



Serving the Forest Products Industry in Products Development, Process Improvement and Training

Manufacture of High Strength LVL from Lodgepole Pine Using State-of-the-art Continuous Press System

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ABSTRACT

The first Continuous Press System (CPS) to manufacture LVL started operating in Rocky Mountain House Alberta, Canada in October 1997. The major components of the line include a veneer scarfer/stress grading line, veneer feeder with a skew correction system, dual level lay-up line, microwave pre-heater, and a continuous press system. The main species of wood used to manufacture LVL is Lodgepole pine.

Material flow and the function of each process center are discussed. Among other techniques, a combination of veneer stress grading and densification is used to increase the amount of Lodgepole pine veneer that can be used to manufacture high strength LVL for structural applications. The performance of this line is examined after 18 months of operation. The advantages of the technology and opportunities that it provides in product development are also discussed.

In light of the available technology, the paper concludes by questioning the current approach taken towards new forest products development and adaptation of new technologies by the industry. It is proposed that a mutual three party alliance involving researchers, equipment manufacturers and the forest products industry is important in order to realize the opportunities offered by the technology and advance the utilization of the resource further.

INTRODUCTION

As opposed to the newer generation panel products, mechanization of the plywood manufacturing process has always been a challenge. Being born out of the veneer and plywood industry, Laminated Veneer Lumber (LVL) was no different until the first highly automated production line was started in 1997. Using a microwave pre-heating system installed before the press entrance, the capacity of the line is 70,000 m³ (2,500,000 ft³) per year.

The line is designed to manufacture long ribbons of LVL with a maximum thickness of 88.9mm (3 in) operating with manpower of only 4-5 people. The conveying system is 1500mm (59 in) wide and the veneer clipping strategy determines the width of LVL. Up to 1245mm (49 in) wide LVL is manufactured as determined by the veneer with.

The veneer scarfer and the eight-bin veneer feeder along with the skew correction system were designed and installed by Corvallis Tools Corporation of Oregon USA. The dual level continuous lay-up line, the microwave pre-heater, and the continuous steel belt press were designed and installed by Dieffenbacher of Germany.

During the start-up period, besides the normal issues of starting up a new plant there were issues that had to be resolved regarding veneer handling and placement at speeds of over 120m (400ft) per minute. Resolving these issues required some changes in machine design and programming as well as the way veneer is prepared and handled. A lot has been achieved in both regards since then and a second such plant is in operation in southern USA with a third one planed to start in June 1999 in the Northwest. The preceding sections discuss about this new process with a brief note on veneer peeling.

VENEER PREPARATION

Debarked blocks of Lodgepole pine with an average length of 2600 mm (102 in) and 200 mm (8 in) diameter are conditioned to 90⁰ C. The blocks are then fed through a round-up lathe before they are peeled on a spindle-less lathe. The veneer is peeled to 3.3 ± 0.5 mm (0.130 ± 0.020 in). As opposed to conventional lathe, this peeling technology does not use chucks to center and spin the blocks during the peeling process and relatively smaller cores, measuring 50 mm (2 in) are left after peeling each block. Full sheets of green veneer are clipped to 1350 mm (53 in) and sorted into three moisture groups using a five-bin green veneer stacker. A standard veneer dryer is used to dry veneer to an average moisture content of 6%. Visually graded full sheets of dry veneer are then moved to the scarfing and stress grading line.

Dry veneer is fed through a Metriguard Ultrasonic Veneer Grading Machine. At start-up veneer was classified as structural or none structural based on its Ultrasonic Propagation Time (UPT). The structural veneer was used to make 12.4 Gpa (1,800,000 psi) MOE LVL using uniform grade veneer. This grade of LVL, which is referred to as 1.8E product in the North American market, is the most common structural grade LVL and referred to as high strength LVL in this presentation. It should be noted, however that small quantities of stronger and stiffer engineered wood products including LVL are being sold in this market. Up until recently all structural LVL was made from mainly Douglas Fir with limited quantities of Southern Pine.

At start-up, less than 50% of the post-stress-graded Lodgepole pine veneer was used to make the 1.8E LVL. The rest was sold for plywood applications or used to make lower grade LVL. Figure 1 is the UPT distribution from 55,000 sheets of Lodgepole pine veneer. The relationship of veneer stiffens (E) with the velocity of ultrasonic wave (V) and density (D) is established such that $E=V^2D$. Thus the faster the propagation time (the lower the UPT) the higher will be the anticipated stiffness of the veneer.

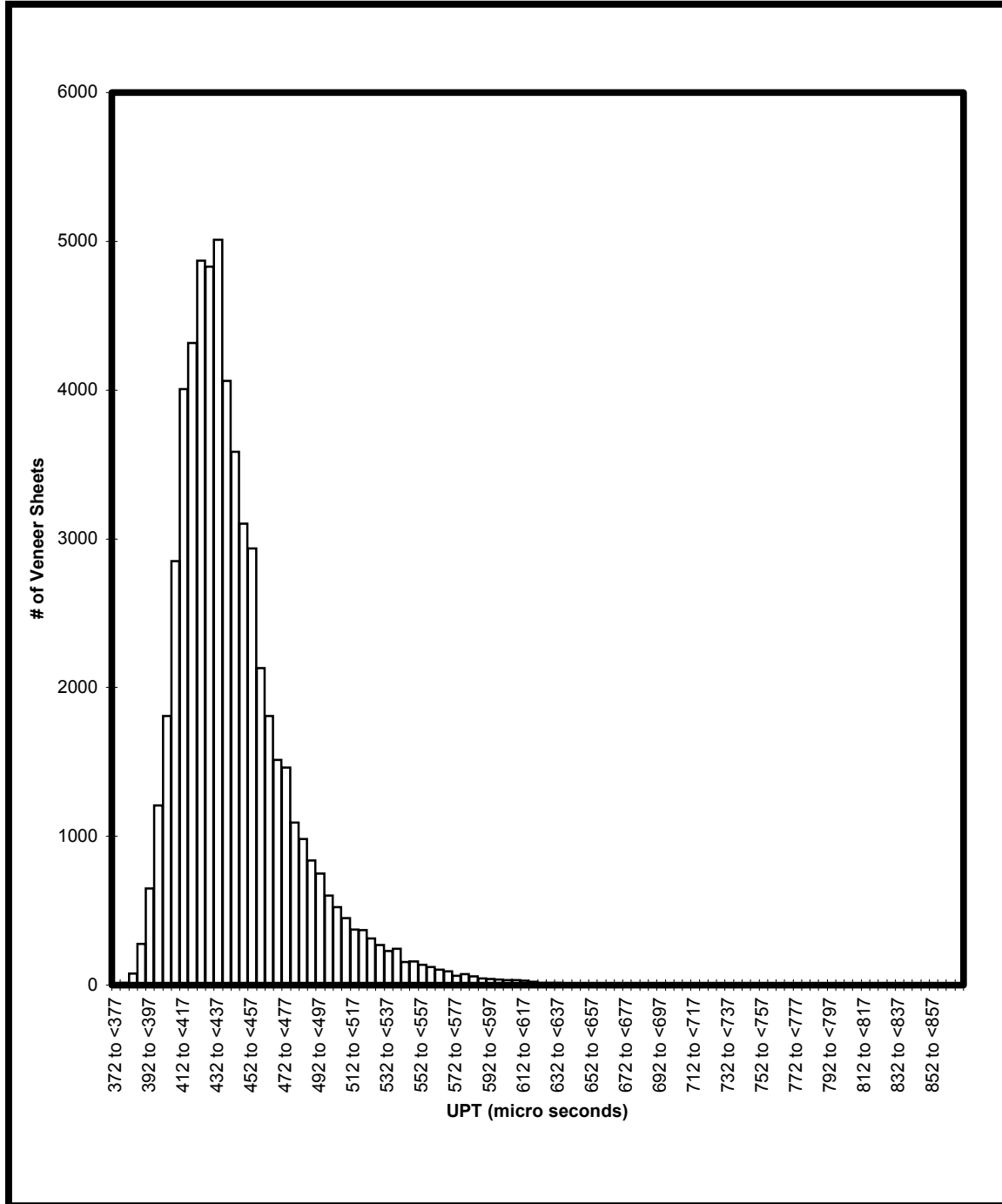


Figure 1: Lodgepole pine UPT distribution

Following further development work, the veneer is now sorted into four grades identified as G1, G2, G3, and G4 (Figure 2). The top three grades of veneer are then scarfed and stacked into different bins for use in the manufacture of high strength LVL. The high strength LVL is manufactured from a proprietary mix of the top three grades. G4 veneers are stacked before scarfing and sold for plywood manufacture or re-graded for the manufacture of lower grades of LVL.

The amount of veneer that is used for high strength LVL is increased to a theoretical volume of over 85% of the post-stress-graded veneer stock. This is achieved using mixed grade veneers as well as extra compression. This volume is about 10% lower in actual production, partly due to variations in log source, veneer moisture content and other operational reasons. It has been also been established that over 20% of post-stress-graded Lodgepole pine veneer can produce stronger and stiffer LVL. Up until now the company concentrated on producing the 1.8E product as dictated by market forces.

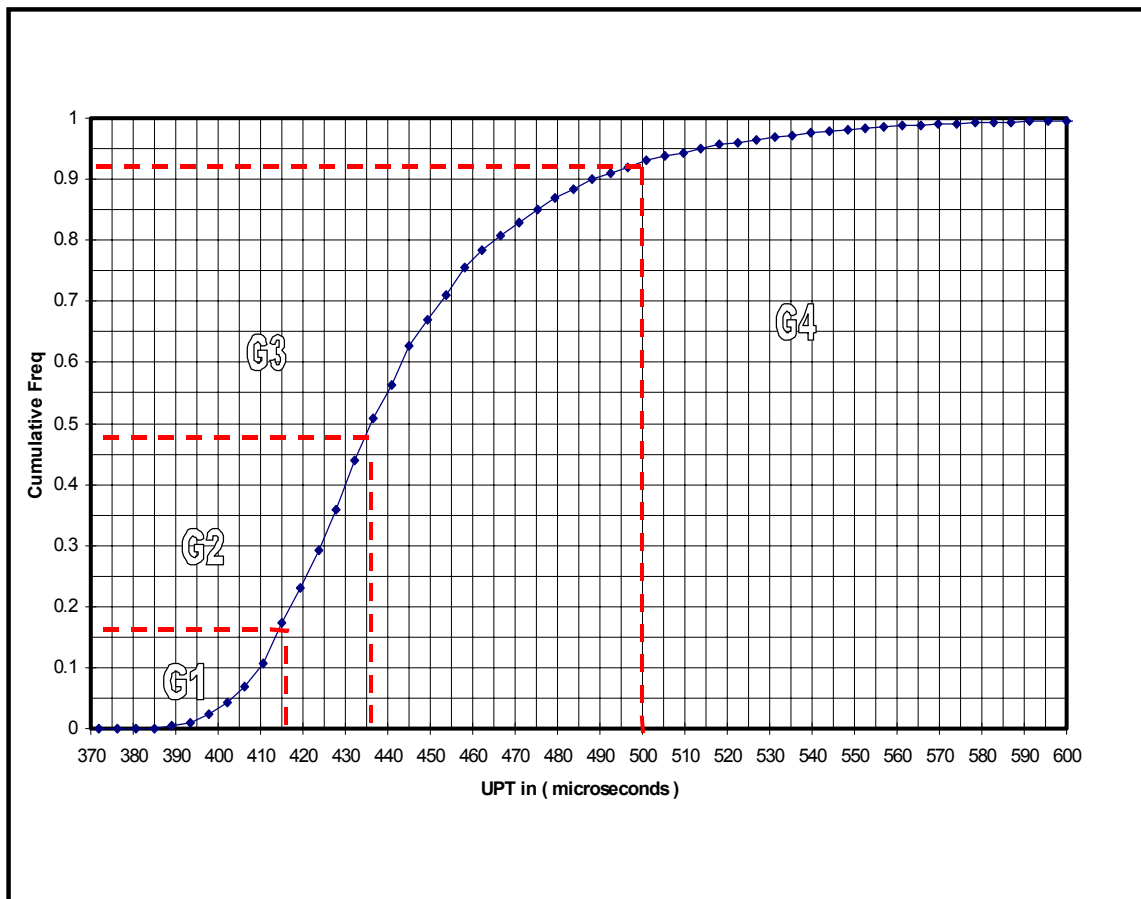


Figure 2: Lodgepole pine veneer stress grade classification based on UPT

All veneer used for LVL is scarfed 25 ± 6 mm (1 ± 0.25 in) from the ends with a ‘bull-nose’ of 0.8 mm (0.03 in). Veneer sheets are squared on three sides during the scarfing process. The target scarfed veneer length is 2540 ± 6 mm (100 ± 0.25 in).

VENEER FEEDER LINE

The feeder line is made up of eight bins. The first bin is designed to handle cross-banding veneer stock and other panel materials like OSB that can potentially be used as core stock. This is followed by five bins to handle various grades of veneer with the tight face of veneer up or down based on the desired configuration of LVL to be manufactured. The seventh bin is used to handle replacement sheets of veneer and the last bin, which is located after the “curtain-coater” is used for face veneer.

The unique feature about the veneer feeder line is that air suction is used in the transport of the veneer to the dual layer lay up line, past the curtain-coater and the skew correction unit. The use of suction air ensures that veneer sheets stay on the line at speeds of over 120m/ minute (400 ft/minute) without misalignment. The skew correction unit (Figure 3) is designed to align veneer sheets with-in ± 6 mm (0.25 in) of the leading edge while the sheets are on transit towards the lay-up line.

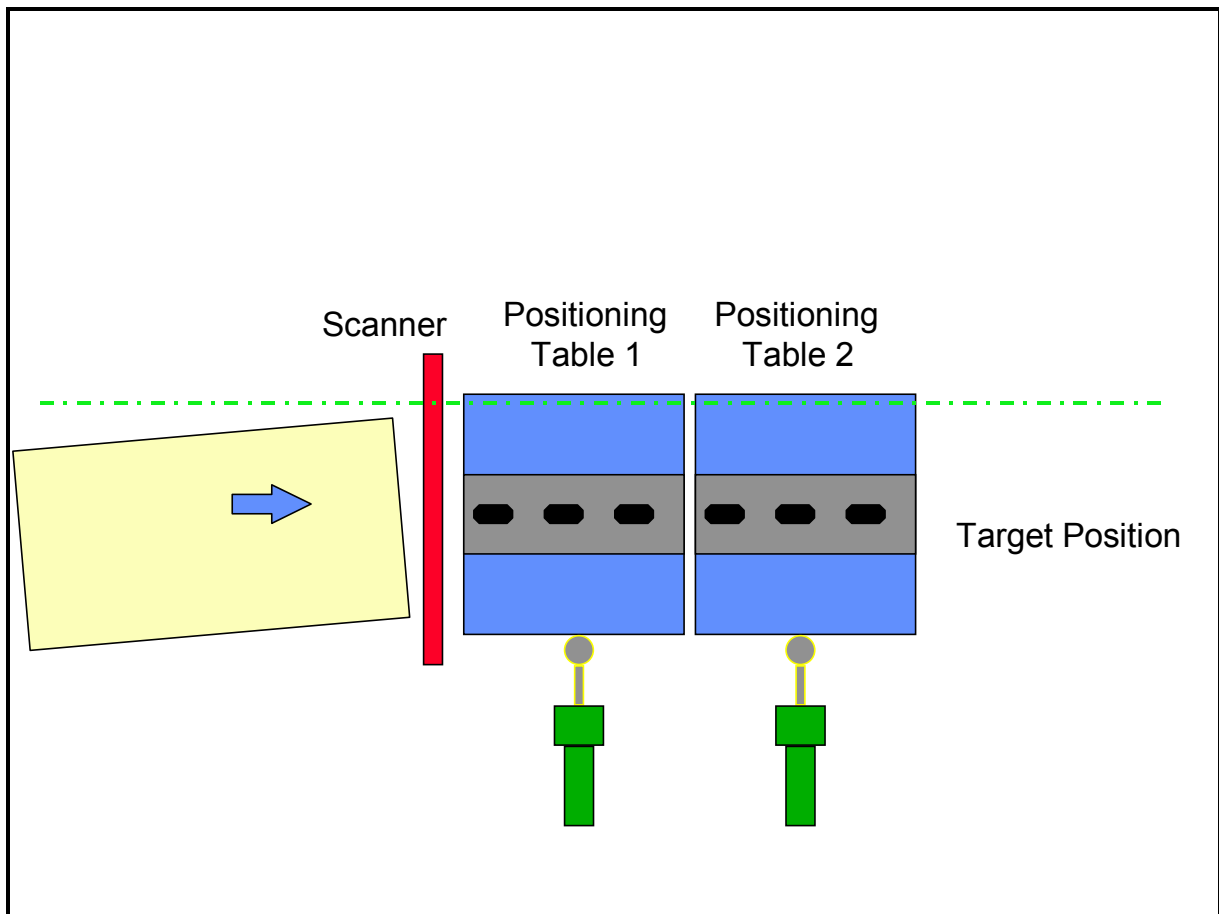


Figure 3a: Veneer before final alignment

The performance of the entire veneer feeder line along with the skew correction process is very much influenced by the quality of veneer and stack integrity. This calls for more sensitivity in veneer production, drying, and handling than is traditionally used in the plywood industry or conventional LVL lines.

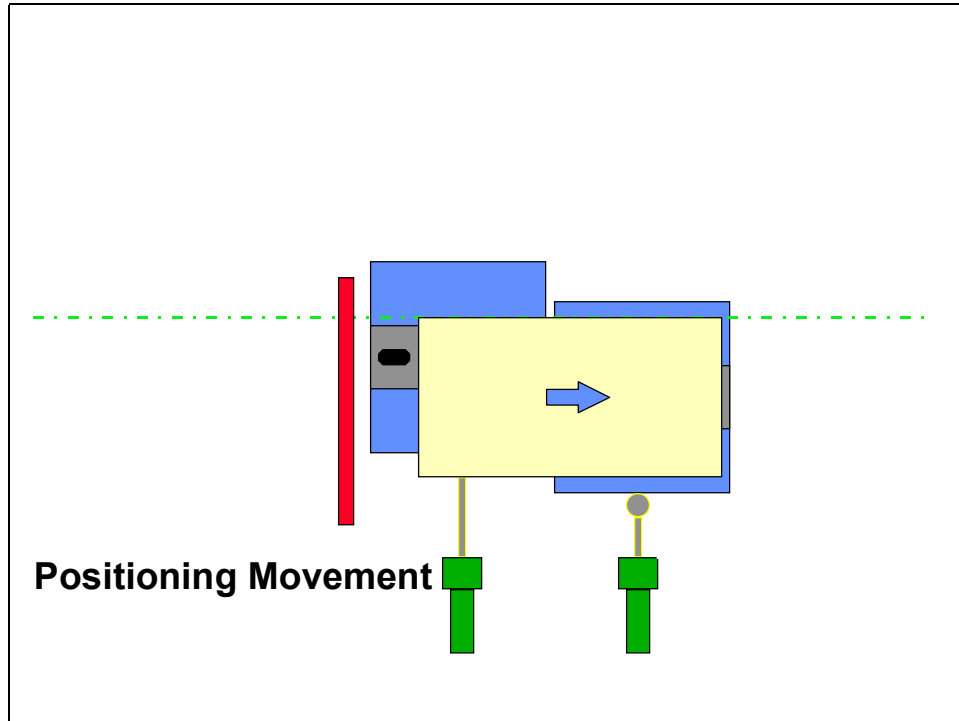


Figure 3b: Veneer after final alignment

LAY-UP LINE

The lay-up line is made up of a dual-level lay-up station. Each level is composed of a tipple belt, a shuttle-nose belt assembly, a set of roller conveyors, and an inclined belt conveyor. Alternating veneer sheets from the veneer feeder line are picked up, either by the top or by the bottom tipple belt. These are then transferred to the shuttle nose belt assembly, which indexes veneer on to the set of roller conveyors. Half of the rollers in the set are designed for lateral movement perpendicular to the veneer surface (Figure 4). This set of rollers raises the veneer once the required number of sheets is accumulated while the forward movement is still maintained. The trailing edge of these sheets is then indexed back to the assembly on transfer to the inclined belt conveyors while the shuttle-nose belt continues to place veneer on to the laterally fixed set of roller conveyors. The leading edge of these veneers overlaps with the tail end of veneers from the raised set of roller conveyors. Once the last veneer sheet is cleared from the raised rollers, these rollers retract side ways to pick up the assembly from the laterally stationary rollers to continue the cycle.

This way, half the number of veneer sheets required for a specific LVL configuration is handled on the top play-up station and the other half are sent to the bottom lay-up station. The two halves merge past the inclined belts.

This system is designed to index veneer in a precise manner forming a continuous ribbon of LVL without manual handling. Its performance is dependant on the variability in the squareness and length of veneer sheets used as well as the scarf quality.

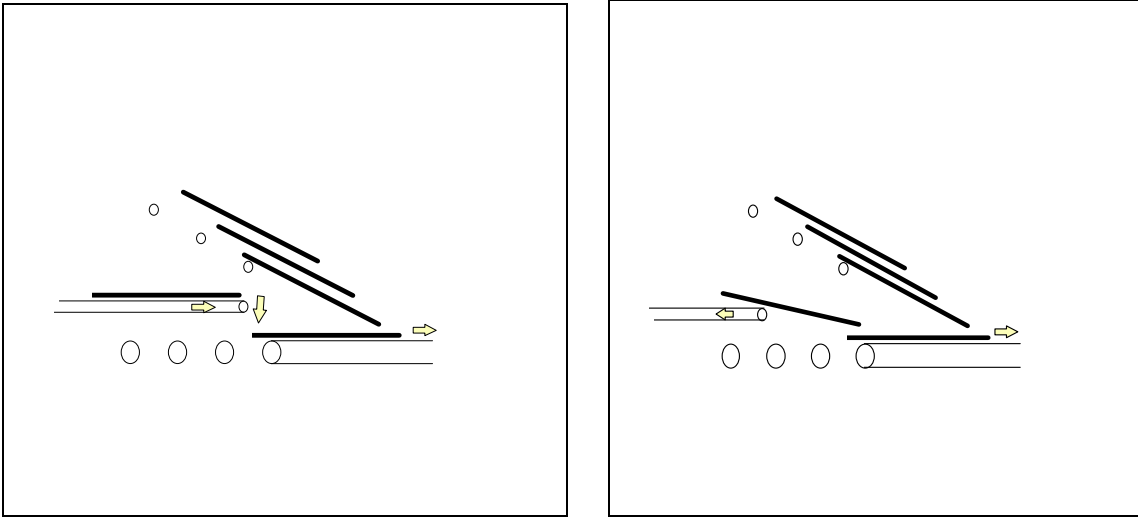


Figure 4: Schematic drawing of the lay-up line

The manner in which the lay-up is formed appears to contribute towards reducing the variability in product properties. This aspect will be discussed later in the section about product properties.

MICROWAVE AND PRESS

The microwave pre-heating unit is used to create a heat profile sloping from the centre of the billet assembly towards the surface before it goes into the press. Up to 85° C temperature is generated at the centre dropping down to 70-75° C on the surface plies depending on the thickness of LVL, line speed, microwave energy, etc.

Unlike conventionally used RF systems, a standard phenolic resin as used in sheathing grade plywood mills is used on this line since start-up. In this case veneer moisture content appears to have more impact on the effectiveness of the microwave system than the resin itself. This potential is actually used to increase dryer production as well as developing pressing strategies for shorter cycle times. Determination of the specific factors involved in creating optimum conditions to enhance the effectiveness of the microwave system will further decrease the overall unit cost of production.

The press is an MDF/particleboard still-belt press with modifications to suit veneer applications. It is 1.22m (60 in) wide and 40.14m (131ft.) long. There are three pressure zones and three temperature zones that can be controlled independent of each other within a limited range. The pressure capability ranges from 2.8 N/mm² (400 psi) at the in-feed to 1.2 N/mm² (170 psi) at the out-feed. The line also has thickness/position control capabilities.

The three major variables that are often used in most conventional plywood and LVL presses are pressure, temperature and cycle time. On batch processing lines the temperature during one pressing cycle is fixed. Most such technologies do not use thickness/position control and the thickness of the final product is usually determined by the amount of pressure used, the number veneers and the individual veneer thickness. The introduction of a third variable (thickness/position control) on this line, coupled with its ability to change temperature through time complicates the development of pressing strategies. This has, however provided greater flexibility and opportunity for further optimization of the production process. The line is now producing a 38.1mm (1.5 in) product at the rate of 3.88m (12.75 ft) per minute. This is equivalent to a 10.3 minute cycle time compared to an average 18 minutes on batch processing lines with no pre-heating systems.

PRODUCT PROPERTIES

Table 1 represents typical MOE and MOR results of a 38.1mm (1.5 in) LVL manufactured on the new line. The summary statistics indicate the relatively low variability in product properties using this line compared to batch-processing lines. This is partly because of a uniform open assembly time along the length of the LVL on the CPS line. The other contributing factor to this is the dual lay-up, which breaks up the weak points (veneer joint) in to two plains instead of one plain as observed on conventional lay-up lines.

It has been over 18 months since this line started with under 3.6m³ (100 ft³) per hour. It is now producing a relatively more consistent product at a rate of 10.8m³ (300 ft³) per hour. The potential to manufacture an even more predictable construction material faster is very well demonstrated by this technology. More understanding of the relationships between some of the resource attributes and handling and processing conditions is, however, is required.

Table 1: Lodgepole pine LVL properties

SAMPLE NO.	MOE		MOR		MC (%)	SP.GR.
	(PSI x 10 ⁶)	(Mpa)	(PSI)	(Mpa)		
1	1.77	12.20	8,429	58.1	8.77	0.58
2	1.87	12.89	9,022	62.2	8.61	0.59
3	1.88	12.96	8,718	60.1	9.63	0.60
4	1.88	12.96	8,809	60.7	8.59	0.59
5	1.97	13.58	9,156	63.1	9.02	0.61
6	1.91	13.17	8,644	59.6	9.52	0.59
7	1.74	12.00	7,794	53.7	9.24	0.59
8	1.89	13.03	8,754	60.4	9.86	0.60
9	1.80	12.41	8,091	55.8	9.41	0.58
10	1.80	12.41	8,669	59.8	8.90	0.59
MAXIMUM	1.97	13.58	9,156	63.1	9.86	0.61
MINIMUM	1.74	12.00	7,794	53.7	8.59	0.58
MEAN	1.85	12.76	8,609	59.4	9.16	0.59
ST.DEV.	0.07	0.49	410	2.8	0.44	0.01
COV (%)	3.8%	3.8%	4.8%	4.8%	4.9%	1.6%

CONCLUSION

LVL is mainly used as beam or as flange stock for wood I-Joist. Both LVL as well as Wood I-Joist are primarily used in residential constructions in North America. This is in place of the traditional solid sawn lumber. A newer generation engineered wood product; Laminated Strand Lumber (LSL) is recently introduced for the same applications to replace LVL. LSL does not require the high grade feed stock required for manufacturing veneer and uses relatively faster pressing cycles, thus making LSL more price-competitive than LVL. A similar trend can be established for most forest products developments used, mainly in construction applications. These are all great achievements in forest products development from the perspective of enhanced wood utilization, recovery, and replacement of a product for which the right raw material may be disappearing, etc. The direction of these developments is, however, focused on replacing another forest product.

Given the current state of available technology and knowledge of the material it is economically feasible to manufacture LVL with even more uniform and more predictable properties. Development of pressing strategies, the extent and the benefits of densification to enhance the volume higher strength LVL, the impact of process technology, veneer moisture content, densification and adhesive technology on the variability of LVL properties still continue to be a challenge. Some of the major challenges, however, have been the manner in which veneer is prepared and handled to

cope with what the technology has to offer. If the above issues are addressed, it will be easier to expand into markets where light steel structures are used.

As mentioned above, the approach taken by the industry in the development of engineered wood products has been to replace another forest product. This time it may probably be glue-lam beams being replaced by LVL. It is my opinion that this kind of an approach in product development strategy has made it relatively easier for the steel industry to intrude into the traditional forest products markets. It appears to me that the forest products industry is inadvertently assisting the steel industry by being engaged in replacing other forest products while undermining the potential of engineered wood products to regain the market that has been lost to steel. It would be interesting to see what direction the industry would take to salvage the LVL market. Indications are such that what OSB did to plywood LSL is positioned to do to LVL.

It is quite common for the scientific community to work with either one of equipment manufacturers or the forest products industry. Under the current conditions, it seems difficult to develop and/or transfer comprehensive packages of product and technology from the laboratory to the industry. A three party alliance between equipment manufacturers, the industry and the scientific community based on mutually recognized rolls may provide a solution. Such an alliance would combine the best of the resource potential, technology and industry together for the best result in promoting the utilization of wood. The major challenge still remains to be convincing the engineered wood industry that we are essentially in the construction industry while we use wood as the material. This, undoubtedly, will lead to a different way treating the material and exploiting what the technology has to offer. The thinking that follows one's identity as a forest products business appears to perpetuate the view of the steel industry that forest/wood products are too variable and unpredictable to be used where steel structures are used traditionally.