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BUCKLE IN VENEER[1]

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Abstract

Discusses causes of buckling in veneer and possible ways to minimize it.

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Veneer buckles or warps in various ways. Some quarter-sliced veneer crooks excessively, generally because of growth stresses in the tree. Other veneer shows end waviness because the ends of the sheets dry faster and set in an expanded size. The most important veneer buckle, however, is evident as overall distortion of the sheet. Tension wood in hardwoods, compression wood in softwoods, irregular grain, and nonuniform drying with resultant set are the primary causes of general buckling of veneer.

In all cases buckle is caused by unequal stresses across or parallel to the grain of a sheet of veneer. Let us consider how these stresses are formed.

[1]Presented at the meeting of the Fine Hardwoods Association in New York City, N.Y., in September 1969.

Stresses and Buckling

Growth Stresses

Growth stresses naturally occur as tree trunks grow in diameter. The wood being formed successively in living trees is wider longitudinal tensile stress that tends to increase continuously toward the periphery of a tree. As a result, the stress of the central core commonly changes from tension to compression. Thus a tree big enough for use as veneer typically is in longitudinal tension in the outer portion and in longitudinal compression at the core. Similarly, growth stresses also develop in the transverse direction of the tree: The wood near the bark is in compression and the wood near the center of the tree is in tension.

Large growth stresses undoubtedly contribute to end splits in green logs. Heating the bolts or flitches causes the green wood to expand tangentially and shrink radially. This enlarges end splits in the logs. Flitches that have longitudinal growth stresses tend to bow during heating,, As long as growth stresses are uniformly distributed, they may cause log end splits and bowing of flitches (and crook in quarter-sliced veneer) but they do not cause other types of buckle in veneer.

Tension Wood

Unfortunately, the stresses in the tree are not always uniform. In particular, the abnormal type of wood known as tension wood occurs in many hardwoods and is characterized by higher longitudinal stresses than normally encountered. As tension wood occurs in bands of various intensities, it may cause green veneer to buckle as soon as it is cut. Tension wood shrinks more in a longitudinal direction than normal wood during drying and is a major cause of veneer buckling. Slicer operators may refer to tension wood as soft spots in the flitch.

Tension wood generally does not occur throughout a sheet but in narrow strips. These strips attempt to shrink more in length than the normal wood and so are subject to a tensile stress. The normal wood resists the attempted shrinkage of the tension wood and consequently the normal wood is subject to a stress in compression. Buckling occurs because the veneer sheet attempts to place itself in a configuration where stresses will be at a minimum.

Tension wood is associated with many highly valuable veneer species and has distinctly peculiar properties of the wood fibers as compared to the typical fibers of the respective hardwood species. The inner layers of tension wood fibers are essentially unlignified. Physically these layers are only weakly attached to the outer fiber Payers and may be torn loose by the knife edge rather than cutting smooth.

Identification in logs.--Tension wood is often found in logs that have bow or crook. Another indicator is an eccentric pith. The tension wood tends to occur in crescent-shaped bands on the wider radius as measured from the pith. Compared to the remainder of the cross section, the tension wood bands tend to be fuzzy because the relatively unlignified cells do not cut cleanly. Ordinary visual identification is aided further by either silvery or glaucous appearance of areas of tension wood which contrast with the surrounding wood.

Identification in veneer.--In veneer form, tension wood may show as silvery bands having a slightly fuzzy surface. Because of the tendency of tension wood to cut with a fuzzy surface, it is sometimes necessary to cool such flitches to slice them into relatively smooth veneer.

Compression Wood

Compression wood is typically found in softwood logs that have a pronounced eccentric pith. The crescent-shaped bands are most often found on the wide radius. They are dull, hornlike in appearance, and sometimes have a reddish cast. Compression wood is dense and superficially appears like extra-wide bands of summerwood. Because it is lignified, compression wood cuts well to form a smooth surface.

Like tension wood, compression wood has different growth stresses and higher shrinkage than normal wood. Consequently it may cause the green veneer to buckle and will very commonly cause pronounced buckle during drying of the veneer.

Irregular Grain

Another cause of buckle is irregular grain as may be found around khots and burls, and wavy grain in species like birch. The cause of buckle in these cases is apparently due mainly to different amounts of shrinkage during drying, depending on the alinement of the wood fibers. Faster drying at end-grain areas probably contributes to the buckle. The faster drying area tries to shrink but is under restraint from the rest of the sheet. Because of the restraint it cannot shrink, so it takes on a set. When the balance of the sheet dries it does shrink and the faster drying set area buckles. In general, buckle due to irregular grain is not as severe as buckle due to tension wood.

Improper Setting of the Lathe or Slicer

A fourth possible cause of buckle is improper setting of the lathe or slicer. Some poor techniques include use of a knife having high or low spots due to improper grinding or improper setting of the bar to the knife edge when the knife is changed. In addition, heat distortion may change the settings of the lathe or slices. A small-diameter core may bend in the lathe because it is insufficiently supported.

Nonuniform Drying

Differences exist in the original moisture content within a sheet of veneer as well as in the rate at which it will dry. Consequently, in veneer that is dried in a mechanical dryer to an average moisture content of 10 percent, moisture contents may actually range from 4 to 17 percent. This variation in moisture content results in stresses and buckle of veneer when the sheet eventually reaches a uniform moisture content in storage.

A specific example of nonuniform drying is the faster drying at the ends of veneer sheets that results in end waviness. Longitudinal grain dries as much as 10 to 15 times as fast as tangential or radial surfaces. Because the end sections dry faster, fibers at the ends have a tendency to shrink first, but are restrained by the rest of the sheet. As a result the fibers in the ends set closer to the green dimension than they normally should have for their average moisture content. This is called tension set. The differential in dimension remains unless removed by a conditioning or stress removal treatment.

Later, when the entire sheet is dried, the rest of the sheet shrinks more than the ends and exerts a compressive stress on the ends. The compression stress is relieved by the formation of waves in the ends of the veneer sheet.

This same phenomenon is probably the mechanism of general sheet buckle caused by nonuniform drying. The zones that dry first in the sheet and that have been held flat by the dryer-conveyor probably have some set. Later, when the moisture content of the veneer is equalized, the veneer buckles.

Control of Buckled Veneer

Just as there are several causes of buckled veneer, several methods can be used to help control this problem.

Identify and Select Wood Free of Tension Wood and Compression Wood

Logs that have crook or sweep and an eccentric pith probably have reaction wood. It will show as fuzzy, crescent-shaped bands on the end sections of hardwoods (tension wood) and as dull hornlike bands in softwoods (compression wood). If these indicators are pronounced, that section of the log having marked abnormal wood should be sawn into lumber or cut into chips rather than cut into veneer.

Relief of Growth Stresses During Heating of Flitches

Growth stresses tend to cause flitches to bow toward the bark side. If the stresses are high enough, the bow may start as soon as the flitch is sawn. Heating the unrestrained flitch accentuates the bow.

Heating wet wood to 180° F. or higher will remove most of the growth stresses. This, and the fact that hot wet wood is plastic, can be used to prevent crook in quarter-sliced veneer. Two flitches are strapped together with the bark toward the outside. When the strapped flitches are heated, the straps prevent bowing and the heating relieves the stress. When the straps are removed after heating the flitches, the relatively stress-free flitches can be quarter sliced without much crook in the veneer.

This technique cannot be used as well with bolts, as heating to high temperatures causes splits at the bolt ends to become much larger.

Control of the Lathe or Slicer Setup

Another area for control is correctly setting up the knife and pressure bar and maintaining this setup during cutting. Specifically, the knife grinder should be checked to see that it is producing straight knife and pressure-bar edges.

The lead and gap from the knife edge to the pressure-bar edge should be set precisely. We have found instruments helpful in making this setting. Care should be taken to see that heat distortion does not change the knife and pressure-bar settings during cutting. The best method is to have the lathe or slicer heated before making the knife-bar settings. Another method is to use the A-frame, installed on some castings that hold the pressure bar, to pull the bar straight after several hot bolts or flitches have been cut. A backup roll should be used to prevent bowing of small-diameter bolts.

Dimensional Stabilization of the Veneer

After the veneer is cut, it is possible to treat it with chemicals to reduce the amount of shrinkage that generally occurs during drying. A reduction in the general shrinkage should reduce the buckling due to unequal shrinkage. One chemical that has been used experimentally to bulk the cell walls and so reduce shrinking is low-molecular weight polyethylene glycol (PEG). The potential advantages of such treatment are reduction in shrinkage of the green veneer, reduction of buckling, and a face veneer that would be more resistant to checking in use.

Polyethylene glycol of different molecular weights from 400 to 1000 has been used experimentally to reduce buckling and checking of face veneer. Lower molecular weight PEG, such as 400 to 600, penetrates and stabilizes the cell walls more readily than the larger molecules, such as PEG 1000. However, lower molecular weight PEG is more hygroscopic. PEG causes some interference with finishing and gluing. The cost of the chemical polyethylene glycol would be about 1 cent per square foot of veneer.

Green veneer from the lathe of slicer could probably be treated by soaking in a solution of PEG for 18 to 24 hours depending on species, veneer thickness, and molecular weight of PEG used. About 25 percent pickup of the chemical is necessary to significantly reduce buckling when the veneer dries. The biggest problem in use of PEG is drying the treated veneer. Good stabilization is obtained by storing the treated veneer for 3 days, then air drying it for at least several hours in controlled humidity rooms. The 3 days of storage are needed to allow the PEG to diffuse into the cell walls. When the veneer dries quickly, as in most mechanical dryers, most of the PEG winds up in the lumen or cell cavity rather than in the cell wall where it must be to stabilize the wood.

PEG has little effect on the color of white woods. It will dissolve some pigments of dark-colored woods and so may change their color slightly. The dry treated veneer is flexible and has a greasy feel somewhat like teak.

Control of Drying Conditions

We found in laboratory experiments that end waviness could be largely controlled by making the sheet ends dry more like the bulk of the sheet. Three methods were effective. The simplest was to overlap the ends of the veneer sheets 1/4 inch. A second method was to dip the ends of the veneer into 1/2 inch of water for 5 seconds at the start of drying and after one-third and two-thirds of the drying cycle. The third method was to apply flexible masking tape over the end 1/2 inch of the veneer sheet prior to drying.

A jet dryer increases the rate of drying from the flat faces of the veneer. Because of the vertical impingement it may not cause a proportional increase in drying rate of the ends of veneer sheets. This should reduce end buckling of the veneer.

Various schemes have been tried to equalize the moisture content of all of the veneer as it is dried. In a kiln, this can be done by controlling the temperature and relative humidity. Similar controls have not been satisfactory for mechanical dryers because of the high dryer temperatures and the short length of time in which the moisture content must be equalized. Other means of obtaining more uniform final moisture contents in the veneer are use of high-frequency or microwave units at the dry end of the dryer. These electronic drying methods apparently work but have not been generally adopted because of the cost.

One function of a veneer dryer is to permit the veneer to shrink while it remains relatively flat. Some movement of the veneer must be allowed or it will split during drying. In a kiln this movement is accomplished by relief stickers; in a platen dryer by breathing; in a roller dryer by the space between rollers; and in a wire-mesh dryer by having the top mesh of a weight that will permit the veneer to shrink without splitting. The closer the veneer is held to a flat surface during drying, the better buckle will be controlled. The hot, wet wood is plastic and will tend to conform to the shape in which it is held while it dries. Further, the veneer should be held in a flat position until it is cool. When the veneer is cool, it is less plastic and so more likely to stay in the desired flat condition.

The importance of holding the veneer flat during drying can be judged by comparing matched sheets of veneer dried with various amounts of restraint. In general, buckle will be greatest in veneer hung from the ends and allowed to dry in an oven. Next will be veneer restrained by stickers and dried in a kiln.

Matched veneer dried in 2 mechanical dryer with a roller or wire-mesh conveyor will be less buckled than that dried in a kiln, The least buckled will be veneer dried between flat hot-plates that are opened periodically to allow the moisture to escape and the veneer to shrink.

Plasticizing and Flattening Buckled Veneer with Moisture, Heat, and Pressure

When the veneer has been dried and is buckled, what can be done? Traditionally, water sometimes with a little glycerine is added to the veneer to plasticize the wood so that it can be flattened without splitting. Glycerine is a humectant and so tends to keep the veneer at a higher moisture content than untreated wood, The dampened veneer is then held between warm, flat plates. Sometimes several treatments are used to gradually flatten the veneer. Variations of this procedure include putting the veneer between damp blotter boards and then between warm wooden cauls, use of a hot press redryer, and even the use of a high-frequency press. In all cases, the principle is the same. The wood is first made somewhat plastic by adding water. The plasticity will increase until the moisture content reaches about 25 percent. Only as much water should be added as is necessary to flatten the veneer without splitting it. The veneer is then held flat while it is heated. The heat makes the wood even more plastic. The higher the temperature, the more plastic the wood becomes. German researchers have studied the interaction of heat and moisture on plasticizing wood. Figure 1 shows their conclusions.

The time of pressing is only that needed to heat the wood through. For a single sheet of 1/32--inch-thick veneer the pressing time might be 1/2 to 1 minute. The time required to heat through a pack of veneer 1 inch thick might be 30 to 40 minutes.

The rate of temperature change is proportional to the square of the thickness of the pack. For example, if it takes 32 minutes to obtain a given temperature at the center of a stack of veneer 1 inch thick, it will require only 1/16 as long, or 2 minutes, for a stack 1/4 inch thick. A practical compromise considering handling, loading, and unloading the press would be to take stacks of veneer about 1/4 inch thick, and flatten them in 3 to 4 minutes.

The most favorable pressure was found to be 1 kilogram per square centimeter or about 14 pounds per square inch.

In other words, flattening veneer depends on the interaction of temperature and moisture content in the wood. The lower the moisture content, the higher the temperature required. For example, veneer at 24 percent moisture content can be flattened with a temperature of about 104° F., while veneer at 4 percent moisture content requires a temperature of about 230° F. to be flattened. These are not exact relationships. The researchers point out the required temperature may be as much as 36° F. higher than indicated by the median line of the curve.

Commercially, veneer is often purposely dried while the buckle is being removed. The moisture content of the veneer pack going into the press may be 8 to 12 percent and the moisture content out of the press 4 to 6 percent. If this is the case, a longer press cycle such as 8 to 10 minutes may be used. The press is opened momentarily every 90 seconds to permit moisture to escape and the veneer to shrink.

The temperature used in plate redrying can darken veneer. Consequently, light-colored woods, and woods such as rosewood that are susceptible to color change, are generally not heated over 250°F. Teak is generally not plate-redried because heat darkens it excessively.

An essential part of the flattening process is to cool the veneer while it is held flat. If the flattened veneer is free to move while it cools, it may reassume some of the buckle. The veneer should be processed soon after it is flattened. Otherwise, it will tend to gradually buckle again with changes in time.

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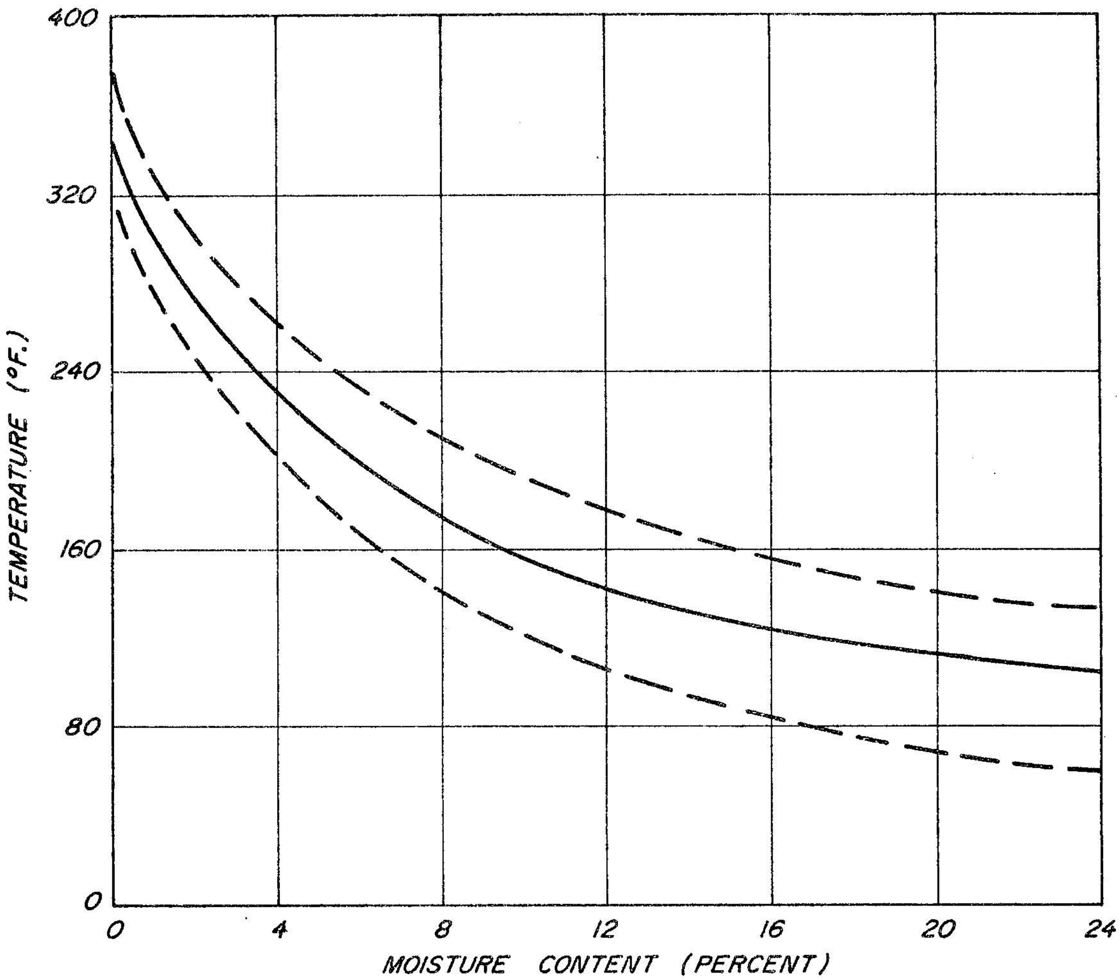

Figure 1.--Temperatures required to flatten knotty hardwood veneer at various moisture contents. The solid line is the average for all species, with the dashed lines indicating the general range. (Adapted from figure 3 on veneer flattening from "Plastische Formung und Spannungsbeseitigung bei Hölzern, unter besonderer Berücksichtigung der Holztrocknung," by Hans Kübler, Holz als Roh- und Werkstoff, Bd. 14 (1956), S. 422-447.

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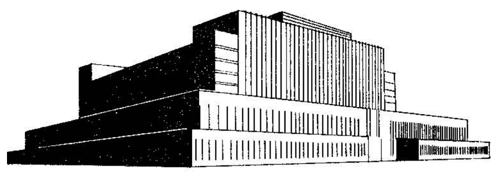

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