Potential uses of laminated veneer lumber in furniture

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Abstract

The increasing scarcity of high quality hardwoods makes it increasingly more difficult for manufacturers to produce quality solid wood furniture at an affordable price. The development of laminated veneer lumber (LVL), which is a solid wood composite product, makes it possible for lower prices. This paper attempts to identify applications and constructions where LVL can be used to best advantage, from both a structural and an economical point of view.

Laminated veneer lumber (LVL) is produced by gluing together sheets of relatively thick veneer with the grain of all plies running in the same direction. The resulting product has good structural properties and allows panels and solid lumber of any desired attainable quality to be produced by a rational selection and combination of low- and high-grade veneers (2,6).

LVL has potential value to the furniture industry for both aesthetic and economic reasons. It is closer in appearance, feel, and structure to solid wood than any other wood substitute and can be produced to meet demanding consumer-based appearance requirements. Furthermore, less expensive "surface clear" material can be produced that satisfies aesthetic surface appearance requirements but can contain defects in the interior laminations. Significantly, all of this material can be produced from veneer peeled from logs judged too low in quality to yield significant amounts of sawn lumber. Even more importantly, LVL can be produced to meet specified technical and strength requirements. A material, almost like solid wood, can be engineered to meet strength requirements of individual products. At the same time, technical improvements can be built into the material (7-9).

The use of LVL in furniture is not new — it has been used for curved laminated parts for years. More recently, it has been used in place of bandsawn material for curved, unexposed structural parts such as side rails and, to a lesser extent, for flat parts.

Conceptually, the manufacture of these parts may be regarded as an extension of laminating and molding technology for the production of specialty parts rather than the introduction of a new commodity into the furniture materials market. In the case of the LVL considered here, however, furniture parts are cut from a sheet-like material that can be mass produced by a process similar in both method and volume of production to that used to make plywood and particleboard rather than curved plywood parts. The size of the LVL produced will likely be somewhere between that of lumber and sheets of plywood or particleboard, although as a commodity, LVL might be produced in sheets or planks of any practical size (9-11).

Changing consumer attitudes and the desire for solid wood furniture coupled with decreasing availability and increasing cost of quality furniture woods indicate there is a place for a "near solid" wood commodity in the furniture materials market. In this paper, a number of potential uses are discussed along with the visual and strength restraints that must be placed on the design models for LVL.

General considerations

LVL may be expected to have many of the desirable properties of both solid wood and wood-based sheet materials such as plywood and particleboard, but it must also be expected to have unique characteristics of its own, both desirable and undesirable. In general, LVL of the type considered here must be regarded as an essentially new material that should have applications in those areas of furniture construction where 1) conventional materials of construction have proven too costly, 2) wood substitutes have not proven entirely satisfactory for mechanical or aesthetic reasons, and 3) there is a market for furniture intermediate in quality (between conventional solid wood furniture and that produced from the various surface-treated wood-based composites).

Selecting potential uses of LVL in furniture must be based on considerations of its ability to satisfy:

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Solid wood exposed tops are used less frequently than in the past. Reasons for their decline in popularity include the high cost of the nearly defect-free materials required and the ease with which the finished surface can be damaged by common household spills. In the case of kitchen and dining room tables along with coffee tables in particular, the market has been lost largely to tops surfaced with high-pressure laminates.

Exposed solid wood tops are still used in many settings that demand quality furniture such as libraries. In addition, the use of polyurethane-type finishes has removed many of the complaints associated with lacquer finishes on kitchen and dining room tables and, in time, there will likely be a renewed demand for tops with natural finishes.

Both planks and full-width tops fabricated from LVL could be used if the understructure of the table is engineered to provide the bending strength needed across the grain. LVL can be used to fabricate planks of any desired size. Defects can be included in the inner plies so the cost of the planks can be minimized and the use of the material maximized. Tops of full width can also be fabricated from LVL. Here, the intent would be to eliminate a veneered surface by replacing it with an essentially solid wood surface. Again, defects could be included in the inner plies to reduce the cost of the materials. In both constructions, it would be desirable to include a thin crossply to reduce the shrinking and swelling that accompany seasonal climatic changes in weather. This shrinking and swelling is responsible for many of the problems associated with attaching edge bands to the ends of the tops and attaching tops to the understructure of the table as well as actual splitting of the top. These are not minor problems and the dimensional stability of cross-banded LVL would be a definite factor in its favor in this application.

Solid lumber cores have largely been replaced by particleboard in most tops produced today. The main reasons cited are the high cost of solid lumber and subsequent processing of it, difficulty in obtaining material, and lack of dimensional stability. For many applications, particleboard cores have proven satisfactory. However, in a number of applications they have not. They lack the strength and stiffness of solid wood and they tend to creep under load. Furthermore, they lack the fastener holding strength needed to attach some types of leg constructions. Hence, there is a need for a material with properties that exceed those of particleboard. LVL cores could satisfy these requirements, subject to the constraint that resistance to bending across the grain is engineered into the design.

Aprons are usually constructed of clear material but only one surface is exposed to view. This represents an ideal application for LVL because the face lamination may be fabricated from clear material while the inner plies may contain defects. Furthermore, the upper edge of the apron is concealed by the top while the bottom edge is normally not visible so the appearance will not be affected.
ance of the edge of the rail would ordinarily not be a factor.

Aprons are commonly joined to the tops with screws. They are commonly joined to the legs by means of mortise and tenon joints, dowel joints, or corner plates and hanger bolts. A thin crossband may be needed in the aprons to improve the strength characteristics of mortise and tenon joints as well as the integrity of the ends of dowel joints.

Similar comments apply to the material used for side rails in tables. Here, however, the edge of the rail will be visible and must be defect free. The appearance of the laminated surface would be objectionable to some manufacturers, but pleasing to others. For example, some manufacturers add a thin crossply to curved laminated parts purely for aesthetic reasons.

Ribs, or under-rails, used to reinforce the top would likely need to have the two wide vertical surfaces defect free and the bottom edge clear. Interior plies could contain defects provided the one edge remained clear.

Headers, as used in tables with some types of cantilever leg construction, would need to have one edge clear in all cases and both ends in some cases. Some manufacturers would require that the bottom face be clear, whereas others would not. Cost and quality of the table as a whole would be the determining factors. Structurally, the header provides bending strength to the top across the table. It must, therefore, be designed to satisfy engineering requirements regardless of aesthetic requirements.

Sofa frames

Previous research (2-4,12,13) has convincingly demonstrated that LVL can be used as frame stock in upholstered furniture frames. Specifically, this research has demonstrated that LVL can be used economically as a substitute for both solid lumber and plywood in this application. Upholstered furniture frame stock presents an ideal application for LVL because visual defects can be tolerated and the strength of LVL can be engineered to meet the specific strength requirements of the furniture. Several publications (as previously noted) have been issued that discuss the use of LVL as upholstered frame stock; therefore, this application will not be discussed further here.

An informal evaluation of the use of LVL for “show” or exposed wood in upholstered furniture construction conducted in the author’s laboratory indicates it could be used to good advantage provided the public will accept the appearance of the exposed gluelines. Potential areas of application include front and back posts, arms, side rails, and front and rear rails. All of these members are relatively large in size and in show-wood parts, must be free of defects.

Many of the designs that utilize exposed frames make use of wire mesh or webbing-type spring systems, which impose high torsional and high front-to-back loads on the front and back rails. For this reason, the material must have good torsional and front-to-back bending strength, and the ends of the rails need to be defect-free so that solid end connections can be made. Visually, the front face and top edge of the front and back rails need to be clear. Some manufacturers would also require that all four faces be clear. The amount of material used in many of these designs is substantial. The cross section of an exposed back rail, for example, may vary from 1 1/2 to 2 inches by 3 to 4 inches in depth.

Material for arms would usually need to be clear on both faces and on the edges. Certainly, it would be necessary to ensure that material used for these parts finished smoothly and had no tendency to splinter. Furthermore, the arms are often joined to other members by means of exposed mortise and tenon joints, which further dictate that the material must have good machining characteristics. Again, these members are relatively large, so considerable amounts of material are used in their construction.

Requirements for front and back posts are about the same as those for arms. Visual considerations largely dictate design of the material. The size of material is relatively large so considerable amounts of material are consumed in the manufacture of these parts.

Requirements for side rails would parallel those for the other members mentioned. In some cases, the inside face and bottom edge of a side rail might contain defects, but ordinarily it would be expected that these faces would also need to be clear.

In summary, it appears that LVL would be well suited for use in exposed wood in sofa frames, subject to the constraint that exposed gluelines are acceptable. These frames are ordinarily constructed of clear stock with relatively large cross sections and substantial length. Clear parts of such large size are expensive to produce and require the use of scarce materials. Using less expensive LVL would make it possible for more people to enjoy the true warmth and beauty of wood.

Chairs

The strength requirements of chairs have been treated in considerable detail by the author (1,5). Results of those studies showed that the design of some members in chairs (for example, back posts) is limited by bending strength requirements, whereas the design of other members (side rails and similar members) is governed by the strength requirements of the joints. Presumably, therefore, LVL in one form or another could be used for essentially any type of member used in furniture construction, except perhaps for turned parts. From a practical point of view it is most reasonable to consider those constructions that utilize large members for aesthetic design purposes. Chairs of this type are commonly used in offices where the furniture is selected to make a statement about the occupant. Usually, such chairs have the side frames completely exposed with the various members laid in the flat position. The front and back rails are also ordinarily exposed, but the seat itself and the back
rest are upholstered, so the members associated with these parts are hidden.

Potential uses of LVL include front and back posts, side rails, arms, stretchers, front and back rails, and the stretchers associated with them. The principal constraint on using LVL in such chairs would be the economics of the material and the acceptability, from an aesthetic point of view, of the gluelines on the exposed edges.

Design of the material for such chairs is primarily governed by aesthetic considerations. Because edge defects cannot be tolerated, all the laminations must necessarily be clear. (Exceptions to this constraint exist for parts in some chairs.) Therefore, only the species that could be tolerated and the thickness of the laminations that would be economically and aesthetically acceptable would need to be taken into consideration in the design of the material.

**Kitchen cabinets**

Most of the kitchen cabinets produced commercially today are of either nonframe pure panel construction or frame with panel construction. The most commonly produced cabinet is one that utilizes a pure panel case with a face frame. In any of these constructions, LVL could be used advantageously in several areas: framing stock, door frame stock, door panels, shelves, and case sides.

Numerous woods have been used for kitchen cabinet framing stock. In hidden applications, primary criteria include low cost, availability, ease of machining, and to some extent dimensional stability and fastener holding strength. Several common woods used include yellow-poplar, sycamore, elm, and occasionally even tropical woods such as banak. When the framing stock is visible, better woods such as maple, oak, and other show woods are used. These members must be clear on all four faces, which tends to make them expensive to produce, particularly in the longer sizes.

In the case of hidden framing members, LVL could be produced to meet essentially any desired need. Cross-laminated material could be produced with excellent dimensional stability and fastener holding power to meet engineering requirements. LVL could also be produced to provide attractive front frame material. A high quality face lamination placed over lower quality interior and back laminations could provide a better face appearance at a cost lower than for a comparable solid. Presumably, however, all the material used in the LVL would need to be clear because all the members are clear on all faces.

Similar comments apply to material used for doorframe stock. In addition, the machining characteristics of the top or face lamination are also of concern.

If it can be demonstrated that a single crossband effectively reduces the swelling of LVL across the grain, 2-ply LVL with a single crossband could find wide use as door panel stock. Shrinking, swelling, and warping are the most troublesome problems that occur in the use of wood-based solid door panels in kitchen cabinets. A product that would eliminate these problems and at the same time provide an essentially solid wood panel would be of real value to the industry.

Tops, bottoms, and shelves of kitchen cabinets could all be made of LVL engineered to meet aesthetic and cost constraints over a broad price and quality range. Tops and bottoms could likely be produced with one clear face while shelves would presumably require two clear faces. Interior laminations could contain defects provided they did not occur on more than one edge of the panel. For some applications, material would also need to be of such quality that the edges could be machined.

Case sides would have requirements similar to those for shelves. Often two faces would need to be clear, but interior laminations could contain defects. Solid machinable edges would often be needed on the side panels. An advantage of LVL for this application is that a much higher grade lamination could be used on the outer face than on the inner without detracting from the appearance of the case.

LVL could also be used for drawer fronts, sides, and backs in base cabinets. Presently, these parts are produced from materials with a wide range of cost and quality. Presumably, LVL could be produced to match the quality of material in most of these categories. Dimensional stability of the drawer stock could be important. Machinability of the stock would be important in the case of high quality drawers. At the low end of the spectrum, the principal advantage of LVL might be the simple possibility of marketing a product with the feel of real wood.

The ability of the rear face of the drawer front to accept a French dovetail and other machined grooves cut into it to provide for attaching the sides would be important. Likewise, the front face would need to be free from checks and of a quality that various patterns could be machined into it.

**Shelving and bookcases**

Presumably, LVL could be used for nearly any shelving that is used in furniture construction. Library-type shelving and large bookcases provide one of the most promising outlets for LVL. The high cost of solid wood shelving has essentially eliminated solid wood from all but the most expensive book-type shelving. Furthermore, bookcases, even plain functional types, have increased in price substantially in recent years. As a result, libraries and other institutions are now using prefinished particleboard shelving in place of solid wood wall shelving and solid wood bookcases. In general, this wall shelving has not proven entirely satisfactory because the support points often must be spaced less than 32 inches apart in order to prevent excessive creep of the shelves and this shelving, although less expensive than solid wood, is still too expensive for many applications.

Attempts have been made to use inferior wood species for shelving. Some manufacturers have constructed their shelves from species not typically used for show wood and then banded the front edge of the
shelf with a species such as red oak to improve its appearance.

Informal discussions with both manufacturers and consumers indicate that they prefer solid wood shelving, often oak and walnut, to particleboard and medium density fiberboard shelving. Neither of these two materials has been found to be entirely satisfactory. The problem encountered is that the cost of materials for solid wood shelves and functional solid wood bookcases has become prohibitive.

The design of LVL for shelving can allow for the use of considerable defective material. For example, a shelf might have clear faces with filled edges so that defective material could be used in the center plies. Alternatively, the front edge might be banded rather than filled, which would still allow the use of low-grade material in the inner plies. In either of these cases, the face laminations could be constructed of high-grade veneer while the interior plies could be constructed of lower-grade material with either the same or different species. As an example, high-grade walnut face veneer might be laminated over poplar or sweet gum interior laminations.

Another interesting concept is the possibility of laminating high-grade walnut face veneer over lower quality interior walnut laminations to produce a "solid" walnut shelf. Other woods such as oak could also be used in this manner. Assuming the laminated edge would be acceptable, this construction would allow the production of solid wood single-species shelves at nominal cost compared to the production of clear solid wood shelves. Edge banding would be needed if the laminated edge were not acceptable.

Beds

Many of the bed styles in use today provide opportunities for the use of LVL in their construction. In particular, military beds are well suited because they are constructed from relatively large members that are rectangular in cross section. In general, the headboard of these beds consists of two posts, the head panel or rail, bottom rail, and an intermediate rail. The footboard consists of two posts, the head rail, and the bottom rail. Typically, the posts and the top rail are constructed of material that measures about 2 by 3 inches in cross section, whereas the bottom rail on the headboard measures about 5/4 by 5 inches in cross section.

The bed rail system consists of two bed rails that measure about 7/8 by 5 inches in cross section and four cross rails that tie the bed rails together and provide support for two drawers that are slung below the rails. The cross rails are constructed of either plywood or hardwood and measure about 7/8 by 5 inches in cross section. Ledger strips are fastened to the inside of the rails to provide support for the spring frame.

Because of their size, these members would be expected to be costly when cut from hardwoods and would accordingly provide an application in which less costly LVL could be used to good advantage. It would be expected to be difficult to obtain clear bed rails, for example, because of their length.

The design of LVL to be used in military beds must take numerous design variations into account. In general the material used for the posts, top rail, bottom rail, and intermediate rail of the headboard and footboard of the bed would need to be clear on all faces. It must also be designed to allow the construction of strong dowel joints and material used in the posts must provide sufficient resistance to splitting to allow the use of bed hooks and pins in the post-to-bed rail connections.

In the case of the bed rails, all four faces must be clear. Presumably, the laminated edges would not present a design problem in the case of military beds.

In some cases, the laminations necessarily would be constructed of one species alone; however, in other cases, the inside and interior laminations could all be constructed of interior-type frame woods such as yellow-poplar, whereas the outer laminations could be constructed of a figured wood such as red oak. In yet other cases, a thin veneer rather than a full thickness LVL ply might be applied over an LVL core.

In all cases, rail strength must be taken into consideration. Both bending strength and torsional strength are of concern. When aesthetic edge requirements are coupled with strength requirements, it seems likely that clear material will be needed to satisfy the design model. The unique strength requirements of the ends of the rails must also be taken into consideration. The use of bed hooks to effect the rail-to-headboard connections imposes severe shearing stresses on the material in these areas. Furthermore, movement of the bed in service for purposes of cleaning impose severe racking forces on these joints. To resist the shear stresses imposed on the ends of the rails by the rails used to secure the bed hooks in place, it will likely be necessary to provide at least two crossbands that are symmetrically located on either side of the sawkerf, which is cut into the ends of the rails to allow for the installation of the hooks. Delamination of the ends of the rails owing to racking forces imposed on them can likely best be prevented by using through-bolts to secure the bed hooks rather than pins.

Another application of LVL in beds in general lies in the use of dimensionally stabilized LVL for headboards. Shrinking and swelling of wide solid wood headboards creates a problem in the joining of this member to the posts because an allowance must be made for the expansion and contraction of the panel. A dimensionally stabilized LVL panel, i.e., one containing a single thin crossband, would provide a worthwhile solution to this problem.

Specific furniture parts

In addition to the use of LVL for entire pieces of furniture, certain specific furniture parts lend themselves well to the use of LVL so it is worthwhile to consider at least one of them in detail. An application of particular interest is drawer sides. Use of LVL for
drawers was mentioned briefly with regard to kitchen cabinets, but its potential use extends well beyond that product.

In the past, high quality drawer sides were made largely of oak. With the increasing cost of oak, lower cost and less desirable woods were substituted, and finally, even some soft tropical woods were used. In other cases, printed particleboard has been substituted for solid wood. None of these materials is entirely satisfactory for higher quality furniture, particularly from an aesthetic point of view. LVL, because of its near-wood appearance, is a much more acceptable medium.

The design model for drawer material would need to take into account the wearing of the drawer sides in those cases where the sides actually slide on the frame. When drawer slides are used, which are attached to the sides of the drawers, the ability of the material to carry the drawer loads without splitting the sides at the points of attachment would be of importance. A single center crossply should provide this strength. Machining characteristics of the material would also be important. In particular, the nature of the material must allow the machining of clean dovetails into the ends. Again, a single center crossply should help to provide the machining characteristics prescribed by the design model.

In general, drawer side stock would need to be laminated from clear material. Two-ply construction with a center crossply should provide the necessary thicknesses of 3/8 to 9/16 inch that are most commonly used.

Conclusions

An examination of currently used furniture construction materials indicates there is a growing place for LVL as a commodity in the furniture materials market. An examination of trade journal articles, for example, indicates that manufacturers are trying to follow all-wood construction whenever possible. Meanwhile, European demands for real wood in furniture continues and even increases. Changes in furniture design will also create a demand for quality LVL type wood products. Economic inflation is predicted to shrink room dimensions with an accompanying demand for furniture that better utilizes available space. Less space and smaller furniture will likely lead to demand for higher quality furniture, a demand that can be satisfied through the use of LVL.

As a commodity, LVL would provide a solution to the need for a furniture material that can be engineered to meet specific strength and engineering requirements of each design problem. A survey of the potential uses of LVL in furniture indicates that it could be used in place of or along with solid wood in most furniture constructions. Furthermore, in many applications it could also be used instead of panel-type substitute materials currently in use, except in cases where the primary requirement is for a low-cost, large, flat surface. The obvious primary constraint is LVL's ability to compete with materials currently in use. A second constraint is consumer acceptance of the laminated gluelines.

Studies have shown that LVL can compete on a one-on-one basis with some of the materials currently used in furniture construction, such as upholstered furniture frame stock. In other cases, because of its higher cost, LVL would necessarily be linked to replacing materials that are currently being used but are not entirely satisfactory, either for aesthetic or mechanical reasons, LVL could be used to produce wood furniture for markets that are unthinkable today because of the high cost of clear solid stock.

Finally, a further use of LVL lies in foreign markets where the high cost of shipping makes it impractical to ship lumber that contains defects, which must subsequently be removed and discarded. Here, the higher cost of the LVL would be offset by the reduced shipping charges. This situation occurs in Europe and also in areas such as Mexico and Taiwan.

Literature cited