SEMINÁRIO INTERNACIONAL DE UTILIZAÇÃO DA MADEIRA DE EUCALIPTO PARA SERRARIA

PLANTATION GROWN EUCALYPTS: UTILISATION FOR LUMBER AND ROTARY VENEERS – PRIMARY CONVERSION

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INTRODUCTION

There is great appeal in a maturing stand of planted Eucalypts. To most, this appeal is aesthetic and to the uninitiated, it extends to the assumption that the trees have great utility. However, on a global basis thusfar, for most species of Eucalypts, that utility has been largely limited to pulping and use as firewood. On a global scale, there is not yet a substantial utilisation of plantation grown Eucalypts for primary conversion into, for example, higher value products such as lumber and rotary veneer.

The first part of this paper examines why this is so. The second part is devoted to an examination of special techniques required to maximise the success with which this raw material can be converted into lumber and rotary veneer.

REASONS FOR PROBLEMS IN PRIMARY CONVERSION OF *PLANTA TION EUCALYPTS*

Imperfections or problems in the material cut from apparently high quality trees *and/or* logs include the following. They are listed in an approximate order of significance:

(1) growth stresses - which are initiated during the development of the secondary wall of fibres and may be necessary for the normal growth and development of the tree. Longitudinal growth stresses are the most significant and will receive our exclusive attention here. The incorporation of lignin between microfibrils in the cell wall causes swelling in the transverse plane and an associated shortening in length. Full expression of this shortening tendency is prevented by the rigidity of neighbouring differentiated fibres to which the younger cell is laterally attached. The result is that a longitudinal tensile force is continuously generated within successive layers of newly formed cells as the diameter of the tree expands. There is a compensatory development of high compressive stresses on the core of the stem which will ultimately lead to the development of "brittle heart" and decay. (Refer to Exhibit 1.).

Prior to 1970, growth stresses could be assessed only by observation of their effects when logs were converted. These effects will be well known to all who have harvested and sawn plantation grown Eucalypts. They include:

(i) the often rapid development of radial shakes in logs after cutting, the enlargement of these shakes during conversion and the development of splits during product drying;

(ii) when sawing a slab or board from a log, the immediate development in that slab or board of “bow" if the slab or board if back-sawn (wide face tangential) or of "spring" if the slab or board is quarter-sawn (wide face radial). The radius of curvature or "bow" in back-sawn slabs or boards decreases (Le. expression of growth stresses is more severe) with the square of the length of the log and increases (Le. is less severe) with increasing log diameter. It follows that sawing longer, smaller diameter logs results in quite severe "bow" or "Spring". (Exhibit 2.);

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(iii) when sawing near the core of larger, sound logs, compressive forces there may cause "binding" on the saw blade. In larger, sound native Eucalypt forest logs, "binding" may also occur when sawing from the periphery of large halves or quarters;

(iv) on a conventional log carriage, in the process of sawing off boards, the residual log may develop a curvature or "bow" face. A similar effect may be observed in cutting a flitch on a re-saw. In both cases, a "face" cut may be required.

Direct quantitative measurements since 1970 have improved understanding of the distribution and intensity of growth stresses. The intensity of growth stresses is highly variable - between species, between adjacent trees of the same species, at different locations on a common circumference of a single tree and at different heights of the same tree. Greater variations in stress intensity have been found in leaning trees. Direct measurement has demonstrated stress levels as high as 45 mPa though lower levels are more common.

No research findings have provided positive correlations between the intensity of growth stresses and tree size, tree age, stem diameter or growth rate. However, it is generally recognised that with increased log diameter (achieved by thinning and / or extending rotation length) the effects of growth stresses are diminished. This is attributed to the decreasing stress gradients with increasing diameter rather than to a decrease in the intensity of the stresses themselves. (Refer Exhibit 1.). It was demonstrated long ago (by Jacobs, one of the pioneers in research into growth stresses) that the effects of growth stresses could be virtually eliminated by boring out the core ofthe log, creating a cannon-like cylinder. Early Australian sawmillers recognised this by selecting mature, native forest logs with restricted core defect as the preferred furnish for their sawmills.

Many techniques have been applied to minimize the effects of growth stres5es before conversion. For trees, techniques have included killing the tree some time prior to felling and partially defoliating the tree with herbicides. For logs, techniques have included air-drying debarked logs, storage of logs in water or under sprays, heating logs with steam or hot water, girdling with saw cuts at the ends, coating ends with impervious bitumen, grease or wax, banding with metal and nail plating the end sections. It is considered fair to say that no single technique can be confidently recommended as providing universal security in minimising the effects of growth stresses. Indeed, several recommendations in the literature, admittedly referring to different situations and species, are contradictory.

However, for rotary veneer peeling, heating billets by steam or hot water bath to temperatures of about 60 deg. C. seems worthy of perhaps universal recommendation, not only because it appears to diminish the intensity of stresses, but also because it results in much smoother veneer.

(2) knots - which are a major defect facto r in plantation grown logs, even those of excellent form and apparently sound. Knots do not only directly contribute to defect in converted products. They are often associated with other defects such as grain curvature and decay. Decay enters through branch stubs which, in Eucalypts, do not become filled with protective resins as is the case with conifers. This signals a caution for pruning Eucalypts which is otherwise to be strongly recommended as minimising the defects associated with knots.

In tall native forests, the species of Eucalypts with good branch shedding habits (e.g. ***E. grandis*** and ***E. globulus*** ssp. ***globulus***) will normally have a knotty core diameter which is closely related to the diameter of the branches. For example, a branch diameter of ca. 2.5 cm. diameter will result in a knotty core of ca. 15 cm. diameter. However, with the faster growth experienced in exotic, plantation grown Eucalypts, the natural branch shedding habit of the genus is not so efficient. Perhaps, this is due to the inadequate time for the branch to develop the "brittle zone", one of the early stages of branch shedding. As a result, exotic Eucalypt plantation logs exhibit knotty cores of greater diameter than is common in logs of the same species and diameter in Australian forests. It follows that the diagram in Exhibit 3. may understate the situation experienced internationally.

Exhibit 3. illustrates typical tree form and knotty core zones for young, fast grown Eucalypts. In Australia, these are exemplified by regrowth (resulting from wild fires), older regeneration (resulting from reforestation by aerial application of seed after clear felling the old-growth forest and burning the logging trash) and plantation trees.

Immediately it will be clear that the opportunities for recovery of knot-free lumber or veneer are limited - not only by the extent of the "clear wood" zone, but also by the form of the log containing this zone. The "dry" knotty core zone is dominant in that part of the log which has a more limited taper rate (typically an under-bark rate of 1 cm. in diameter per meter of length). It is in the "dry" knotty core zone that directly contributed defects in converted products are most common and the risk of induced defect, such as decay, highest. The "green" knotty core zone will typically have fewer defects up to the level of green branch height. However, its volume is clearly limited and proximity to the core of the tree, with prospects that "brittle heart" will be encountered, severely limit its value.

All of this leads to the unqualified conclusion that, in an ideal situation, utilisation of plantation grown Eucalypts logs for conversion to lumber and / or rotary veneer would be confined to purposefully managed stands in which pruning (to minimize the knotty core diameter) and thinning (to maximize diameter growth) were a routine practice. However, in the real world situation, there is need to utilize existing plantation grown logs which have not had the benefit of such silvicultural management regimes.

The frequency with which knots may occur in lumber from plantation grown **E. grandis** is illustrated by data from Argentina showing that 75 % of boards contained "dry" knots and 57 % contained green knots. Dealing with this reality is a significant challenge for the utilisation of lumber and rotary veneer produced from such logs.

(3) high rates of normal shrinkage and, in some cases, the prevalence of abnormal shrinkage or "collapse"

Because the topic of this paper is restricted to aspects of primary conversion of plantation grown Eucalypt logs, this subject is mentioned but not further elaborated upon.

(4) kino veins and gum pockets - involving the same dark coloured phenolic exudate - are particularly common in plantation grown **E. grandis** They are also one of more common sources of degrade and rejection in Australian native forest Eucalypt lumber and rotary veneer. Small kino veins lower the visual quality of lumber and veneer while large pockets weaken the materials and can deny structural applications.

There is some uncertainty in conclusions regarding the causes of kino formation. For a single species, the extent to which kino is present appears to depend on: (i) the degree of cambial injury (caused by fire, insects, mechanical injury or "dry" knots), (ii) thickness of bark. (iii) tree vigour and (iv) other environmental and genetic factors. Included among the other environmental factors are causes such a frost and drought which induce physiological stress.

An Argentina report on sawing plantation grown *E.* ***grandis*** 1:1as'indicated46 %of sawnboards exhibited kino veins or gum pockets.

(5) "brittle heart" and, perhaps, core decay . If the peripheral longitudinal growth stresses are sufficiently high, the counter-balancing internal compressive stresses will exceed the maximum crushing strength of the undried wood fibres. The affected wood has low strength and a brash-fracture due to minute compression failures in the walls of some fibres.

It can be detected by its easier sawing characteristics. broken ar "fuzzy" fibres on end-grain surfaces, a relatively lower density and, perhaps, a paler Colour.

There is little value in "brittle heart" wood for lumber and rotary veneer.

(6) tension wood may be common on the upper side of leaning stems in Eucalypt plantations. It is characterised by having fibres with a non-lignified, higher density "gelatinous" layer on the lumen side of the secondary wall and can be sometimes recognised as a zone of darker colour.

Tension wood exhibits abnormally high longitudinal shrinkage when dried.

(7) wetwood, discolouration and decay are stages of imperfection having a common cause - the introduction of fungi through branch stubs and /or injury. It is possible for these symptoms to be evident at sites remote from the fungal ingress point - for example, wetwood and discolouration near the core of the tree opposite a branch stub.

POLICIES REQUIRED FOR THE SUCCESSFUL PRIMARY CONVERSION OF *LOGS FROM PLANTA TION GROWN EUCALYPTS*

It is imperative to set an appropriate framework of policies for the primary conversion of plantation grown Eucalypt logs. Unless the logs have been grown under a silvicultural management regime which has involved pruning and thinning, it is pointless to have too high an expectation of the quality of products which can be produced. For typical plantation logs, even with stringent selection, standard and utility grade materials will dominate conversion products. Select and clear grade materials will be in a small minority. Thus, average value of the production will be relatively low. An immediate policy consequence is that the costs of primary conversion must be minimised.

There are two approaches to minimising production costs. One involves low capitalisation and dependence upon low cost labour. Technological input is low as are throughput, recovery and quality. The second, which it is believed is more realistic in a liberalised global economy, embraces the latest technology and accepts that this requires large scale facilities, greatly diminished labour requirements per unit of production while also ensuring higher quality of the production. Examples are given later of production facilities relevant to this second approach.

The second policy area requires definition of the products to be manufactured from the available logs. It might be referred to as the product policy – i.e. what to manufacture for recognised markets from the available log raw materials. Clearly, realistic appraisal of market opportunities is required for definition of a product policy, as is an equally realistic appraisal of the potential of the log raw materials.

The writer would not pretend to be in a position to evaluate market opportunities in this region, However, it can be clearly stated from experience that in the lumber business there is too often a clearly evident tendency for an inordinate dependency to be placed on traditional products for which markets are often in decline. This is well demonstrated by an Australian case involving hardwood flooring. Because of changing house building systems in Australia which now very strongly favour concrete slab flooring, N.S.W. hardwood sawmillers found that their most significant value-added lumber market was contracting rapidly. With some encouragement from the Australian Government's trade promotion agency and at a not inconsiderable expense, they ventured into the supply of hardwood flooring to the U.S. market. They have failed to appreciate that solid, unfinished hardwood flooring in the U .S. market, although relatively huge by Australian standards, is a product struggling to hold market share - in a growth market against more cost effective alternatives such as pre-finished solid flooring and pre-finished laminated flooring.

The second component of developing a product policy is a realistic appreciation of the limitations on product choice imposed by the log raw materials. This will determine what can be produced. Growth stresses, high shrinkage, a distinct sapwood, knot frequency and type and other log imperfections require the establishment of a set of rules under which conversion can be undertaken.

For sawing plantation grown Eucalypts, experience in Australia and internationally would suggested that the following rules are applicable.

- keep log lengths short, preferably not greater than three metres;

- use sawing systems which relieve growth stresses simultaneously on both sides of the logs i.e. double or multiple sawing lines. (Refer Exhibit 4.);
- use "back sawing" techniques to put expression of residual stresses into "bow" rather than "spring" and to restrict the dimension of knots in the face of boards produced. (Exhibit 4.);
- keep sawn sections small. Do not attempt to cut wide and thick, especially in opening initial faces. (Exhibit 4.);
- rack all sawn products immediately, keep racks undercover and restrained;
- use "hot" logging with minimal storage between tree felling and conversion. If logs must be stored, use water sprays;
- select largest diameter logs for conversion. Avoid those with apparent defects such as borer holes, sloping grain, rot and off-centre core.

From all of the considerations above, it will be clear that realistic expectations must be for most plantation Eucalypt lumber to be predominantly of short length, small section and containing significant defects such as end splits, knots, kino veins or gum pockets. Until such time as superior logs are sourced from plantations managed under silvicultural management regimes involving pruning and thinning, this is probably an inevitability

Rotary veneer will be similarly affected by a high frequency of defects, particularly knots, kino veins and gum pockets. However, those defects associated with growth stresses and drying difficulties are probably more easily managed because the conversion to rotary veneers involves thinner sections of material and a superior relief of growth stresses.

In these circumstances, what product policies are appropriate **?**

Clearly, dependence upon products for structural applications must have a priority. While, for lumber, this application would seem to be denied by the small sections produced, glued lamination offers the opportunity to fabricate a valuable engineered structural material for a wide variety of applications.

For rotary veneer, structural plywood is tolerant of even open defects, such as are caused by "dry" knots, splits and gum pockets. In "DD grade", this tolerance extends to face and back veneers. Perhaps a superior opportunity is in the fabrication of laminated veneer lumber, a product which requires a single thickness of veneer in sheets as small as 1.2 metres x .2 metres, can be composed entirely from "D grade" veneers (containing open defects) and has a substantially higher selling price than conventíonal plywood.

The anticipated limited production of select and clear grade lumber in small sections is also compatible with a product policy having a focus on glued lamination. Pre-finished laminated parquet flooring is a product with exciting global market potential. Its fabrication is dependent upon short lengths, narrow widths and thin sections. A conventional panel of the product at 14 mm. thickness requires only a 4 mm. thickness of top grade material for the surface layer. The core is tolerant of material of significantly lower grade.

With a minor modification to the fabrication techniques, a lami-panel product range can have significantly wider market applications. Table-tops for the furniture market and pre-finished wall panelling are just two examples. In this area, innovation is the key to success. Technologies are available to allow that innovation full opportunity.

EXAMPLES OF APPLICA TIONS OF MODERN TECHNOLOGY IN PRIMARY CONVERSION OF PLANTA TION GROWN EUCALYPTS SAWMILLlNG

Recently, the writer and an associate have been involved in a strategic planning exercise for a very large integrated forest products enterprise in the Republic of the Philippines. This corporation is in a transition period between the utilisation of tropical rainforest logs of large dimension and plantation hardwood logs, including a tropical Eucalypt species. We were required to design a sawmill to use a component of those plantation hardwood logs which in quality and size terms were intermediate between those required for rotary veneer production and those required for chipping for pulp production. We took the view that, very low labour costs notwithstanding, an internationally competitive cost structure was essential and this required the design concept to adopt a technology involving a high speed mill able to saw logs in the diameter range 20 cms. to 50 cms. (average 23 cms.) at very low cost and to provide chips suited to chemical pulping.

A quad reducer band mill was selected as the most appropriate technology for log reduction, operating at a linear feed rate of 50 metres per minute. The centre cant is turned down and passes through a second quad reducer band mill unit operating at the same speed. The squared cant proceeds to a multi-saw gang while boards from the quad reducer band mills are processed by four chipping edgers capable of 15 boards per minute. Ali sawn products pass to the greenchain where there is provision for pulling off selected boards for deep sawing (by 150 cm. band mills) prior to the products returning to the greenchain. All products are end-trimmed prior to entry to a sorter-stacker. This mill has a design capacity for the conversion of 570 cubic metres of logs per shift of 273 effective operating minutes. It had a direct labour requirement of 15 per shift. Costs of primary conversion, including depreciation over a period of only five years of the $ U.S. 4.8 million capital cost, were estimated at only $ U.S. 12 per cubic metre exclusive of the cost of log raw materials.

It is an interesting reflection on the global state of sawmilling that subsequent to this design work, we obtained an offer for second-hand heavy-duty European equipment covering all specified items at a c.i.f. cost of only $ U.S. 3.4 million.

ROTARY VENEER

Modem high speed smalllog conventionall at he lines represent a technology well suited to low cost conversion of plantation grown Eucalypts to rotary veneer. However, some care needs to be applied to avoid the temptation to select the extremely fast units which are primarily suited to conifer conversion.

A recent project provides us to opportunity to examine some of the production characteristics for an appropriate high speed small log conventionall at he line. For the billet diameter distribution shown in Exhibit 5., billet conversion rates are seen to decline rapidly with increasing diameter (Exhibit 6.). However, billet volume also increases. This results in increasing conversion volume per effective hour of operation as billet diameter increases (Exhibit 7.) and annual billet demand (Exhibit 8.) can be high. To complement this high rate of conversion, dried veneer recovery estimates for the "ash" group Eucalypts are indicated (Exhibit 9.).

Capital costs for rotary veneer production are higher than for sawmilling. About $ U.S. 7 million would be required for conversion of the volumes indicated above (Exhibit 7.) if new equipment is purchased. Second hand equipment can reduce this cost. Further, unit production costs are considerably higher. (In the Australian context. costs are estimated at $ U.S. 85 per cubic metre, exclusive of log raw material costs). However, rotary veneer production must not be ignored in planning higher value utilisation of Eucalypt plantations.

Three reasons provide us with enthusiasm for rotary veneer conversion of plantation Eucalypts: (1) the higher potential recovery of dried veneer compared to that obtained in sawmilling, (2) the perception that rotary veneer products (such as L.V.L.) have exciting global market opportunities and (3) the conviction that rotary veneer conversion will afford superior returns to pruning and thinning in intensified silvicultural management regimes in Eucalypt plantations.

CONCLUSION

Despite having drawbacks attributed to inherent imperfections and defects, plantation grown Eucalypts have potential for conversion into higher value products such as lumber and rotary veneer. Establishing appropriate policies, particularly realistic product policies wherein conversion rules properly recognise the imperfections and defects in the raw material, is central to realisation of this potential.

Modern technology in conversion is probably essential to economic production of lumber and rotary veneer and it is available. The higher capital cost will demand high volumes of secure log supplies. However, it will also underwrite competitiveness, maximise recoveries and improve product qualities.

The investment appeal in value adding conversion to lumber and / or rotary veneer will be greatly enhanced if silvicultural management regimes for Eucalypt plantations are intensified through pruning and thinning.

Integrated conversion facilities - involving sawmilling, rotary peeling and pulpwood chips utilisation (by either export or domestic pulping) - are probably essential to maximise the benefits of such intensification.