RECENT DEVELOPMENTS IN INCISING TECHNOLOGY

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Summary

The refractory heartwood of species such as spruce and lodgepole pine can now be treated to meet Canadian wood preservation standards. This is a consequence of a series of innovations in incising technology originating in the Pacific Coast region of North America. Double-density[1] incising, developed by Forintek, coupled with the Gen II PermacisorR developed by B.C. Clean Wood Preservers Ltd. provides a sufficient density of incisions for spruce-pine-fir lumber to be effectively treated without destroying its surface appearance. However, drying to around 30% moisture content and pressure treating for longer than is commonly done at present will be required to meet the standards.

Historical Background

Although perforation of wood to improve preservative penetration has been around as long as pressure treating, it is only in the last five years that the technology has been developed to incise lumber of refractory species for the residential market, where the appearance of the product is crucial. Prior to 1915 incising was generally done by hand with a variety of knives, spikes or drills. The first machine in the United States for mechanical incising was designed, built and operated in Portland Oregon. It was used to improve creosote treatment of Douglas fir railway ties (4). Since that time the Pacific coast of North America has continued to be the birthplace of new developments in incising technology (3,8,12,18,19,20,21).

Until the increase in use of treated wood for residential construction in the 1970's, incising technology had not changed in 60 years (13). The dimensions being incised were now smaller, the preservatives had changed from oil-borne to water-borne and the products had changed from railway ties and bridge timbers to landscaping products where surface appearance was important. Nevertheless, lumber incisors were built based on the technology developed for railway ties using large blunt teeth and spacings of 800 to 3800 incisions per square metre (i/m^2).

Some of the higher incision densities were adequate to achieve a continuous envelope of preservative treatment in more treatable sources of coastal hem-fir, using water-borne preservatives, but they proved ineffective for Engelmann spruce, western white spruce, lodgepole pine and Douglas fir (9,17). Closer spacing of incisions was needed.

A significant development in achieving closer spacings and improving the flexibility of incisors was the tooth-ring and spacer-ring system patented by Toberg (21). This system allowed the spaces between rows of incisions to be varied. Unfortunately, using closer spacings the incising teeth gripped the lumber surface causing stripping, hence a number of systems were developed to overcome this problem.

Silcox (19,20) took the use of spacer-rings a stage further in his clean-ring concept; using moveable spacer-rings to push off the strips gripped between the incising teeth. Using a different approach de Lissa (8) dispensed with spacer-rings to achieve an extremely closely spaced pattern and used mechanical damping between the tooth rings to minimise stripping. Using these systems and thin sharp teeth, the two incisors achieved incision densities of approximately 6000 i/m^2 (19,20) and 8000 i/m^2 (8) respectively.

The incisor described by De lissa is currently operating at Western Wood Preservers Ltd., Surrey, B.C., but only the incisor developed by Silcox (19,20) became widely available (as the Gen II Permacisor^R). Unfortunately this incisor still did not have a sufficiently closely spaced and deep incising pattern to allow Canadian standards to be met with Canadian wood species (14).

Incisor development at Forintek

At Forintek's Vancouver Laboratory, Ruddick (16) increased the density of incisions from a conventional roller incisor by passing the lumber through twice. From this work arose his concept of synchronised pairs of rollers laying down two superimposed patterns of incisions on each face of a board in a single pass (18). This process allowed the gaps left by the spacer-rings on the first roller to be filled with incisions from the tooth rings on the second roller (Figure 1) doubling the density of incisions.

Keith and Chauret (10) and Ruddick (16,17) had already shown that the area penetrated by chromated copper arsenate (CCA) from a single incision was a thin lens shape in cross section, typically 25-40 mm long and 3-4 mm across for white spruce and Jack pine or lodgepole pine. For incising to provide a continuous envelope of treated wood the area of wood treated as a result of penetration from individual incisions must merge. The depth of the treated shell would then be determined by the length of the tooth. By calculation from the above measurements the minimum incision density should be around 9,000-10,000 i/m^2 for a tooth width of 10 mm and tooth thickness of 2 mm. These incisions densities could readily be achieved by converting a conventional roller incisor to run with synchronised pairs of rollers: double-density incising (DDI).

Transferring Forintek's technology to the industry

Only one company, B.C. Clean Wood Preservers Ltd., showed interest in this technology. Fortunately, their Gen II Permacisor^R was ideally suited to be converted to double-density incising. It had the clean-ring system for coping with stripping and this effectively limited how closely the teeth could be spaced. It also had thin sharp teeth which leave an acceptable surface appearance on green lumber and should not cause excessive strength loss at high incision densities. Most importantly it already had two sets of top and

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[1] The Double-density incising technology has been licensed to Timber Specialties Ltd.

bottom rollers holding two alternative tooth profiles, one with thin, short teeth (code number 16ST) for decking and one with larger, thicker, wider and less closely spaced teeth (code number 15ST) for preserved wood foundation lumber. Double-density incising could be achieved by synchronising the two pairs of top and bottom rollers, adding one additional set of side rollers and using the same tooth profile on all rollers. A collaborative project was therefore set up between B.C. Clean Wood Preservers Ltd. and Forintek Canada Corp.

Earlier work on a laboratory prototype (15) had demonstrated that double-density incising using the 16ST teeth (Figure 2) could provide a continuous envelope of treatment around 7 mm deep. A longer tooth was required to achieve 10 mm deep incisions. The 16ST tooth profile was therefore extended from 10 to 12 mm (Figure 2) and tooth rings were manufactured with the new profile. One of the Gen II incisors at B.C. Clean Wood Preservers Ltd. was modified as outlined above and a number of additional engineering improvements were made to the original design (Figure 3). The DDI Gen II is now operational at B.C. Clean Wood Preservers Ltd. (Figure 4).

A number of laboratory experiments have been carried out using spruce, pine and alpine fir, double-density incised with this machine and many of the results have been submitted for publication in the Forest Products Journal. These experiments have shown that SPF treats much better at 30% then at 16% moisture content, that a 6 hour pressure period may be required to meet the standard and that the strength reduction caused by double-density incising does not exceed the allowance in the building codes. The work described here is one part of an experiment designed partly to compare the effects of two different planing, incising and drying procedures on treatability and partly to compare the results achieved by commercial treatments to those obtained in our laboratory experiments. Only the latter comparison will be discussed here.

Materials and methods

Fifty 3.6 m (12 ft) nominal 2 x 6 inch boards each of green, white spruce (Picea glauca (Moench) Voss) or Engelmann spruce (Picea engelmannii Parry), lodgepole pine (Pinus contorta Dougl.) and alpine fir (Abies lasiocarpa (Hook.) Nutt.) were obtained from a sawmill in Valemount British Columbia. Each board was cut in two and half was kiln dried for an experiment reported elsewhere. The green half was planed, then a 300 mm sample was cut from it and end-sealed with a two-part epoxy resin. The remaining 1.5 m length was then incised using the double-density incisor. The incised boards and unincised samples were then dried to a mean moisture content of 30% using a conventional kiln schedule (71° C dry bulb, 60° C wet bulb). A 250 mm sample was then cut from each board and end-sealed. The remaining 1.2 m length and the 300 mm unincised samples were returned to B.C. Clean Wood Preservers Ltd. and pressure treated with 2.0% CCA type C using treatment schedule A below. The 250 mm incised samples were treated with 2.5% CCA type C in Forintek's pilot plant using our standard treating schedule, schedule B below

Schedule A

- 1/2 hour vacuum 580 mm Hg
- Flood chamber
- Pressure increased to 1035 kpa over 5 minutes
- 3 hours at 1035 kpa
- Release to atmosphere
- Drain cylinder
- 1 hour clean up vacuum 580 mm Hg

Schedule B

- 1/2 hour vacuum 700 mm Hg
- Flood chamber
- Pressure increased to 1035 kpa (150 psi) in 172 kpa increments with a 5 minute period after each increment
- 6 hours at 1035 kpa
- Release to atmosphere
- Drain cylinder
- 15 minute clean up vacuum 700 mm Hg

The treated boards were left for a minimum of 4 days for fixation to take place prior to sampling.

Increment core samples, 6 mm in diameter, were then removed from the heartwood face of each board or sample and longitudinally split in two halves. From each group of 50 cores the first 20 comprised charged number 1 and the second 20 comprised charge number 2. The remaining 10 were not used in this study. They were checked for copper penetration, using the chrome-azurol-S reagent on half of the split core (1) and for preservative retention using X-ray fluorescence spectroscopy (2) on analytical discs made from the sets of 20 aggregated half cores.

The cores were ground in a Wiley Mill to produce wood flour passing a 40 mesh screen. Analytical discs consisted of a mixture of 0.4 g of oven dried wood-flour and 0.1 g of cellulose powder pressed at 132 kPa for three minutes. X-ray counts from the Tracor Northern X-ray spectrometer were converted to weight of preservative per unit weight of wood using a computerized fitting procedure which corrects for inter-element interference and sample matrix effects. This data was then converted to weight of preservative per unit volume of wood using a standard density for each wood species.

Results and discussion

As expected, the commercial treatment of unincised material gave results which did not come close to meeting the CSA 080.2 standard (80% ≥ 10 mm and 4.0 kg/m^3 for above ground, 80% ≥ 10 mm and 6.4 kg/m^3 for ground contact) or the Canadian Institute of treated wood PS1 standard which requires 80% ≥ 5 mm penetration and 6.4 kg/m^3 (Tables 1 and 2). In contrast double-density incised spruce and pine with commercial treatment met CITW PS1 and came very close to meeting CSA 080.2 for above ground uses. In both cases one charge met the CSA 080.2 and one just failed on penetration. Under the same conditions alpine fir passed not only CITW PS1 and CSA 080.2 above ground requirements but also CSA 080.2 ground contact requirements.

Under pilot plant conditions, but simulating an industrial schedule, spruce, pine and alpine fir treated for 6 hours all passed CITW PS1, CSA 080.2 above ground and CSA 080.2 ground contact requirements. Indeed spruce and alpine fir met the higher retention requirements of CSA 080.15 (8.0 kg/m^3). They both failed the penetration requirement of CSA 080.15 because, although they had over 80% of cores with greater than 10 mm penetration, they had individual cores with under 6 mm penetration. Lodgepole pine met the penetration requirement of CSA 080.15 but failed on retention. The lower retention in pine may have been due to its higher density resulting in a lower void volume available to be filled with preservative solution.

The much higher preservative retentions in the pilot-plant-treated material than in the commercially treated material would have been due partly to the higher solution strength used and partly to the better preservative penetration. Although the pilot plant treatments were done under laboratory conditions with a different treatment schedule, it seems likely that the better preservative penetration in the pilot plant treatments was due, in a large part, to the longer press time. This conclusion was supported by the results, of increasing press time on preservative treatment of double-density incised spruce, pine and alpine fir reported elsewhere (11).

In comparing treatability between species, alpine fir stood out as the most treatable of the three, as in other similar experiments (11). Spruce, although less treatable than pine without incising, gave very similar penetration results to pine with both the commercial and pilot plant treatments when double-density incised. This has been confirmed in other experiments (11).

By double-density incising and using a 6 hour pressure period, the differences in preservative penetration between the species were overcome, suggesting SPF could be pressure treated as a species group. This would significantly reduce raw material costs to the treaters who are now purchasing pine lumber sorted from SPF. This technology will allow Canadian treaters to produce SPF lumber, with an acceptable surface appearance treated to meet the requirements of CSA 080.2.

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TABLE 1

TREATABILITY OF SPRUCE, PINE AND ALPINE FIR WITH TWO TREATING PROCESSES

DDI	Treatment	Charge	Spruce		Pine		Alpine Fir	
			Penetration % ≥ 10 mm	Retention kg/m^3	Penetration % ≥ 10 mm	Retention kg/m^3	Penetration % ≥ 10 mm	Retention kg/m^3
Yes	Pilot Plant 6 hour press 2.5% solution	1	100	11.4	95	7.5	95	12.4
		2	95	12.0	85	7.7	95	11.5
Yes	Commercial 3 hour press 2.0% solution	1	70*	4.8	75*	4.8	90	7.1
		2	8	5.7	80	4.7	100	6.5
No	Commercial 3 hour press 2.0% solution	1	0	1.7	20	2.3	10	4.2
		2	10	2.7	20	3.2	25	3.0

* plus 1 sample (5%) at 9 mm

TABLE 2

COMPLIANCE OF SPRUCE, PINE AND ALPINE FIR WITH THE 5 mm PENETRATION REQUIREMENT IN THE CITW PS1 STANDARD USING TWO TREATING PROCESSES

DDI	Treatment	Charge	Spruce Penetration % ≥ 5 mm	Pine Penetration % ≥ 5 mm	Alpine Fir Penetration % ≥ 5 mm
Yes	Pilot plant 6 hour press 2.5% solution	1	100	100	95
		2	95	100	95
Yes	Commercial 3 hour press 2.0% solution	1	85	90	95
		2	100	90	100
No	Commercial 3 hour press 2.0% solution	1	5	30	35
		2	25	30	45

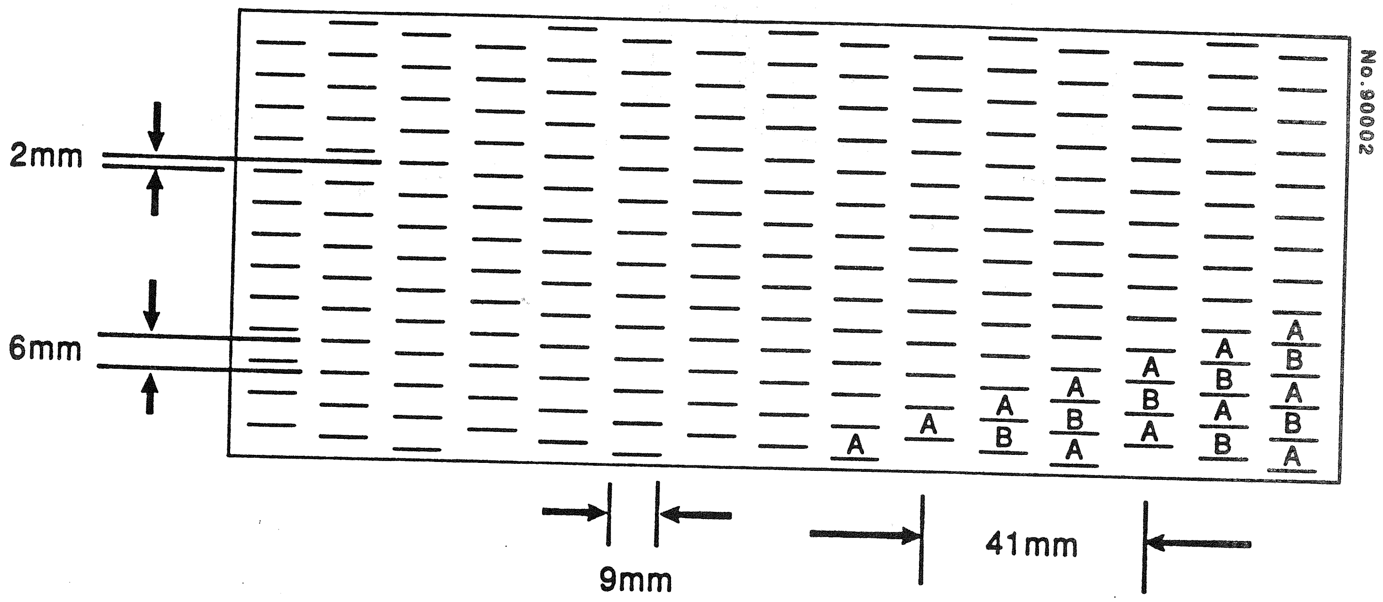

Figure 1 The double-density incising pattern. Incisions labelled "A" and "B" were made by the first and second rollers respectively.

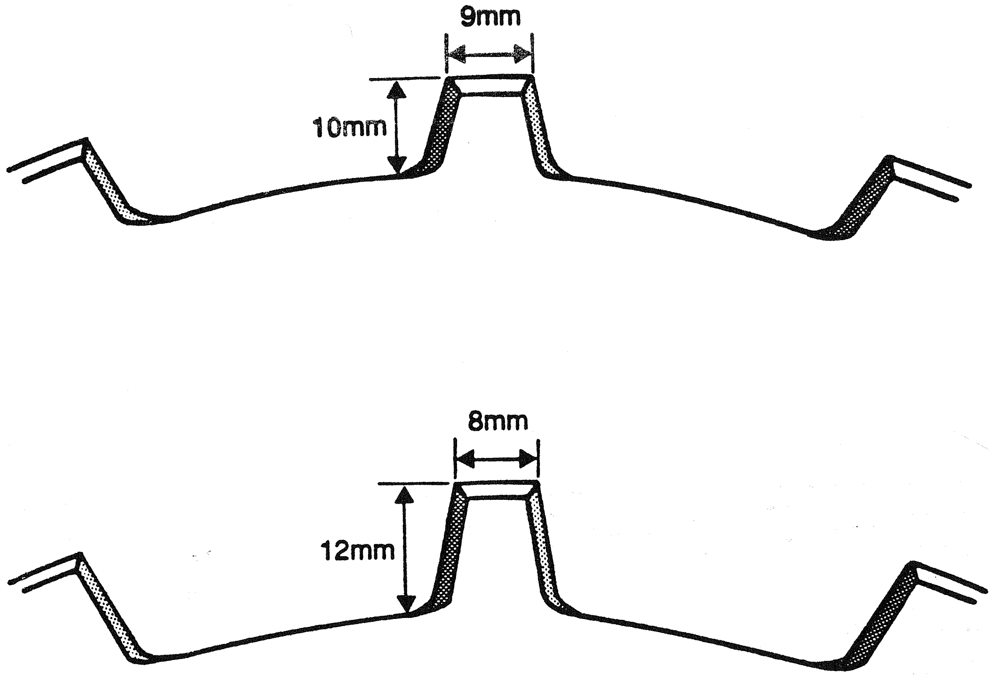

Figure 2 The Gen II Permacisor^R 16ST tooth (top) and the new extended tooth profile (bottom).

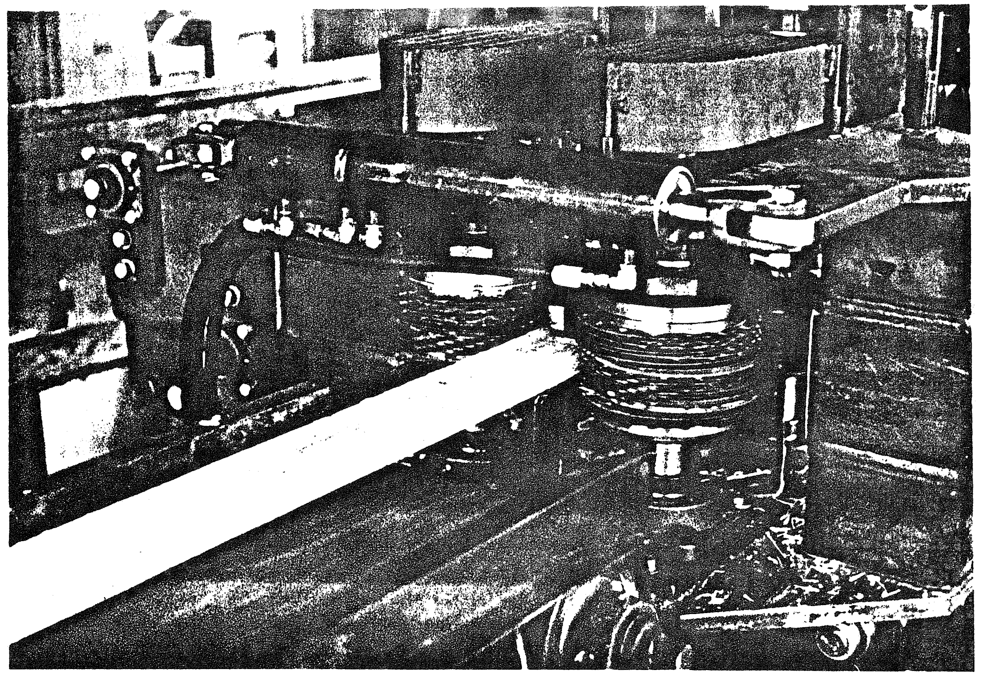

Figure 3 SPF lumber emerging from the two pairs of side heads on the commercial prototype double-density incisor. The clean rings can be seen on the parts of the rollers not in contact with the lumber.

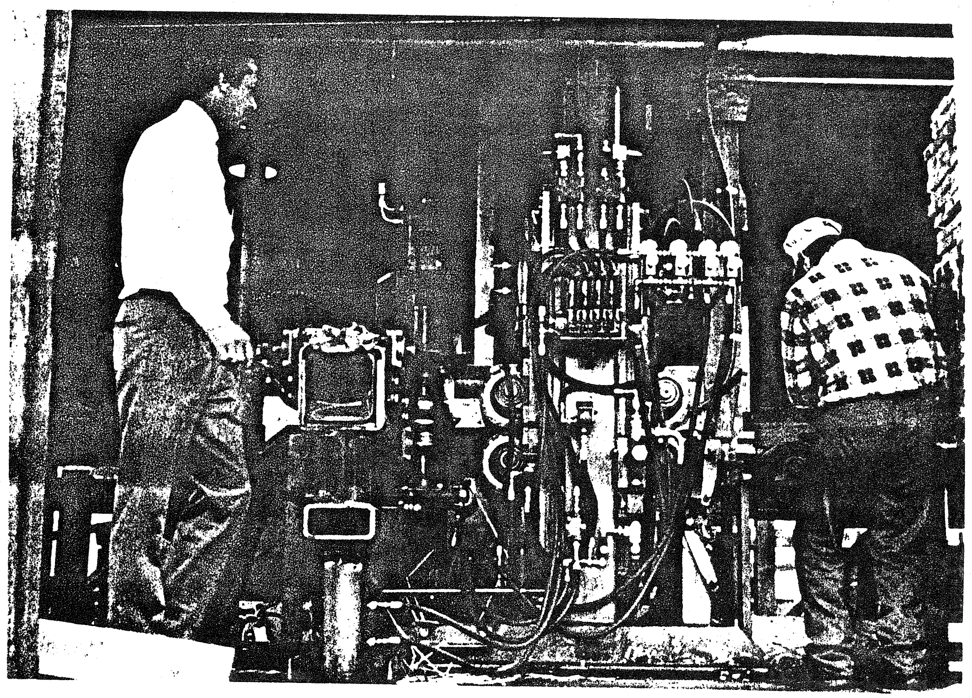

Figure 4 The commercial prototype double-density incisor in operation at B.C. Clean Wood Preservers Ltd. The two pairs of top and bottom rollers can be seen on each side of the frame supporting the hydraulics.