metric ton) needed for the reaction process during fiber loading causes only small decreases

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in Canadian Standard Freeness (CSF) (30 to 40 ml) (4,6). By enhancing fiber bonding without any significant loss in CSF, fiber loading is thus a key factor in producing lightweight high opacity paper.

To estimate the potential reduction in greenhouse gas emissions from all U.S. newsprint mills converting to production of FPLCC lightweight, high-opacity newsprint, we determined first the greenhouse gas emission reductions for a single hypothetical newsprint mill. The analysis consisted of calculating the reduction of CO_2, N_2O, and CH_4 emissions for various levels of grammage reduction and increased FLPCC levels possible with fiber loading. The calculations covered the savings in drying both from reduced fiber needs and increased FLPCC levels and reduced energy needed for processing pulp. This was balanced by the increased energy needs to operate the fiber loading processing equipment.

ENGINEERING ANALYSIS

Process assumptions and estimated energy uses, which effect the associated greenhouse gas emissions, were made for a hypothetical newsprint mill producing 600 metric tons of newsprint per day. The mill was assumed to operate 350 days per year and use a mix of 80% softwood thermomechanical pulp (TMP) and 20% deinked pulp (DIP). The fiber-loading process consists of four major operations: fiber fractionation, dewatering of long fiber fraction, mixing of bleach chemicals and calcium hydroxide into pulp, and precipitating calcium hydroxide on and within pulp in a high-consistency pressurized reactor (refiner) under carbon dioxide pressure (1).

Drying energy savings for reduced grammage were obtained by multiplying the ratio of grammage at the lower level to grammage at the original level (assumed to be 49 g/m^2) by the energy needed for drying paper (1.98×10^6 kT/metric ton)(7). The energy source for drying was assumed to be natural gas. The reduction of greenhouse gases as a result of a reduction in natural gas use was calculated on the basis of 50.7 metric tons of CO_2 /10^9 kJ, 3.5×10^{-3} metric tons of $N_2O/10^6$ kJ, and 1.29×10^{-3} metric tons of $CH_4/10^6$ kJ of natural gas (8).

The beneficial effect of FLPCC in increasing solids content prior to drying has been determined experimentally and published (9,10). Thus, we multiplied the drying energy needed for drying pulp by a factor proportional to the fiber fraction of the solids.

The energy needed for processing the pulps was estimated at 1.8×10^6 kJ/metric ton for DIP and 10.1×10^6 !&metric ton for TMP (7). Energy for processing pulps was assumed to be electricity from bituminous coal. The reduction of greenhouse gases from a reduction in the use of coal was calculated on a basis of 88.4 metric tons of $CO_2/10^9$ kJ, 3.0×10^{-3} metric tons $N_2O/10^9$ kJ, and 2.0×10^{-3} metric tons $CH_4/10^9$ kJ of coal (8).

The reduction of greenhouse gases as a result of a reduction in coal use was calculated by the percentage of energy saved times the energy needed for processing pulps times the appropriate greenhouse gas factor for the energy saved,

Reductions in energy and greenhouse gas emissions were balanced by the energy needed for operating the fiber loading equipment. The energy for operating the fiber loading equipment was estimated at 2.4×10^{10} kJ/year (1).

DISCUSSION OF RESULTS

Figures 1-3 show the reduction of green house gas emissions as a result of the reduction in grammage and the increase in FLPCC possible for various scenarios. The greenhouse gases reported are carbon dioxide, nitrous oxide, and methane.

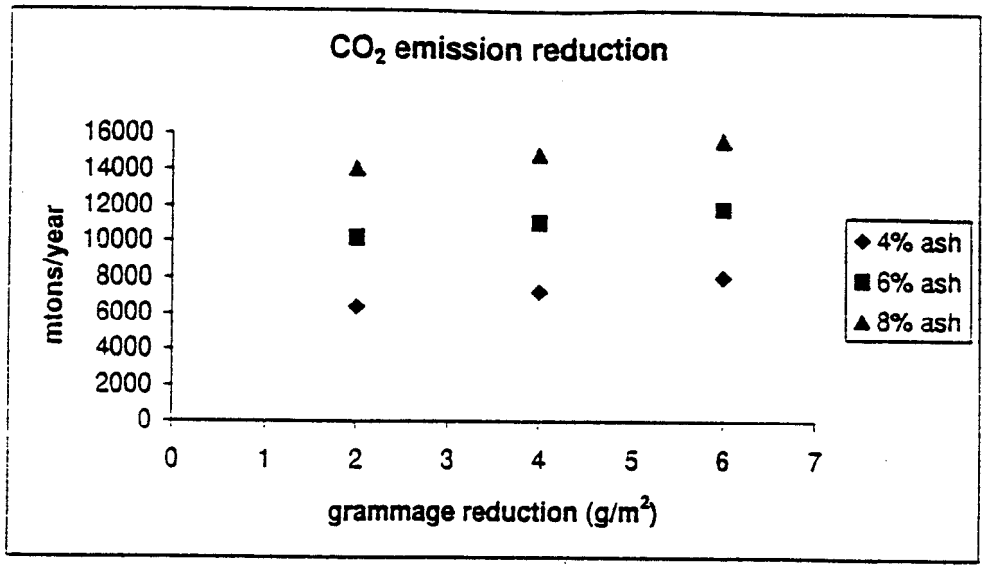
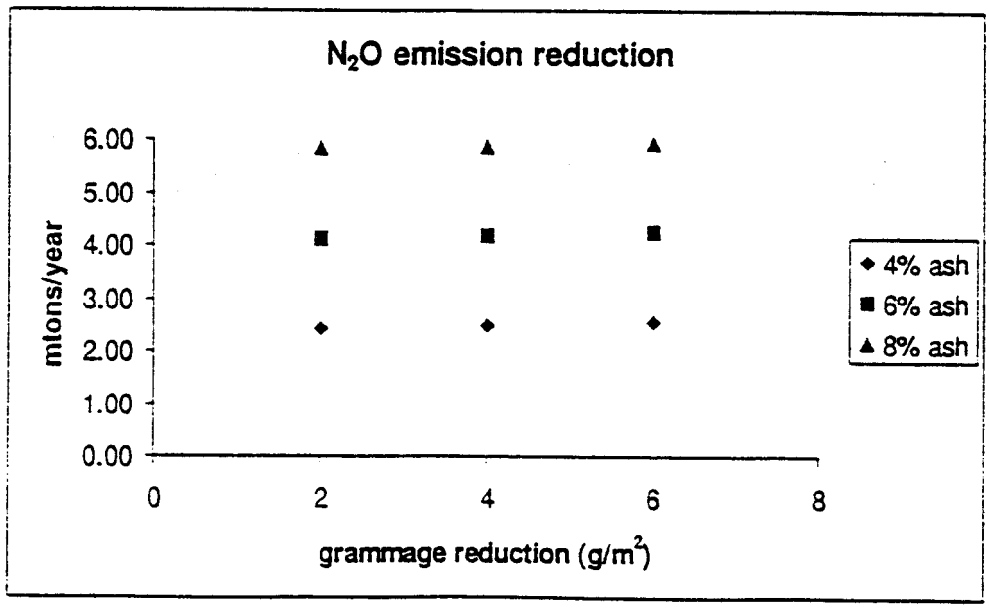


Figure 1. Annual reduction in CO_2 emission as a result of reducing grammage and increasing FLPCC.



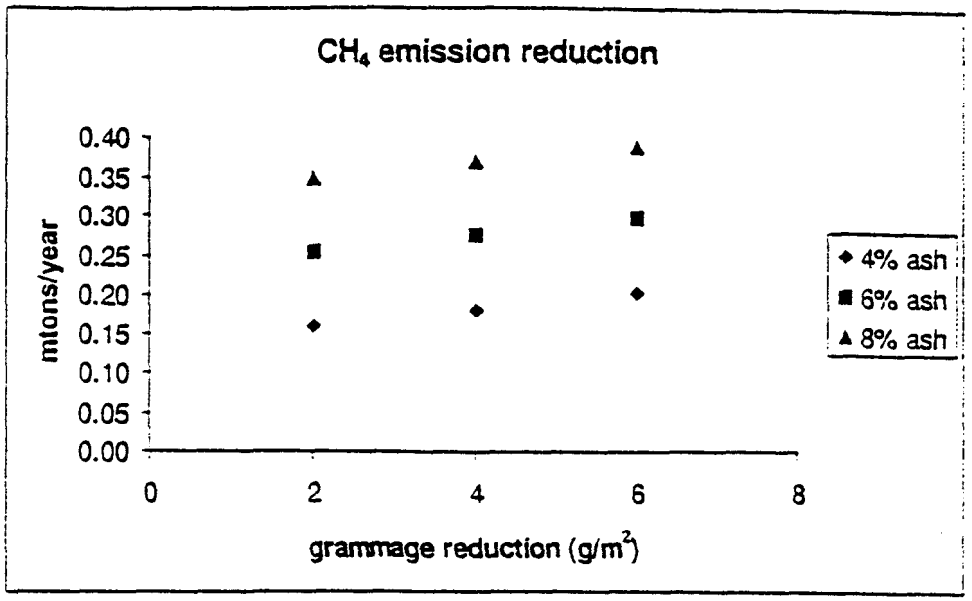


Figure 3. Annual reduction in CH_4 emissions as a result of reducing grammage and increasing FLPCC.

The largest greenhouse gas reduction was for CO_2, as shown in Figure 1. Increasing the FLPCC levels with fiber loading was more effective for reducing CO_2 emissions than for reducing grammage.

In Figure 2, we also see a similar pattern for N_2O emissions as for the previous CO_2 pattern. The level of FLPCC has a greater effect on N_2O emissions than does grammage reduction and results in about three orders of magnitude smaller than for CO_2 emissions. The emissions for methane-type gasses from reduction in grammage and increases in FLPCC are an order of magnitude lower than for the N_2O type gases (Fig. 3).

Using the above estimates for a single newsprint mill, we estimated the potential reductions in greenhouse gas emissions for me entire United States. The U.S. production of newsprint is about 6.5×10^6 metric tons per year **(6).** Assuming that a reasonable goal for lightweight, high opacity newsprint by fiber loading is for a reduction in grammage of 4 g/m^2, and an increase of 6% FLPCC, the following estimates can be made: 341,000 metric tons/year of CO_2, 127.1 metric tons/year of N_2O. and 8.7 metric tons/year of CH_4 can be reduced from present newsprint manufacture in the United States.

The main use of energy in newsprint manufacturing is in the drying process (8). However, even the small percentage reduction (10% to 20% potential reduction in drying energy needs)(11), possible by producing lightweight high-opacity newsprint, significantly reduces greenhouse gas emissions in terms of absolute numbers.

CONCLUDING REMARKS

- Adopting fiber loading for domestic production of FPLCC lightweight, high-opacity newsprint for current newsprint production has the potential for reducing CO_2 emissions by more than 340,000 metric tons per year, as well as more than 120 metric tons of N_2O and 8 metric tons of CH_4.
- Given the large reductions in greenhouse gases possible by FPLCC lightweight, high-opacity newsprint the environmental benefits for producing lightweight high-opacity mottled and white-cop linerboard and printing and writing grades need to be assessed.

REFERENCES

1. Klungness, J.H., Stroika, M.L., Sykes, M.L., AbuBakr, S.M., Witek, W., and Heise, O.U., "Engineering analysis of lightweight high-opacity newsprint production by fiber loading," *In*: 1999 Tappi Joint Conferences, Mar. 1-4, 1999;Atlanta, GA, (1999).
2. Klungness, J., Caulfield, D., Sachs, I., Sykes, M., Tan, F., and Shilts, R. U.S. Patent 5,223,090, RE 35,460 (Feb.25, 1997).
3. Klungness, J.H., Caulfield, D.F., Sachs, I., Tan, M., Sykes, M.S., and Shilts, R.S. "Fiber loading: a progress report," *In*: 1994 Tappi Recycling Symposium, May 15-18;Boston, MA.Atlanta,GA:283-290.(1994).
4. Klungness, J.H., Stroika, M.L., Sykes, M.S., Tan, F., and AbuBakr, S.M., "Development of fiber loading from laboratory to industrial application," *In*: 1998 AIChE Symposium Series in cooperation with Tappi Pulping Conference, Oct.25-29, 1998;Montreal, Canada.(1998).
5. Sykes, M.S., Klungness, J.H., Tan, F., and AbuBakr, S.M., "Value-added mechanical pulps for lightweight high-opacity paper," *In*: 1998 Tappi Pulping Conference Proceedings, Oct.25-29, 1998 Montreal, Canada, Atlanta, GA: TAPPI press, 539(1998).
6. Heise, O., Finneran, W., Klungness, J., Tan, F., Sykes, M., AbuBakr, and Eisenwasser, J., *In*: 1996 Tappi Pulping Conference Proceedings, oct.27-31, 1996;Nashville,TN. Atlanta, GA: TAPPI press,895(1996).
7. Pesonen, K.V., "Recycled vs. virgin-energy and manufacturing cost differentials: four hypothetical case studies," *In*: Focus'95, Landmark Paper Recycling Symposium, mar. 19-21, 1991, Atlanta, GA, Atlanta, GA: TAPPI Press, 251(1991).
8. Anonymous, "National industrial competitiveness through energy, environment, and economics," U.S. Department of Energy, No. DE-PS44-97R490004, Atlanta Regional Support Office, 730 Peachtree Street, NE; Suite 876, Atlanta, GA, Sept. 11, 1996.
9. Sykes, M., Klungness, J., Tan, F., AbuBakr, S., Rantanen, W., and Aziz, S., *Progress in Paper Recycling*, "Effects of processing and recycling on properties of fiber-loaded handsheets," 6(4):37(1997).
10. Allan, G.G., Carroll, J., P., Devekula, M., L., P., Gaw, K., Joseph, A., A., and Pichitlamken, J., *Tappi Journal*, "The effect of filler location on the drainage, pressing, and drying of pulp and paper," 80(8):175(1997).
11. Klungness, J.H., Sykes, M.S., Tan, F., and AbuBakr, S., "Fiber loading-theory and application," *In*: Proceedings of 4th International Refining Conference, Mar. 18–20, 1997, Fiuggi, Italy. Pira International, paper 6, (1997).