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A cost analysis of CHIP MANUFACTURE at hardwood sawmills

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AN OPPORTUNITY TO INCREASE INCOME

BECAUSE of the growing need for wood fiber in the pulp and paper industry, there is an opportunity for sawmill operators to increase their income by converting hardwood sawmill residues (slabs, edgings, and trim) to pulp chips. By selling wood chips and reducing residue-disposal costs, sawmills could improve their utilization of sawlogs.

But to justify the installation of debarking and chipping machines, and to know what such machines could contribute to his business, the sawmill owner must have a thorough understanding of the costs involved in chip production.

To help him in this we have made case studies of seven sawmills in southeastern Ohio, eastern Kentucky, and Tennessee, and have analyzed all the factors of cost involved in chip production.

THE STUDY APPROACH

When a sawmill, which is accustomed to producing lumber as its sole product, undertakes to produce wood chips from its residues, some of the cost factors change. The merging of chip production with lumber manufacturing modifies or replaces certain of the operations that are necessary in producing hardwood lumber.

For example, if a sawmill owner invests in debarking and chipping machines for producing wood chips, the cost of these machines can logically be charged to chip production. But at the same time, these same machines are also used in operations that contribute to lumber production. And these machines have side effects on lumber production. For example, debarking logs before sawing them changes saw-maintenance requirements and affects lumber production rates. The cost changes in lumber production are chargeable to debarking, which is a step in chip production.

Therefore the cost for the sawmill to produce pulp chips may be viewed as the change in its total net cost resulting from sawlog-debarking and chip-production activities. It costs a given amount per thousand board feet to produce lumber if logs are debarked and wood residues are chipped. Without debarking and chipping facilities in the mill it would cost a different amount to produce the same lumber. This cost difference expresses the change caused by debarking and chipping facilities, regardless of whether they were included in the original sawmill construction or were installed later.

All sawmills included in this study were in operation before embarking upon chip production. These mills (three band mills and four circular mills) were selected to determine cost changes in lumber-production activities caused by addition of log-debarking and chip-producing facilities.

To compute pulp-chip production costs as the change in total net cost to the sawmill firm, the following items were considered chargeable to chip production:

- Fixed costs (debarking and chipping), including (1) equipment depreciation charges, (2) interest charges, (3) insurance, and (4) taxes.

Table 1.—Average hardwood chip-production costs for seven sawmills

Item		Cost		
Chip-production rates:				
1. Daily average	19 tons			
2. Annual average	4,525 tons			
Chip-production costs:				
3. Fixed cost:		*Annual cost*		*Cost/ton of chips*
Depreciation		$4,435.50	=	$0.98
Property tax		339.00	=	.08
Insurance		411.00	=	.09
Interest on average investment		1,514.75	=	.33
All fixed costs		—		$1.48
4. Variable costs:		*Daily cost*		
Labor:				
Debarker		15.20	=	$0.80
Chipper		13.87	=	.73
Power:				
Debarker		—		.12
Chipper		—		.33
Maintenance & repair:				
Debarker		—		.16
Chipper		—		.42
All variable costs		—		$2.56
5. Total cost		—		$4.04
Change in lumber-production cost:				
6. Variable cost saving:		*Per MBF*		*Per ton of chips*
Saw maintenance		$0.42	=	$0.34
Log washing		.67	=	.55
Wood residue disposal		.29	=	.24
Total variable cost saving		$1.38		$1.13
Total net cost to firm per chip-ton (at sawmill):				
Chip-production costs		—		$4.04
Lumber production savings		—		1.13
Net cost per ton of chips		—		$2.91

- Variable costs (debarking and chipping), including (1) labor, payroll-based taxes, and insurance; (2) power (electricity); (3) equipment maintenance, parts, and labor; and (4) raw material.
- Cost changes in activities altered by debarking and chipping: (1) saw maintenance, (2) sawlog cleaning, (3) wood-residue disposal, and (4) supervisory and office overhead.
- Chip transportation costs.

Costs for the above items were compiled at each mill. From this information an all-mill weighted average cost per ton of chips (green) was computed for each expenditure item (table 1). The weighted averages are used in the following discussion of individual expenses.

ANALYSIS OF CHIP-PRODUCTION COSTS

Depreciation Charges

Depreciation of buildings and debarking and chipping equipment — including associated facilities such as bark drags and slab and chip conveyors where applicable — was treated as an annual expense, permitting an even spread of these charges over chip production for the entire useful life of the equipment. The expected useful or productive life of these facilities varied from 6 to 15 years depending mainly upon the amount of use in terms of annual chip production. The weighted average output of chips for all mills amounted to 4,525 tons annually. The average indicated useful life of equipment was 9 years. The following equation illustrates the method of calculating depreciation:

$$\text{Annual depreciation} = \frac{I - R}{N} = \$4,435.50$$

Where:

I = Purchase cost of $32,402 plus installation cost of $10,586 = $42,988.

R = Estimated salvage value after N years = $3,068.

N = Expected useful life = 9 years.

Interest Charges

Interest charges represent income foregone by investing capital in debarking and chipping facilities rather than in securities or some other investment. Since annual depreciation allowances are presumably funds available to the firm, they should be earning interest. Therefore calculated interest charges are based on the average investment — the average profit-bearing capital at work in the operation. Using the same values from the calculation of depreciation, average profit-bearing capital would be:

$$APBC = \frac{(I-R)\ (N+1)}{2N} + R = \$25{,}245.78$$

And using an interest rate of 6 percent:

$$\text{Annual interest charges} = 6\%\ (\$25{,}245.78) = \$1{,}514.75$$

Insurance and Taxes

The average amount spent for insurance coverage on debarking and chipping facilities was $411 per year. Although this amounted to 1.6 percent of the average investment, the insurance rates ranged from 0 to 4.9 percent at individual mills. Taxes varied from 0.7 percent to 2.3 percent of the average investment, depending upon mill location, and averaged 1.3 percent ($339).

Labor

Labor costs for equipment operation ranged from $1.25 to $1.60 per hour for base wages. Additional associated employment costs for social security, unemployment insurance, workmen's compensation, and other fringe benefits ranged from 14 to 26 percent of base wages, averaging 19.7 percent. The average base wage for debarker and chipper labor was $1.42 and $1.39 per hour, respectively.

Measurements made at each mill determined the actual amount of labor used daily in chip production. Ranging from 8 to 10 man-hours per day, debarker operation averaged 8.5 man-hours of labor, while chipping facilities required 8.2 man-hours for total daily labor costs of $15.20 and $13.87 respectively. Where mill employees worked more than 40 hours per week the average hourly labor costs were adjusted to include overtime wages.

Power

The volume of sawlogs processed and the resulting lumber and chip output were measured at each mill. Machine operating time and metered electric consumption were recorded. Metered electric consumption was apportioned to each machine on the basis of its installed horsepower and operating time. The all-mill average power consumption per chip ton was 4.86 kwh. for debarking and 13.68 kwh. for chipping. Electric power rates varied from 1.25 cents to 3.65 cents per kwh., averaging 2.44 cents. Accordingly, the average electric power costs for debarking and chipping were 12 cents and 33 cents per chip ton.

Maintenance and Repair

Aside from routine preventive maintenance such as lubricating, sharpening, and adjusting equipment, unexpected and sometimes costly breakdowns can occur. So total maintenance and repair costs are subject to wide variation. To include unusual as well as routine maintenance and repair, parts and labor costs were compiled for the longest production period for which records were available, at each mill. The weighted average cost for maintenance and repair amounted to $.58 per ton, distributed as follows:

	Dollars per ton		
	Parts	*Labor*	*Total*
Debarking facilities	0.11	0.05	0.16
Chipping facilities	.25	.17	.42
Total	0.36	0.22	0.58

Raw Material

Cost for raw material has not been included as a chip-production cost. Raw-material cost is logically charged against the cost of producing lumber. However, in the concept of total net cost change, it is irrelevant whether raw-material cost is charged against chips or lumber; if it were charged to chip production a corresponding saving in lumber production would occur.

CHANGE IN LUMBER PRODUCTION COSTS

Saw Maintenance

Sawing debarked sawlogs reduced the number of saw changes per day and increased daily lumber output at all the mills studied. Some mills reported a reduction in filing time per saw, and circular mills found a marked increase in saw-bit life. Since the basis for these changes was different at band and circular sawmills, comparing changes between the two types of mill is not valid. For each type of mill, however, average changes indicate what may be expected from sawing debarked sawlogs.

Mill type	*Number of saw changes per shift* (*percent*)	*Daily lumber output* (*percent*)	*Filing time per saw* (*percent*)	*Volume sawed between saw-bit replacement* (*percent*)
Band saw	—25	+6	—14	—
Circular saw	—54	+18	—28	+46

The above comparison suggests substantial differences in saw maintenance between band sawmills and circular sawmills. However, computed cost changes for saw maintenance[1] are not a function of mill type but depend upon the maintenance-cost structure of each mill itself. Consequently we cannot say that cost changes are greater for one type of mill than for the other. But we can say that the all-mill-average saw-maintenance cost was reduced $0.42 per thousand board feet as a result of sawing debarked logs.

Sawlog Cleaning

At six of the seven study mills, sawlog debarking displaced labor that formerly was needed to wash or otherwise clean sawlogs. In effect, these labor costs are no longer chargeable to lumber

[1] Change in saw-maintenance cost per thousand board feet is the cost for rough sawlogs minus the cost for debarked sawlogs, each computed as:

$$\text{Saw maintenance cost/M b.f.} = \frac{\text{Number saw changes per day} \times \text{Filing time per saw (hrs.)} \times \text{Filing cost per hour}}{\text{Daily lumber output (M b.f.)}} + \frac{\text{Saw-bit cost per set}}{\text{M b.f. sawed between bit replacements}}$$

production, although the laborers may have been retained to operate debarking equipment. In this case the labor cost becomes chargeable to chip production and therefore must be credited as a saving in lumber-production costs.

For example, those mills that now debark logs formerly had an average daily lumber production of 15,750 board feet, requiring 7.91 man-hours or a cost of $12.66 per day to wash sawlogs. Since their log cleaning is now done by debarking and is chargeable to chip production, an average of $.80 per thousand board feet of lumber produced is saved.

Wood-Residue Disposal

Similar labor displacement occurred in wood-residue-disposal activities at three study mills. Before the mills installed chipping facilities their average daily production of 14.1 thousand board feet required 6.83 man-hours or $10.79 per day to keep wood residues moving out of the mill. Now, by chipping their residues, these mills realize an average saving of $0.76 per thousand board feet.

All-Mill-Average Cost Saving

Before determining the average cost saving for all the mills, it was necessary first to measure cost savings on a per-thousand-board-foot basis because changes in saw maintenance, log cleaning, and wood-residue-disposal activities, and the subsequent assignment of some costs to chip production, affect the cost of producing lumber. On this basis, the average cost saving for all the mills was $1.38 per thousand board feet — $0.42 on saw maintenance, $0.67 on log cleaning, and $0.29 on wood-residue disposal (item 6, table 1).

However, to relate the effect of these variable cost savings to chip-production costs, it is necessary to convert these savings to a per-ton basis. Yields of chips varied from mill to mill — ranging between 1.0 and 1.5 tons per thousand board feet of lumber sawed. The average chip yield was 1.22 tons per thousand board feet. Therefore the $1.38 lumber production cost-saving converts to a $1.13-per-ton credit against chip-production costs in figuring this firm's total net cost change.

Supervision and Office Overhead

No measureable change was evident in supervisory or office overhead at any of the mills studied. Consequently their effect upon chip-production cost is considered negligible.

TRANSPORTATION

In the western-Appalachian Region sawmill chips are usually sold f.o.b. sawmill. The chip buyer pays rail freight charges, or a per-ton mileage allowance if chips are delivered by truck. The actual delivery cost varies widely according to the distance and the type of transportation. Maximum one-way truck-haul distances generally range between 50 and 70 miles, but rail service extends market access for sawmill pulp chips to approximately 300 miles.

Additional handling costs result when chips cannot be put directly into truck-trailer or railroad chip cars for the main haul to market. Chip producers located beyond practical truck-hauling distance, and not situated on rail sidings, encounter further costs for transferring chips from the sawmill to the railroad. Where intermediate transfer is necessary, chips are transported in large-capacity dump trucks or palletized portable bins that are moved either by fork lift or dump truck. Typical short-haul costs ranged from 18 to 40 cents per ton-mile. The actual cost varies according to the distance and the method used.

EVALUATING THE OPPORTUNITIES

Although costs per ton for the individual inputs differ from mill to mill, overall chip-production costs are related to the combination of average daily and annual chip output of each installation (table 2).

Effective evaluation of a chipping operation requires identifying all the costs and determining the change in total net costs to the sawmill as a result of producing chips. On the basis of only total cost per ton, for example, pulp-chip production at two study mills would have been unprofitable at a chip price of $6 per ton (at the sawmill). But the corresponding change in total net cost per ton,

Table 2. — Hardwood chip-production costs at study mills

Item	Mill						
	A	B	C	D	E	F	G
Chip-production rates:							
Annual average—tons	1,725	2,250	2,400	4,750	5,725	6,800	8,000
Daily average—tons	14	10	10	20	23	31	32
Chip-production costs:							
	Cost per ton (dollars)						
Fixed costs:							
Depreciation	2.62	1.38	1.06	1.27	0.71	0.80	0.83
Property tax	.17	.15	.14	.06	.05	.02	.08
Insurance	—	.09	.17	.08	.06	.14	.07
Interest on average investment	1.04	.66	.51	.24	.28	.17	.22
All fixed costs	3.83	2.28	1.88	1.65	1.10	1.13	1.20
Variable costs:							
Labor:							
Debarker	0.86	1.50	1.42	0.82	0.70	0.56	0.46
Chipper	.86	.28	1.50	.71	.66	.52	.55
Power:							
Debarker	.05	.15	.40	.18	.01	.03	.07
Chipper	.19	.13	.50	.58	.27	.12	.26
Maintenance:							
Debarker	.17	.14	.18	.23	.15	.18	.06
Chipper	.27	.11	.61	.36	.49	.62	.19
All variable costs	2.40	2.31	4.61	2.88	2.28	2.03	1.59
Total cost	6.23	4.59	6.49	4.53	3.38	3.16	2.79
Change in lumber-production cost:							
Variable cost saving:							
Saw maintenance	0.34	0.31	0.46	0.42	0.31	0.39	0.20
Log cleaning	.94	—	1.70	.75	.41	.56	.41
Wood-residue disposal	.94	—	—	.75	.36	—	—
Total cost saving	2.22	0.31	2.16	1.92	1.08	0.95	0.61
Total net cost per ton at sawmill:							
Chip-production costs	6.23	4.59	6.49	4.53	3.38	3.16	2.79
Lumber production savings	2.22	.31	2.16	1.92	1.08	.95	.61
Net cost per ton of chips	4.01	4.28	4.33	2.61	2.30	2.21	2.18

because of savings in lumber production, indicates that each firm would have a net return from chipping operations even if the assumed price for chips were only $5 per ton.

Disregarding sawing-cost savings also overestimates the volume of lumber output needed to support a sawmill chip-producing facility. Many sawmill chipping operations have been established without benefit of knowledge about how cost changes in sawmill activities are altered by debarking and chipping. Accordingly today's average-size installations do not provide a very good indication of the volume of lumber output required to justify sawmill log debarking and chip production. Whether or not a sawmill has sufficient residue to justify debarking and chipping is best decided by estimating the potential net-cost-change facing the firm if it engages in chip production.

Increasing Output with Purchased Slabs

An awareness of unused chipping capacity has led some firms to supplement their own mill residues by purchasing debarked slabs from other sawmills.

When purchased slabs are processed within the existing capacity of a mill's chipping system (fixed and variable inputs as well as physical capacity), the firm has added expenses for slab purchases and extra chipper maintenance. But the additional chip output makes more efficient use of machines, men, and money, thereby decreasing chip-production costs per ton. For example, at two sawmill firms that supplement their own chip output by purchasing slabs, an average increase of 750 tons per year decreased the production cost per ton by 10 percent (table 3).

Aside from improving the profitability of operations at some firms, purchased slabs also play a key role for small sawmills that otherwise could not support a chipping operation. By planning to supplement their mill's insufficient chippable residue with purchased slabs, these firms may find it possible to justify their entry into the chip-producing business.

Chip Quality and Quantity

Specifications for pulp chips, species, bark content, foreign matter, and type of transportation equipment acceptable to the buyer

Table 3. — The effect on chip-production costs of raising the annual production by purchasing debarked slabs[3]
(Number of operating days = 215)

Item	Chip-production rate					
	1,650 tons/year direct from logs sawed at mill		Additional 750 tons/year from purchased slabs		Combined production 2,400 tons/year	
	Cost per year	Cost per ton	Cost per ton	Added cost per year	Cost per year	cost per ton
Chip-production costs:						
Fixed costs:						
Depreciation	$2,900.00	$1.76	—	—	$2,900.00	$1.21
Property tax	341.00	.21	—	—	341.00	.14
Insurance	300.00	.18	—	—	300.00	.13
Interest	1,366.00	.83	—	—	1,366.00	.57
All fixed costs	—	2.98	—	—	—	2.05
Variable costs:	*Cost per day*					
Labor:						
Debarker	14.00	1.82	—	—	3,003.00	1.25
Chipper	13.76	1.79	—	—	2,953.50	1.23
Power:						
Debarker	—	.29	—	—	478.50	.20
Chipper	—	.59	—	—	973.50	.41
Maintenance:						
Debarker	—	.16	—	—	264.00	.11
Chipper	—	.36	.36	270.00	864.00	.36
Slab purchase	—	—	3.25	2,437.50	2,437.50	1.02
All variable costs	—	5.01	—	—	—	4.58
Total cost	—	7.99	—	—	—	6.63

Change in lumber-production costs:	*Per MBF*							
Variable cost saving:								
Saw maintenance	0.46	=	.42	—	—	693.00	=	.29
Log cleaning	2.33	=	2.12	—	—	3,498.00	=	1.46
Total saving	—		2.54	—	—	—		1.75
Total net cost (at sawmill):								
Chip-production costs	—		7.99	—	—	—		6.63
Lumber production savings[1]	—		2.54	—	—	—		1.75
Net cost per ton of chips	—		5.45	—	—	—		4.88

[1] Values are actual weighted averages from two mills that purchase slabs.

are necessarily rigid. Chip buyers indirectly maintain quality-control standards by rejecting shipments or deducting penalties from payments to sawmills that produce substandard chips. But with proper maintenance, adjustment, and operation, the debarking and chipping facilities at hardwood sawmills can produce good quality chips.

Besides quality, chip buyers are also interested in quantity — particularly the assurance of a reliable flow of chips to their plant. This means that sawmills producing chips must be essentially year-round operations.

The quantity or rate of chip output must also be coordinated with the type of transportation available to a sawmill firm. This is usually no problem for mills situated within trucking distance of markets. However, where railroad transportation is necessary the situation is more complex. Railroad chip-cars vary in capacity from 35 to 70 tons. And mills loading chip-cars must have sufficient production or storage facilities, or both, to avoid demurrage charges for detaining cars beyond the normal 24 or possibly 48 hours allowed for loading. Therefore, potential loading delays need to be considered in determining the minimum chip-production capacity needed for a successful chipping business.