DIFFICULTIES DURING INDUSTRIAL DRYING OF HEMLOCK AND POTENTIAL GAINS BY USING ACCELERATED SCHEDULES

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INTRODUCTION

Recent trends in the international market of some western species such as Hemlock, have focused on improved lumber quality standards. As part of a large scale quality improvement program, interest in the drying operation has been intensively renewed.

Construction lumber, most of which used to be sold green, is becoming less acceptable unless it has been dried to a moisture content below 19%. More and more buyers are adhering to this relatively new trend and therefore, it is expected that in about five years, all construction lumber will have to be dried to conform to these standards.

For many producers, drying constitutes a new phase in their production sequence and in addition to significant investments, there are many associated challenges associated with the drying operation. Simultaneously and not least important, is the emphasis that must be given to training programs for the personnel directly involved with the drying operations.

Drying is a time consuming operation as well as an energy intensive process. Quality of the final product is extremely dependent on how well the drying process has been carried out. In addition to all the factors that affect drying results, including lumber preparation and the process itself, initial lumber characteristics may significantly determine the degree of success of the drying operation. For instance, large moisture content distributions will certainly bring considerable difficulty in controlling the drying process, thus increasing the risk of degrade development. Large final moisture content distributions will inevitably occur producing overdried lumber which in turn means wasting of time due to prolonged kiln residence time and downfall due to warping.

Initial and final moisture content distributions for hemlock have been of great interest for a number of years. Initial moisture contents usually vary to a great extent and this causes considerable difficulty in exercising proper control of the drying process. In addition, current kiln control strategies become difficult to apply successfully when large initial moisture content variations exist. Although the problem of initial moisture content variability has been recognized for a number of years, it is still a problem to the lumber industry and it becomes more important as tighter target moisture contents are required.

Sorting green lumber seems to be the immediate technical solution to the problem, however, it may represent some difficulties, for some mills, to be implemented.

Drying of hemlock should be viewed with a broader approach which would involve several phases of the lumber manufacturing process. For example, it should begin earlier in the log yard where logs could be segregated according to their origin and species. Sorting by basic density and moisture content after sawing presorted logs will eventually improve uniformity even further. The idea is to load the kiln with material as uniform in drying properties as possible, and therefore be able to attempt optimizing the drying schedule for each class of material prepared according to the sorting strategies.

In industry, taking action in several processing phases as outlined above can be costly and difficult, however, new imposed quality requirements may justify taking steps towards improving several practices before drying. The main hypothesis is that if findings indicate a significant amount of processing problems and downfall losses occurring due to current practices, then new and non-conventional manufacturing strategies will have to be proposed and evaluated industrially. Another hypothesis is that if accelerated drying schedules can be used without increasing degrade, then potential gains such as reductions in drying times and energy, can be achieved.

OBJECTIVES

To assess management information regarding difficulties during industrial drying of hemlock.

To explore potential gains by using accelerated drying schedules.

MATERIAL AND METHODS

A total of 3,391 pieces (2-in x 10-in x 16-ft) of the Hem-fir species group were included in the study. No sorting or separation of green lumber was carried out. Packages to be used for moisture content and quality assessment were selected at random as the kiln carts were being loaded.

Three different drying runs were monitored. A conventional drying schedule was utilized in the first run followed by two accelerated processes. all drying runs were performed using an industrial dryer with capacity around 200 Mfbm.

Each control piece was weighed and graded prior to drying. At the end of each run, all pieces were weighed and had three moisture content measurements (using an electrical moisture meter) taken along their length. All pieces were then taken to a planer and graded after planing. Grade groups were formed as follows:

a. No. 2 & Better
b. No. 3
c. Economy

In this study, when a piece was graded after the planer, it may have been upgraded or downgraded depending upon the trimming performed. Thus it was possible to have a board that was initially 16-ft long and graded as No. 3, upgraded to No. 2 & Better after being trimmed to 14 feet.

The drying schedules utilized were as follows:

<u>Run A</u>

	Dry Bulb (°F)	Wet Bulb (°F)	Time (h)
heat to	85	80	
ramp to	155	150	12
ramp to	160	155	24
ramp to	170	155	24
ramp to	175	155	16 or to dry

Run B

	Dry Bulb (^oF)	Wet Bulb (^oF)	Time (h)
heat to	85	80	
ramp to	160	150	8
ramp to	175	160	10
ramp to	190	170	12
ramp to	210	185	12 or to dry

Run C

	Dry Bulb (^oF)	Wet Bulb (^oF)	Time (h)
heat to	85	80	
ramp to	175	160	6
ramp to	190	170	6
ramp to	210	185	12
ramp to	220	185	24 or to dry

RESULTS & DISCUSSION

Initial Characteristics of the Lumber

As can be seen in Table 1, there was a large variation in initial moisture content for all drying runs. Although the basic density also showed a considerable variation within each drying run, similar variation was also observed for all runs (Figure 1).

Figure 2 indicates that 50% of the lumber utilized in Run A was already below 50% moisture content before drying began. Approximately 10% of the lumber was even below 35% moisture content and about 10% of the lumber had moisture contents between 100% and 180%. Figure 3 shows the distribution of initial moisture contents and as can be seen, a greater part of the lumber had initial moisture contents ranging from 40% to 70%.

It is also clear in Figure 3 that the normal distribution may not be the best model for the distribution of initial moisture content. The distribution observed is probably better modelled using a lognormal distribution as described by Zwick and Cook[1] 1985.

Figure 4 illustrates that about 40% of the lumber monitored in Run 3 had initial moisture contents below 50%. Similarly as in Run A, 10% of the lumber in Run B had initial moisture contents in the range 100% - 180%. As is shown in Figure 5, the distribution obtained presented similar characteristics to the previous one.

Figure 6 indicates that approximately 50% of the lumber monitored in Run C was below 38% moisture content. Comparatively, it seems that the lumber utilized in Run C was, in general, drier than the lumber utilized in runs A and B. The distribution of initial moisture contents showed a similar trend and a greater part of all lumber had moisture contents, ranging between 30% and 50%.

The results presented were obtained by sampling about 10% of the total lumber being dried in each run. Assuming these give an accurate representative moisture content. Therefore, no matter how sophisticated the kiln controls may be, it is very likely that processing and quality problems will result due to the heterogeneity of the lumber at the beginning of the drying process.

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[1] The modelling of moisture content distributions on censored readings from a resistance meter. R.L. Zwick and J.A. Cook. In Proceedings, Western Dry Kiln Clubs Annual Meeting, 1985. Vancouver, B.C.

Table 1. Initial moisture content and density for the three runs.

		Run A	Run B	Run C
Initial MC (%)	Max	178.1	181.7	132.6
	Min	23.6	28.6	21.1
	Avg	59.6	64.2	42.3
Basic Density (lbs./ft3)	Max	34.5	29.9	28.5
	Min	14.1	14.8	14.7
	Avg	23.0	22.1	21.4

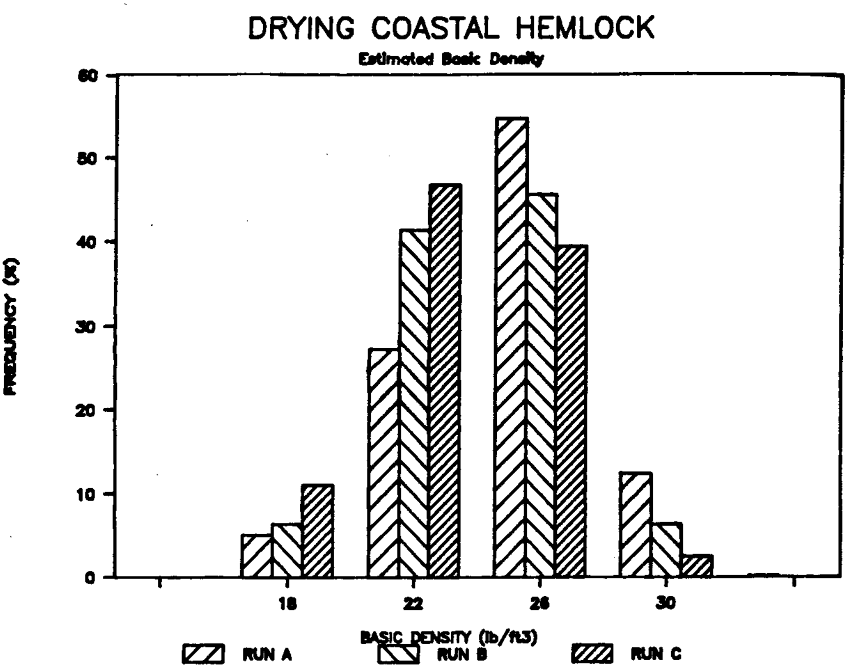


Figure 1.

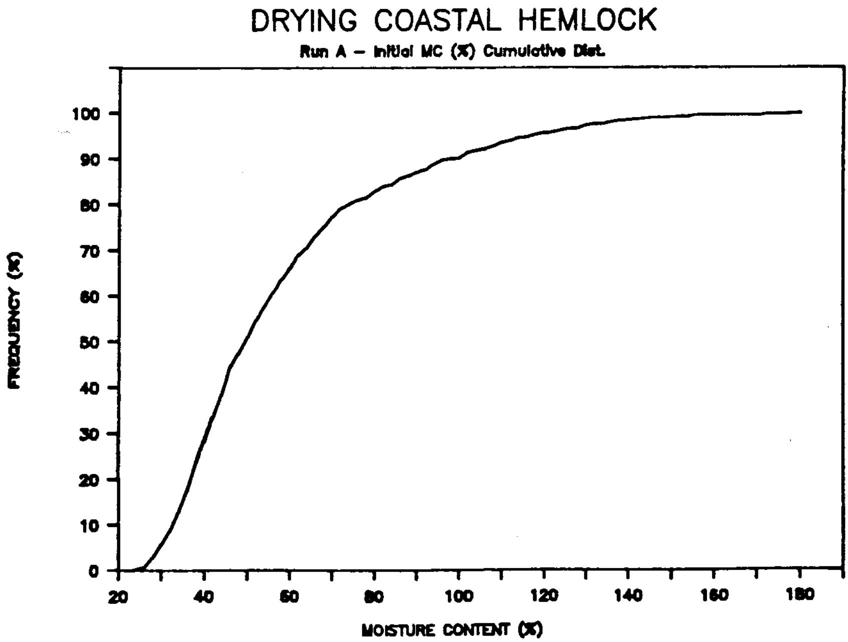


Figure 2.

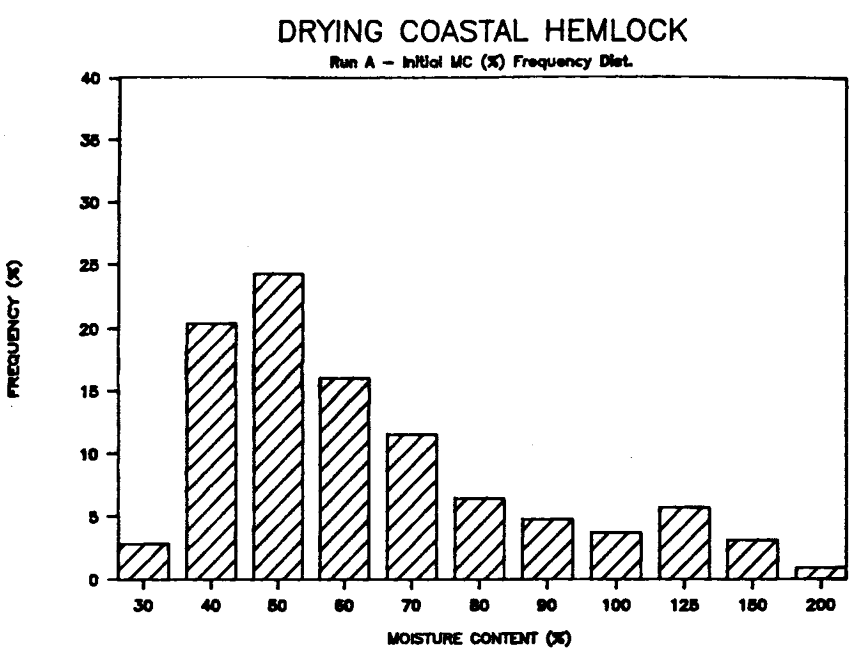


Figure 3.

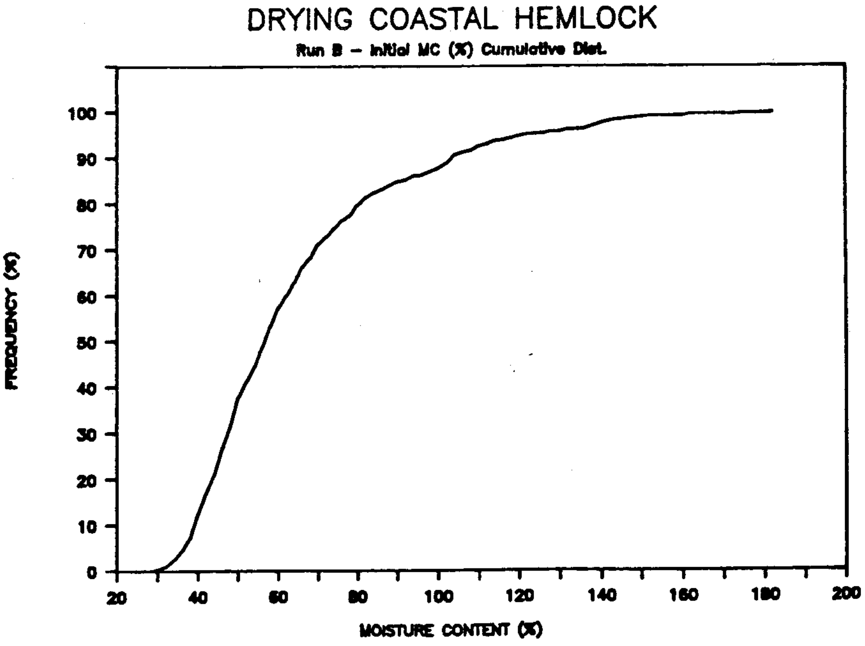
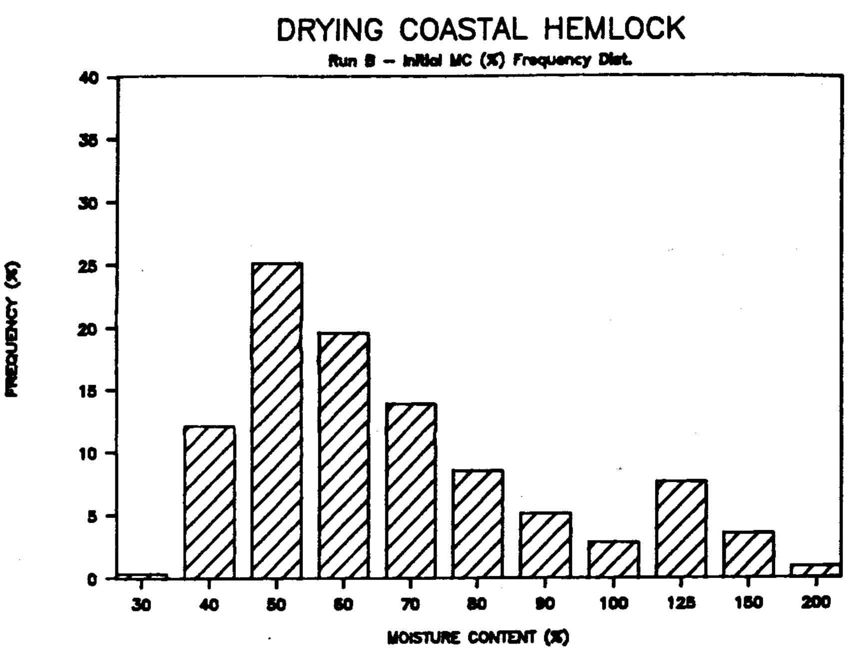


Figure 4.



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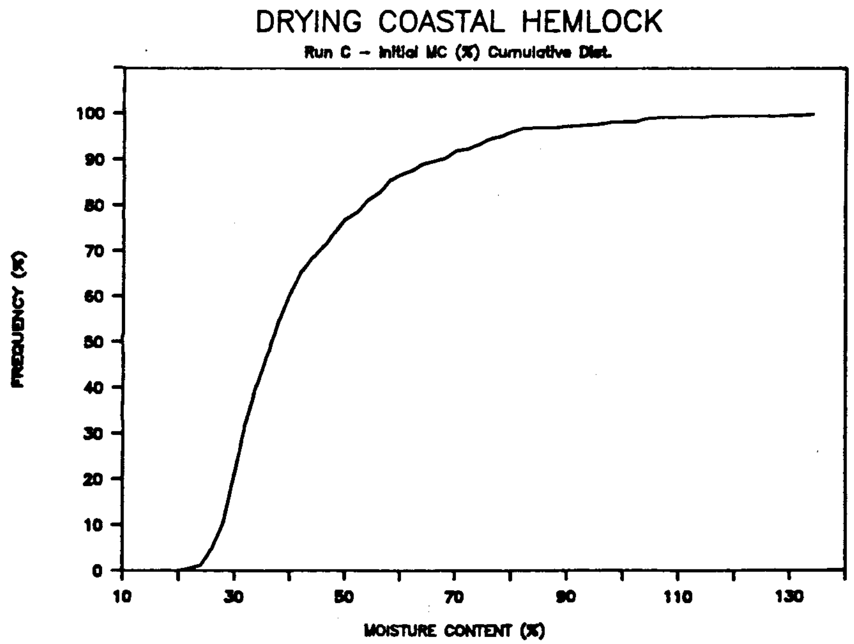

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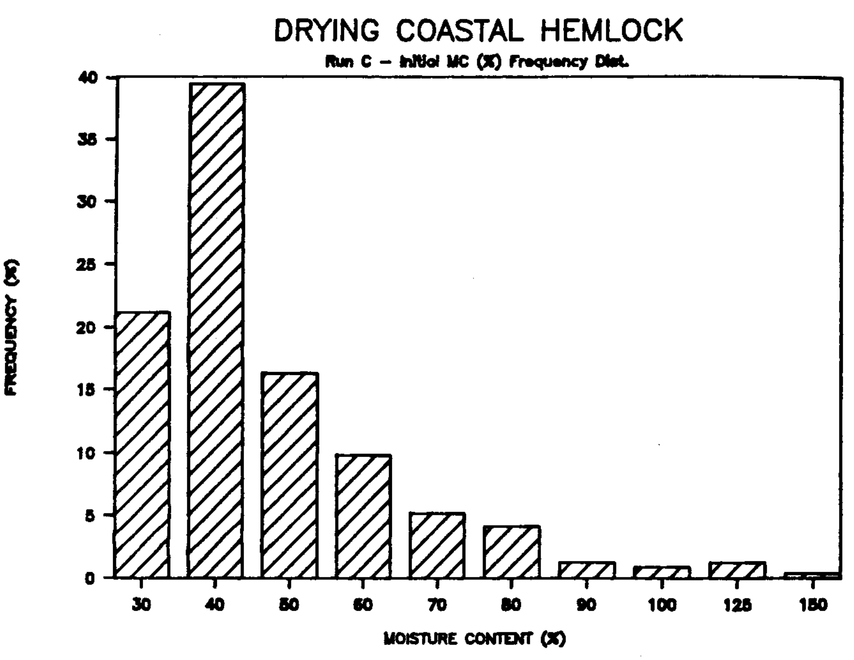

Figure 7.

Final Moisture Content Distributions

From Figures 8, 9, and 10, the following information can be summarized:

	% overdried	% underdried	within target	Kiln resid. time (h)
Run A	25	15	60	78
Run B	50	20	30	46
Run C	85	10	5	52

The amount of overdried lumber in all runs was considerable. Even using a more conservative drying schedule as in Run A, the amount of lumber out of the required range was still too high. Runs B and C, which used high temperature schedules, resulted in much higher percentages of lumber out of the range. On the other hand, drying times could have been reduced even more, thereby minimizing or eliminating the quality problems due to overdrying.

When kiln residence times are compared, it can be seen that even though the total drying time for Run A was about 60% longer than for runs B and C, it still produced an excessive amount of lumber above the target moisture content.

Runs B and C were unnecessarily extended and because initial moisture content distributions showed a wide variation, both runs produced a great amount of overdried lumber. These runs were characterized as attempts to substantially reduce drying times using accelerated drying schedules. Although these cannot be considered to be optimized schedules for Hem-fir, they do illustrate the potential of high-temperature schedules for reducing drying times.

The results obtained for runs B and C indicated that depending on the initial moisture content distribution, drying times will possibly be reduced even further and thereby provide two immediate benefits:

1. increase kiln throughput;
2. avoid excessive overdrying and therefore improve grade recovery.

An important contributing factor for the overdrying problem observed in all three runs was the wide distribution of initial moisture contents. In general, 30% of the lumber in all runs had initial moisture contents below 45%. In Run C, the problem was even more severe since 70% of the lumber had initial moisture contents below 45%.

Independently of the drying schedules used, the overall results have shown that the wide variation in initial moisture content resulted in inevitably large variations in final moisture content and most importantly, a large amount of overdried material. The schedules themselves did little to decrease moisture content variation.

Table 2. Final moisture content distributions for the three runs.

	MC < 13%	13 < MC < 16%	MC > 16%
Run A	25	60	15
Run B	45	34	18
Run C	85	7	8

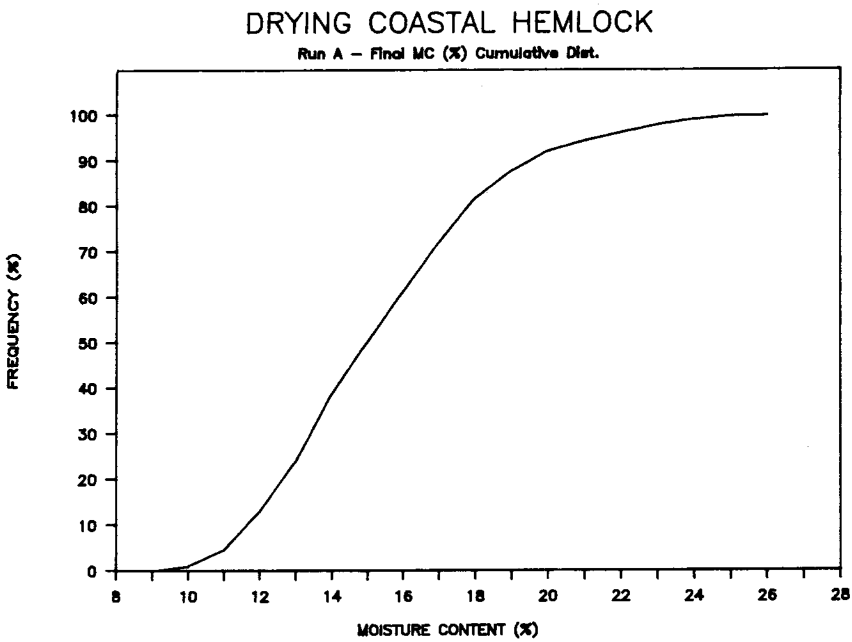

Figure 8.

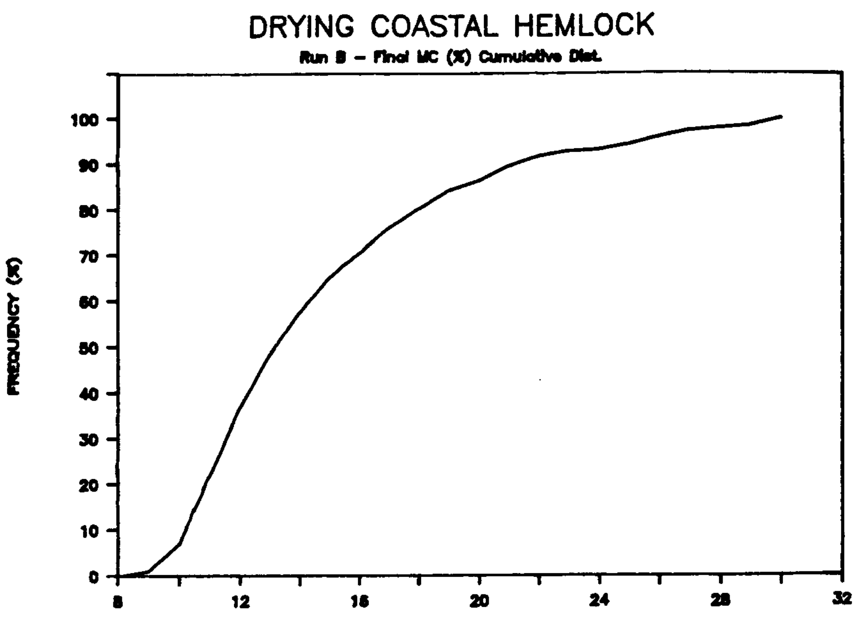

Figure 9.

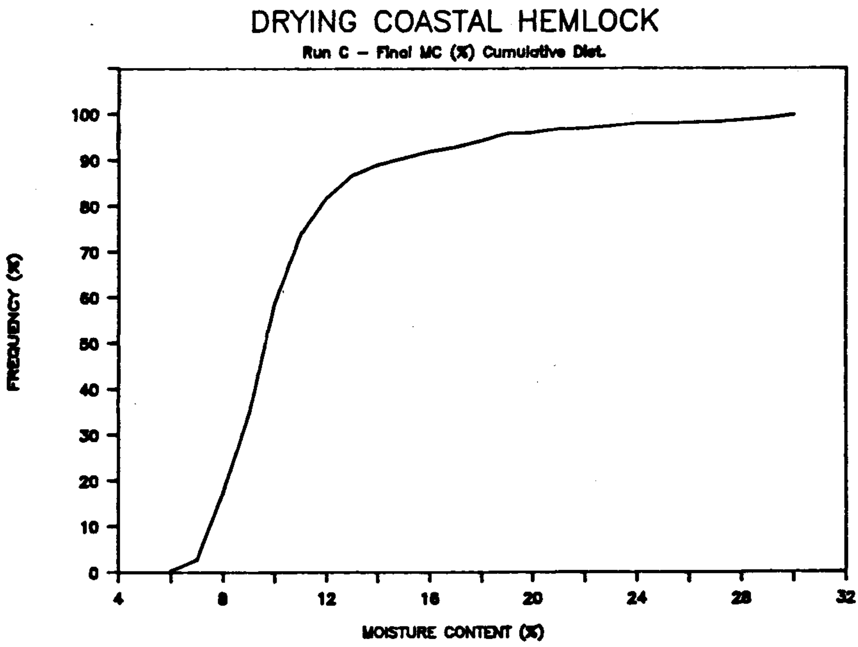

Figure 10.

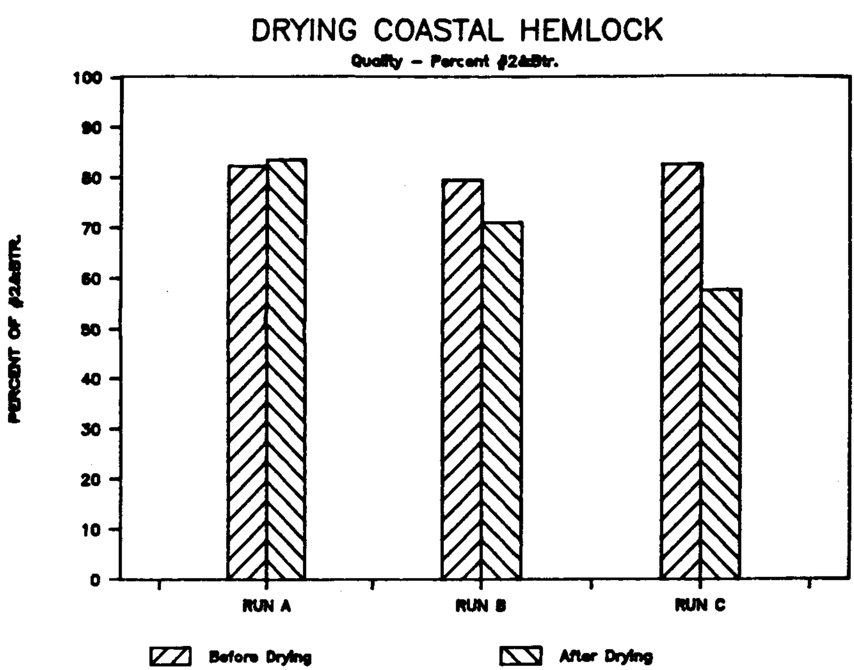

Figure 11.

Quality

As was expected, degrade, mainly warping and checking, was strongly influenced by final moisture content. Figure 11 illustrates the changes in quality for all drying runs. Comparing figures 8, 9 and 10, it can be observed that final moisture contents for Run C were lower than for Runs A and B. Figure 11 illustrates quality before and after drying and it is clear that the amount of degrade increased for Run C which also produced lumber with the lowest final moisture content range. The high decrease in the amount of lumber classified as No. 2 or Better and consequently, the increase in the amount of lumber with lower grades, can certainly be associated with the amount of overdrying.

Although Run B had a lower grade recovery when compared to Run A, it seems that the reduction in drying time, for certain purposes, may justify speeding up the drying process to increase productivity. More uniform initial moisture contents will probably benefit grade recovery for the schedules used in all three runs and possibly, there will be no appreciable difference in quality in lumber being dried by a schedule similar to that used in Run A or Run B.

FINAL COMMENTS

Although the findings presented were observed in the course of a normal industrial operation, they are not intended to simply generalize the problems discussed. Clearly, the extent and severity of the problems mentioned vary greatly among the lumber processing industry. Nonetheless, the problems pointed out do occur and constitute significant difficulties during lumber processing with serious implications on competitiveness and profit losses. The problems discussed can hardly be solved by attempting only to modify the drying process. Rather, a broader approach connecting and establishing control measures in several stages of processing must be carefully designed. Sorting procedures such as segregating lumber into several moisture content classes will definitely reduce variation and consequently minimize quality problems due to overdrying. Technology for moisture content sorting is already available and results have already indicated significant benefits.

Equally important, studies designed to investigate drying rate variability within a species should be pursued in order to establish a well defined "dryability" concept taking into account characteristics such as basic density and their relation to water removal. Knowledge of how drying rates vary throughout the moisture content range should provide valuable information for control systems.

More success in drying of hemlock will likely be achieved when the problems are approached simultaneously outside and inside the usual dry kiln boundaries.