Economics of increasing the use of recycled fiber in linerboard

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There are economic incentives for research and development of processes to increase use of recycled fiber in linerboard, such as through upgrading size fractionation and removing contaminants. Generally, producing more kraft linerboard in the future will mean using more wood fiber. There are two options: using more virgin pulp or using more recycled fiber. Reduced product strength and contaminants are problems that now limit use of recycled fiber in kraft linerboard. Yet, technological developments may soon overcome some problems and permit increased use of recycled fiber. A comparison of raw material costs, process costs, and capital costs shows the economic benefits to be gained from increased use of virgin kraft pulp in linerboard. Present values of potential economic benefits and affordable break-even investments in such technological developments are estimated.

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Old corrugated containers are recycled and used in addition to virgin wood fiber in manufacturing unbleached kraft linerboard. Recycled fiber is apparently economical to use, as many mills have secondary fiber systems. However, as late as 1980, the recycled material used in unbleached kraft paperboard was estimated to be just 6% by weight of total production (1). This low usage reflects present technological limits on the amounts of recycled fiber that can be used in linerboard, such as reduced product strength with increased use of recycled fiber and problems associated with contaminants (2).

Research is focusing on ways to upgrade recycled fiber to improve product strength and to obtain better removal of contaminants. If these problems can be overcome (3), the use of recycled fiber in kraft linerboard could be expanded up to 50% or more of the fiber furnish. The economic question is, what are the potential economic advantages and consequences of increased use of recycled fiber in kraft linerboard?

Economic variables

Fiber raw material cost is one economic variable in comparing recycled fiber and kraft pulp. Fiber raw material costs depend on market values: the values of recycled old corrugated containers vs. pulpwood. Market value of recycled corrugated containers is highly variable, recently reported in the range of $40-$75/metric ton in the U.S. (4). Franklin reports that market value of recycled corrugated containers follows a cycle that averages about 3 years in duration and in which peak values can be 3-4 times higher than previous low values (5). By comparison, reported market values of pulpwood appear more stable, recently around $40-$50/metric ton (dry weight) for softwood mixed chip and roundwood in the southern U.S. (5). However, fiber yield from pulpwood in a kraft mill is only around 50% by weight, while fiber yield from old corrugated containers can be over 90%. Consequently, there is a variable and sometimes a substantial difference in fiber raw material costs between virgin kraft pulp and recycled fiber.

Other economic variables are less obvious than fiber raw material cost but may be more significant in the overall analysis. Some cost variables are determined by the linerboard production process. For example, process fuel and energy costs per unit of linerboard product will change as more secondary fiber is used in the process. On the positive side, increased use of recycled fiber proportionately reduces energy requirements for black liquor evaporators and concentrators, pulp digester and liquor heaters, wood preparation, chemical recovery, and lime kiln areas. On the negative side, increased use of recycled fiber reduces proportionately the amount of black liquor and wood residues available for combustion, therefore increasing the need for auxiliary fuel, which is typically more expensive. Another negative effect, is that electrical cogenerating capacity may decline per unit product with increased use of secondary fiber, since there will be lower process steam demand per unit product.

The effects on process chemical costs are also somewhat equivocal. Increased use of recycled fiber reduces proportionately the chemical requirements for kraft pulping and chemical recovery per unit product. However, chemical requirements for flue gas desulfurization may be increased if coal is used in larger proportions in the power boiler to make up for the lack of incremental output of wood residue and black liquor fuels. Another negative effect is that output of naval stores, turpentine, and tall oil soap will be reduced per unit of product by increased use of secondary fiber as opposed to increased kraft pulping capacity.

Another economic variable is the unit labor cost. It is estimated that per-unit labor cost is reduced with increased use of recycled fiber because labor required for secondary fiber processing is lower overall than labor required for kraft pulping, which includes labor for wood preparation, pulp mill, and chemical recovery areas.

The amount of working capital required for raw material inventory may also be decreased slightly with increased use of old corrugated containers as opposed to increased kraft pulping capacity. With either a secondary fiber system or kraft pulping, an inventory of at least 2-4 weeks of fiber raw material will typically be required at a
mill. Because of the lower fiber yield from raw wood, inventory requirements will be higher for pulpwood than for recycled corrugated containers.

Finally, perhaps the most significant variables of all are capital investment requirements, related depreciation allowances, and fixed costs. In general, kraft pulping facilities of a given capacity require a much larger capital investment than secondary fiber facilities of the same capacity. Added kraft pulping capacity requires capital investment in the wood-preparation facilities, kraft digester, chemical recovery area, recovery boiler, electric power, water supply, waste disposal, and cogeneration areas. Added secondary fiber capacity requires only investment in facilities for receiving and storing recycled raw material, fiber processing and refining, and a relatively small investment in expansion of water supply, waste disposal, and electric power systems.

Other economic variables related to capital investment include overhead costs and depreciation allowance. The larger capital investment required for kraft pulping would raise overhead costs for maintenance, insurance, and local taxes more than for the same added capacity with secondary fiber. However, depreciation allowances would be larger, affording larger future reductions in tax liability with the kraft pulping option.

Thus, in summary, there are a number of prominent economic variables to consider. Among these are material, energy, labor, and other operating costs, capital investment, fixed expenses, and depreciation allowances. All of these variables are included in our analysis.

Analysis

Our analysis evaluates increased use of recycled corrugated containers for linerboard by comparing it with the alternative, which is to produce and use a larger quantity of kraft pulp. The major opportunity for such increased use of recycled corrugated is at existing linerboard mills that are in a favorable position for capacity expansion. This analysis, therefore, is based on the hypothetical situation of an impending decision to expand production volume in a linerboard mill. We have assumed that expanded use of recycled fiber up to 50% of fiber furnish in linerboard would be technologically feasible in the future if problems of product strength and contaminants in use of recycled corrugated containers can be overcome. Therefore, whatever positive benefits are estimated to result from increased use of recycled corrugated containers, beyond conventional levels, may be ascribed to potential new technologies for upgrading recycled corrugated containers for use in linerboard.

In our analysis, we used a mathematical computer model of the unbleached kraft linerboard production process. We used the model to simulate material and energy balances for a hypothetical 635-metric-ton/day mill (700 short tons/day) based on design engineering data. Some key assumptions in our analysis were as follows:

1. That recycled old corrugated containers were available at about $75/dry metric ton and that pulpwood suitable for linerboard (e.g., 90% softwood mixed chip and roundwood) was available at $44/dry metric ton.
2. That kraft pulp yield was 55.3% (o.d. wood basis) and secondary fiber yield from the recycled old corrugated was 85% by weight
3. That the mill was of conventional design, with integrated pulping process, chemical recovery, recovery boiler, power boiler, paper machine, and so forth
4. That process variables were set at values typical for a modern mill
5. That beyond a limited capacity for wood residue fuel, the fuel for the power boiler was assumed to be coal, at $76/metric ton.

Our analysis then examined the economics of capacity expansion from 635 to 1270 metric tons/day (700-1400 short tons/day). 3 doubling of production volume, either by incremental expansion in secondary fiber capacity, or incremental expansion in kraft pulping capacity.

In our analysis, we estimated the capitalized net present value of the economic differences between the secondary fiber and kraft pulping options for expanded production volume. Net present value is a meaningful criterion because it can serve both as a measure of the net value of benefits that can be obtained by improving technology for upgrading secondary fiber and also as a measure of the break-even point for potential investment in such systems.

In deriving our estimates of the capitalized net present value of the differences between expanded production volume with secondary fiber and expanded production volume with kraft pulping, we included the following estimates: (a) the capitalized present value of the difference in the after-tax value of profit contribution, sales revenues minus variable costs, (b) the difference in capital investment requirements, (c) the capitalized present value of the difference in overhead costs on an after-tax basis, (d) the capitalized present value of the difference in depreciation allowance tax savings, and (e) the difference in working capital required for raw material inventory. We used a 20-year planning period (assumed life of pulping equipment), a high-risk 20% after-tax discount rate, and a 40% effective annual income tax rate of adjusted gross income.

Results

Looking first at the difference in unit revenues and variable costs (profit contribution) per unit of linerboard product, our results showed that incremental secondary fiber capacity has an economic advantage over incremental kraft pulping capacity. Labor and fiber raw material costs appear in our analysis to be lower, while energy and chemical costs are slightly higher. In our analysis, increased use of secondary fiber as opposed to increased kraft pulping capacity leads to reduced steam and electrical process-energy requirements per unit product but to slightly increased energy costs per unit product, based on coal as the auxiliary fuel. Results depend on the quantity of recycled fiber used (Fig. 1). Total variable costs decline
from $172/metric ton to $161/metric ton of linerboard as recycled fiber goes from 0% to 50% of fiber furnish. However, naval stores revenue per unit product declines in proportion to increased use of recycled fiber. Assuming that the value of the linerboard product remains the same with increased use of recycled fiber, profit contribution will increase only a small amount with increased use of recycled fiber, under the given assumptions. Profit contribution (total revenue - total variable cost) improves only about 5% over the range of increasing use of recycled fiber from 0% to 50%.

The really major advantage of using recycled fiber to expand linerboard production appears to be in capital costs. Our estimates are that installation of 635 metric tons/day of added capacity through adding kraft pulping facilities would cost over $90 million more than the same incremental secondary fiber capacity, as summarized in Table I. Overhead costs and depreciation would vary accordingly. We assume that added linerboard production capacity with either added kraft pulping or secondary fiber systems would also require equivalent investments for capacity expansion in stock preparation, power boiler, and paper machine facilities. We estimated the net difference in profit contribution, capital costs, overhead, and depreciation between the alternatives of expanded production with secondary fiber and kraft pulping. The present values of these differences are each estimated in dollars/daily metric ton of production volume, at various incremental production volumes above an initial volume of 635 metric tons/day. Summary results are shown in Fig. 2, at three levels of secondary fiber usage.

Use of recycled fiber is shown to have a net economic advantage that increases with increasing use of recycled fiber. For example, at 10% recycled fiber in linerboard, the net advantage in using recycled fiber relative to using kraft pulp is about $32,000/daily metric ton of linerboard production volume.

At 50% recycled fiber in linerboard, the net advantage is about $74,000/daily metric ton of linerboard production volume. This net advantage derives from an $8000/daily-metric-ton advantage in profit contribution, a $77,000/daily-metric-ton advantage in investment requirements, a $6000/daily-metric-ton advantage in overhead costs, and a $17,000/daily-metric-ton disadvantage in depreciation allowance tax savings, all expressed on a basis of after-tax present value. As expected, capital investment and depreciation are found to be the most significant factors, under the given assumptions. However, as the value of raw materials varies, profit contribution can become more significant in the analysis. The sensitivity of our results to change in the value of old corrugated was analyzed further.

Figure 3 shows how the net economic advantage in using secondary fiber changes as the value of old corrugated raw material changes. The net advantage in using secondary fiber, over kraft pulping, is illustrated over a range of incremental secondary fiber usage from 10% to 50% by weight of fiber in finished product and for a range of values up to triple the current assumed value of old corrugated containers. Results are again presented in terms of present value per daily ton of linerboard production volume.

Discussion

The results show there is substantial economic advantage in increased use in recycled old corrugated containers for incremental capacity expansion at an existing linerboard mill, relative to the alternative of expanded kraft pulping capacity. The advantage at current market values derives primarily from the large difference in capital investment requirements between a secondary fiber system and added kraft pulping capacity. This advantage is not transitory, because it is structurally a result of the technology and equipment available for producing kraft linerboard. This advantage provides, therefore, a tangible and lasting incentive for development of improved systems for upgrading and increasing use of recycled old corrugated containers in kraft linerboard.

Given that new technology is on the horizon for upgrading recycled fiber, such as the concept of the wide-lip disc separator described by Klungness et al. (3), we considered what the likely macroeconomic or market effects will
3. Estimated economic advantages (net present value) in using recycled corrugated containers in linerboard as the market value (in dollars/metric ton) of this material changes.

be for the industry. The direct effect of improvements in technology for upgrading recycled fiber will be most likely to promote increased use of recycled fiber, notably increased use of recycled old corrugated containers in linerboard. Certainly there is economic incentive for such a development provided that technological problems can be solved at a reasonable cost relative to the economic advantages, as we think they can. According to economic theory, the market will react to increased demand for recycled corrugated containers with an increase in the market value of this material. A nominal increase in the value of old corrugated containers will tend to reduce the economic advantage of using recycled fiber (Fig. 3). However, even if there are substantial increases (e.g., twofold or more) in the nominal value of this material, there will still be marginal advantages in using recycled corrugated containers up to levels of at least 50% of fiber furnish in linerboard. Only as the value of old corrugated containers approaches a threefold increase (e.g., to the range of $225/metric ton ($200/short ton), as shown in Fig. 3) does it appear that there is a complete loss of marginal economic advantage with increased use of recycled fiber in linerboard.

The results show that there are economic limits to the quantity of recycled corrugated containers that can be used, since market value will go up as demand goes up, and ultimately higher values will choke off the economic advantage in increased use. However, at today’s market value, there is still a tremendous margin of opportunity in increased use of old corrugated containers in linerboard. Our analysis shows that the value of this material could increase by as much as three times its current value, and yet there would be economic incentive toward its increased use compared with the alternative of increased kraft pulping capacity.

These economic advantages also indicate the break-even level of added investment affordable for technological developments that will permit increased use of recycled fiber in linerboard. For example, the present value of advantages in using 50% recycled fiber instead of kraft pulp to achieve a doubling of production volume is $74,000/daily metric ton (Fig. 2). This is equivalent to a present value advantage of $90 million at a product volume of 1270 metric tons/day ($90 million = $74,000 × 1270), indicating that up to $90 million in added investment could be afforded for the recycled fiber option and still break even with the kraft pulping option in expanding production volume from 635 to 1270 metric tons/day.

The potential advantages for individual mills will vary depending on such factors as existing capacity, potential for capacity expansion, and proximity to sources of supply of old corrugated raw material.

Conclusion

There is substantial economic advantage in increased use of secondary fiber in linerboard compared with the alternative of increased kraft pulping capacity. At today’s market values, the advantage derives mainly from capital investment savings, and it increases with increased use of recycled fiber. Therefore the economics of upgrading recycled corrugated containers for increased use in linerboard look quite favorable. Improved technology for upgrading and increasing the use of recycled fiber in linerboard may capture this economic advantage. Alternatively, this potential economic advantage may be viewed as the investment that can be afforded for future development and installation of such new technology. If the market value of recycled fiber increases, there may still be substantial economic advantages in using recycled fiber.

Literature cited


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