SORTING OF DRY AND GREEN LODGEPOLE BEFORE KILN DRYING

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One of the most frequently mentioned problems in relation to processing beetle-killed wood in the British Columbia Interior is that of kiln drying charges consisting of both green and partly dried stock. This results from the fact that dead beetle-killed stems are currently harvested and processed along with green stems from the same stands.

The losses, or additional costs, associated with the current procedures include the following:

1. extra cost to kiln dry already dry wood,
2. excessive degrade in the already dry stock, and
3. increased planer breakage due to overdry wood, and related planer production delays.

The purpose of this paper is to examine some possible alternatives available for dealing with this problem, the equipment changes required, the advantages and disadvantages of the alternatives and some related considerations. This is done within the framework of a series of studies designed to evaluate the economic merits of the alternatives.

PROPOSAL

In order to reduce the losses referred to above, it is proposed that the dry beetle-killed wood and green normal wood be segregated and the lumber dried separately.

MILL TYPE

The type of operation examined in the following alternatives is a typical British Columbian Interior spruce-pine-fir (S-P-F) dimension mill producing 2 x 4 to 2 x 10 in lengths from 8 to 20 feet, requiring 28 basic length and width sorts.

SORTING ALTERNATIVES

Four basic alternatives for sorting have been identified:

1. No change (control): continue to run mixed dry and green stock throughout the operation;
2. Sort in woods: segregate dead (red top or older) from live stems as early as possible during harvesting. Haul them separately to the mill and store them separately in the yard;
3. Double the sorts: this alternative requires doubling the number of sorts in a typical bin sorter, and adding an in-line moisture meter to identify and separate the dry from the green pieces;

4. Secondary sorting: this is a compromise of the previous method in order to reduce the capital costs. It involves adding the same moisture detector, adding only a few bins for the entire dry sort, removing the dry sort of mixed lengths and widths, and feeding it back through the sorter using a re-entry system, either on a third or partial shift, or Saturday.

There are existing precedents for these last two alternatives, and all of the equipment required is available.

MOISTURE DETECTORS

Continuous moisture detectors, also known as in-line moisture meters and unstacker moisture meters have been available for several years. They are normally located on the dry chain between unstacker and planer. The meters are used to detect and to mark or reject lumber that fails to meet a preselected moisture content (MC) limit. Lumber that is rejected as being too wet can then be returned for further kiln drying, or treated as wet lumber.

It is proposed that a meter of this type be located on the green chain and used to segregate lumber into two sorts:

1. A 'dry sort,' i.e., lumber that is at or below 25 to 30 percent MC, depending on the upper measuring limit of the meter; this sort would be either air-dried or kiln-dried using a shorter schedule.
2. The other sort would be the 'wets' which would proceed in the normal manner to the dry kilns.

Most electronic in-line meters presently available are claimed to be able to identify wood MCs over the range of six to eight percent up to around 27 percent. One supplier provides an optional sensor head with a claimed range of 10 to 150 percent MC.

Another system that could be used to make a segregation is based on the weight of individual boards, measured as they pass over a displacement transducer. This system, which is said to be in use in one or more Scandinavian mills, uses measurements of board length, width and thickness taken by the sorting system to calculate board volume. Using this board volume and average species density values, close estimates of MC can be made.

While it is doubtful whether a weight-based system would be as accurate as an electronic method using capacitance or dielectric loss, there is little doubt that it could be used to separate two groups, e.g., $\leqslant$ 25 percent MC and $\geqslant$ 35 percent MC.

ALTERNATIVES FOR DRYING THE DRY SORT

Once the lumber has been segregated into dry and green sorts, there are three options available for drying the dry wood:

1. Don't dry it: for wood at approximately 19 percent MC,
2. Air dry it: under appropriate climatic conditions,
3. Kiln dry it: for a shorter period, possibly at higher temperatures than normally used since the danger period for degrade is already past.

Obviously the moisture content of the dry sort will have a direct bearing on the option chosen. The moisture content distribution will be largely determined by the length of time since the trees were killed. Since any given stand that is salvaged could contain trees killed over a period of several years, there could be a significant variation in MC among pieces in the dry sort.

Very little data exist on the MC distribution in the dead trees in B.C. However, it will obviously depend on whether the trees salvaged are from green attack, red attack, or grey attack areas. Data from Reid (1961), shown in Figure 1, do indicate that the outer sapwood reaches fibre saturation point (FSP) about one year after attack, based on a study carried out near Invermere, B.C. and Banff, Alberta.

Table 1 contains data from Idaho (Tegethoff *et al.*, 1977) which indicate that the wood of trees in the range of one to three years since death will largely be below FSP, although some heartwood pieces would likely remain above FSP.

Table 1. Average MC (% and Standard Error) of Wood from Beetle-Killed Lodgepole Pine in Relation to Time Since Death

Height in Tree (ft.)	Years Since Trees Died			
	1 - 3		3 - 5	
	Sapwood	Heartwood	Sapwood	Heartwood
1	47 ± 15	20 ± 3	31 ± 11	29 ± 5
16 - 19	20 ± 3	26 ± 8	15 ± 5	16 ± 4
35 - 40	25 ± (1)	27 ± (1)	12 ± 2	14 ± 2

(1) one measurement only
Source: Tegethoff *et al.*, 1977

Another factor which will determine whether the lumber is kiln dried or not is the intended market. If the lumber is to be exported offshore, kiln drying may be required to sterilize the lumber, and the minimum drying conditions may be specified by authorities in importing countries. The following are examples of sterilization schedules:

U.K.	a) 5 hr. @ 140°F @ 100 percent relative humidity
	b) 6 hr. @ 135°F @ 100 percent relative humidity
Australia	6 hr. @ 165°F

EVALUATION OF ALTERNATIVES

To properly evaluate the three sorting alternatives relative to the current situation, several estimates must be made.

1. The savings in costs which would result from sorting,
2. The additional capital and operating costs involved in sorting,
3. The resulting net dollar benefit.

1. Savings Due to Sorting

The savings anticipated from reduced drying costs will be much the same regardless of how the sort is made. The savings include:

a) reduced cost to dry the dry sort,
b) reduced degrade in the dry sort,
c) reduced breakage at the planer, and reduced downtime resulting in higher throughput and lower unit costs.

To precisely quantify these savings is a large task involving studies of each category of savings using dry sort samples and control samples. Although these studies have not been done, it is possible to examine some aspects of the potential savings on a theoretical basis.

a) Reduced drying cost

The savings in drying cost will depend on several factors:

-- the proportion of the total production in the dry sort,
-- the moisture content of the dry sort, and
-- whether the dry sort needs further drying in the kilns or is acceptable as is.

If the wood is sufficiently dry, and no further kiln drying is required, a significant reduction in drying cost is possible. Costs fully or partly eliminated would include:

-- kiln heating costs,
-- electrical costs,
-- labor for loading and unloading the kilns,
-- sticker costs,
-- kiln maintenance costs.

While the absolute amount saved is a site-specific question, savings in the order of $3 to $6/Mfbm or perhaps higher for the dry sort lumber would be possible.

The savings would drop significantly if drying must be completed in the kilns. This would eliminate the savings in sticker and handling costs, and reduce the savings in energy and electrical costs.

Table 2 indicates drying times for lodgepole pine using two typical schedules, and based on four levels of initial MC. These are mathematically derived data based on a Western Laboratory report "Calculating Kiln Schedule Changes" by G. Bramhall (1975). It can be seen that regardless of kiln schedule, if the initial MC of the dry sort lumber is 30 or 25 percent, drying time can be reduced by approximately one-fifth or one-third respectively.

b) Reduced degrade cost

The second source of saving would be a reduction in degrade, accomplished by not overdrying the dry stock. This could be a significant saving, but a degrade study would be needed to quantify it. This would involve making degrade estimates for both a sample containing mixed green and dry lumber, and a sample of dry sort lumber.

The study requires establishing a grade a trim length for each sample piece before drying and after drying.

These would be combined with price data to estimate the amount of degrade for the mixed and dry sort alternatives, and the potential savings in degrade.

This degrade study would be very difficult and expensive to execute at a mill due to the need to accumulate and sticker sufficient 'dry' sort lumber for an entire kiln charge. An alternative procedure would be to select smaller samples of control and dry sort lumber at the mill for drying in a smaller research kiln.

c) Reduce planer breakage

To determine how much planer breakage and associated delays could be avoided by not overdrying beetle-killed wood in mixed green and dry charges, a planer study would be required. Data collected over several shifts would include:

-- duration of each delay,
-- reason for delay,
-- moisture content of pieces broken and removed from the planer.

d) Other benefits of sorting by MC

In the case of both sorting methods performed at the sawmill (Double the Sorts and Secondary Sorting), the savings are limited to those outlined above.

If, however, dead stems are sorted from live stems in the woods, there exists the potential to make further savings, particularly through reduced breakage. This opportunity arises because barker tools or pressure may be altered to suit the log conditions if either all dry or all green wood is being processed at any one time.

Another opportunity arising if dry stems are sorted in the woods is to better control the storage time and storage conditions for these stems. The dead stems can then be processed sooner, minimizing further deterioration in storage, or water sprays can be applied without affecting green stems at the same time.

A further benefit may be obtained if the dry stems are separated and stored in water or under water sprays. The resulting increase in MC should serve to reduce the proportion of chip fines which is higher in dry than in green wood.

2. Cost of Sorting

The other side of the economic evaluation is to estimate the costs of implementing each of the three sorting alternatives.

a) Sort in the woods

This alternative should not require any new capital expenditures, assuming that existing equipment can handle the sorting.

Since some species and size sorts are already being made at woods' landings using delimbing and front-end loading equipment, applying the same techniques to sort green and dry stems should not present any new problems, providing the number of sorts is within reason.

The cost to implement this alternative is strictly in the form of increased operating costs. No capital investment is required.

b) Double the sorts

This alternative is the one requiring the largest capital investment, involving outlays for:

-- double the number of bins,
-- extension of the building and transfer chains to the stacker,
-- an in-line moisture detection system.

A small increase in operating and maintenance costs can also be expected.

c) Secondary sorting

The idea behind a secondary sorting system is to reduce the number of additional bins required to make the dry sort. This saves some of the capital cost of extra bins, building and transfer chain extension. However, a re-entry system is now required to feed the dry sort back to the sorter on a third shift or on Saturdays to complete the sort and run it through the stacker. The in-line moisture meter is required as before.

While some capital is saved with this option, operating expenses are higher for sorting and stacking; these costs will double for the dry sort if run on a third shift, and more than double if the re-sort is done on a Saturday, involving overtime rates.

This option also has a severe logistical disadvantage in that partially loaded bins of green wood should be emptied before commencing the final sort of the dry material.

A further observation on the nature of the overall problem and the level of risk is in order. If there is very limited knowledge of the number of years that dead timber will be processed at a specific mill, the risk involved in the capital investment is large. It is questionable whether a large investment should be made if there is no assurance that the equipment will be used over its useful life, or perhaps even long enough to pay off the investment.

3. Net Benefits Due to Sorting

Once the costs and savings for each alternative have been established, the net benefits of sorting can be estimated and a choice made between alternatives.

For this particular problem, the net present value of each alternative can be calculated and the one with the highest positive value selected as the best.

Alternatively, if the savings obtainable from sorting are assumed to be identical, regardless of how the sort is achieved, the selection could be based on the least cost alternative, with the costs expressed on an equivalent uniform annual cost basis.

CONCLUSIONS

While a detailed analysis of the above type has not been completed, a few relevant points are in order to sum up this discussion.

First, by its very nature, the problem is a highly variable one in the degree to which it will affect any given mill over a period of years. It therefore becomes very difficult to quantify the savings obtainable from sorting and drying the dry wood separately.

Second, only sorting in the woods provides an opportunity to obtain benefits from sorting in addition to reduced drying costs.

Third, only sorting in the woods eliminates the need for questionable capital expenditures.

Fourth, only sorting in the woods provides the opportunity to adjust the total sorting cost in direct proportion to the amount of beetle-killed wood handled from one operating period to another.

While these points certainly favor sorting in the woods and running beetle-killed wood separately through the entire milling process, this alternative is not without its problems. The major one, which is common to all three sorting methods, is in marketing packages in which virtually all the pieces are blue-stained. Perhaps continuing the work of the blue-stain fungi and staining and entire piece could provide a solution.

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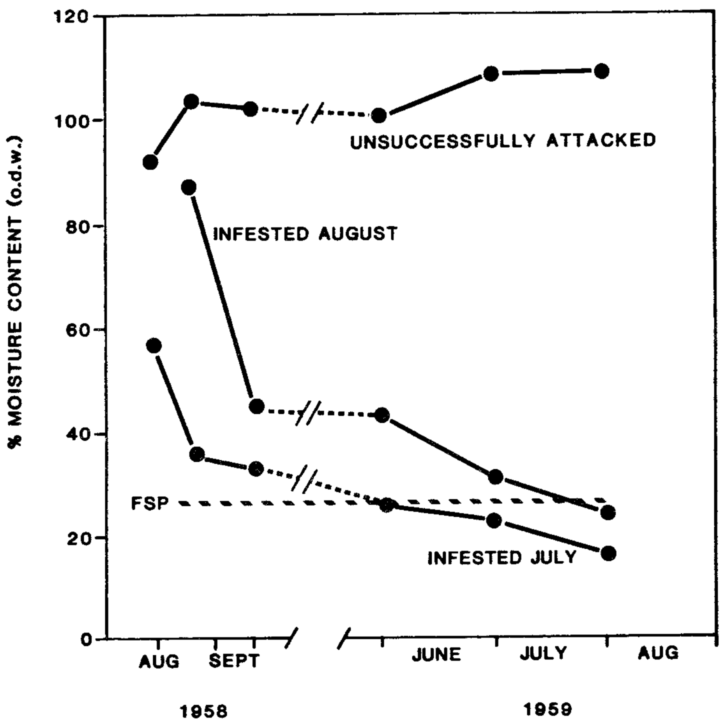

Figure 1. Outer sapwood moisture content of successfully and unsuccessfully infested lodgepole pine at 3 1/2 feet above ground.

Source: Reid, 1961.