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METHOD OF GLUING

Charles B. Norris, Grand Rapids, Mich., assignor, by mesne assignments, to Reconstruction Finance Corporation, a Federal corporation

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It is known that plywood or compound lumber glued with synthetic thermosetting resin or resins, when the gluing is properly done, possesses definite advantages over similar products in which glues of other kinds are used. However, such difficulties have heretofore been encountered in gluing plywood or compound lumber with such a resin that no general or even wide use of that process has been developed. The present invention has for its object to provide a method of gluing with a thermosetting resin or resins that makes production of plywood or compound lumber, glued with this resin, of good, uniform quality, simple and easy.

A glue joint with fusible resin of the thermosetting type is made under the influence of heat and pressure, the resin first becoming soft, so that portions thereof may enter into the crevices or pores of the wood, and then becoming hard and set. Therefore, since it is the resin alone that does the gluing, and, as will hereinafter appear, the presence of moisture in the wood and glue is an important factor in the making of a glue joint, it is preferable that the resin be in a relatively dry state at the beginning of the gluing operation. The resin may be applied as a dry powder or as a varnish or in a colloidal state; the solvent being, however, driven off or the water evaporated before the gluing is begun. I prefer to employ colloidal resin because it can be spread uniformly with ease on the surfaces to be coated and can then be quickly dried; the dry resin adhering to the wood during the handling of the same prior to placing it in the gluing press.

I have discovered that the total moisture content in the laminated mass that is to constitue a panel or piece of lumber, when finished, is a most important factor in the gluing process; and, after long experimentation, I have further discovered that the moisture content should be reasonably high, namely, around ten per cent. or, say, between about seven and about twelve per cent. When a panel to be glued is placed in a press and heated, the heat enters through the opposite outer faces and travels inwardly toward the center. Moisture in the path of the heat is transformed into steam which forces its way inwardly and, as it enters a cool zone, it condenses. In condensing, the steam gives up heat so that, in slow heating of a panel, the center or heart of the panel will be heated largely by the steam that reaches it, rather than by conduction, if there be enough moisture present. When a panel has become heated through, the moisture is all in the form of steam and, after the glue has set, the steam finds itself divided into layers separated from each other by glue layers. Since the gluing is done at a high temperature, say about 340° F., and the steam can escape only slowly through the edges of the panel, there may be sufficient internal steam pressure in the panel, upon opening the press, to split and rend the panel. If the wood and the glue are very dry, containing only one or two per cent. of moisture, there will perhaps not be enough steam created to cause damage, but such a low moisture content gives rise to a further objection. When there is little moisture in the panel the heating of the several glue layers in a thick panel must take place entirely by conduction from the outer faces inwardly. In that event, the inner glue layers may set without having become sufficiently soft to make a good glue joint and an inferior product will be the result. It is therefore necessary that there be enough moisture to enable the center of the panel composed of more than three plies to receive much of the needed heat from the steam that is generated and thus become heated more rapidly than would otherwise be the case, or that different grades or qualities of resins be employed at different levels in the interior of the panel.

Ordinarily it is, of course, impracticable to employ different kinds of glues in the several joints of a panel and therefore a considerable moisture content is needed to make possible the use of a single kind of glue. There are various other advantages in having a reasonably high moisture content in the wood. When wood veneers are too dry they become badly warped and, in that condition, it is practically impossible to lay two sheets side by side and make a good edge joint between them. Also, when a glued panel composed of or faced with such dry veneers is removed from the press the two outer layers immediately begin to take up moisture from the air and thus tend to expand. However, the outer layers are held by the glue and cannot expand; with the result that enormous compression stresses are set up in the outer layers and the fibers are stressed beyond their elastic limit. Upon drying again, the broken down veneers pull apart and present checked surfaces. In the case of a very dry panel having a thick core in which the grain of the wood crosses the grain in the veneers glued to opposite faces thereof, the core will take up moisture and swell across the grain. The two veneers between which it lies cannot expand in the direction of their grain, which is the direction in which the core swells and, as a

consequence, the glue joints between the core and the veneers are subjected to severe shearing stresses which are often great enough to produce open joints at the edges of the panel where the swelling of the core is greatest.

On the other hand, when the plies or layers of wood have a reasonably high moisture content, the difficulties just pointed out may all be avoided and I therefore do not dry the wood too much before gluing. Seasoned wood housed in a dry heated room or building contains much less moisture than does the same wood exposed to the damp outside air. If the wood that is being glued has a moisture content that lies somewhere between these two, it will not afterwards take up as much moisture as it would if it were much drier or dry out as much as it might at times if it had originally contained more moisture. I therefore do the gluing with wood that may be said to have a medium or reasonably high moisture content. Seasoned wood in a dry heated room may contain about five per cent. of moisture and after lying outside may contain around fifteen per cent. of moisture. A moisture content about half way between these two or, in the neighborhood of ten per cent., has been found to give very good results: providing enough moisture to heat the interior of a panel largely by steam into which the moisture is transformed; preventing damaging compression or expansion stresses from arising in the wood; and causing the wood, in the form of veneers, to be in a flat condition instead of being curled and warped.

Coupled with medium dryness I employ slow heating of the panel. By slow heating I mean that the temperature of the heat interchangers must be low at the start of the gluing process and then be caused to rise. The initial temperature of the heat interchanger may be the same as that of the panel or it may be somewhat higher. If the heat is being supplied by steam chest platens, these must be cooled before the beginning of a gluing operation. If the heat interchangers are electrically heated panels they will ordinarily cool off very rapidly upon the shutting off of the current and the removal thereof from the press, and will be found to be cool enough when they are again needed. In actual practice good results have been obtained by having both the heat interchangers and the work to be glued at room temperature upon the closing of the press. With slow heating, steam is generated while the two outermost layers of resin are melting and travels toward the center of the panel where it gives up heat to raise the temperature of the wood and the glue. I have found, also, that slow heating is very desirable for additional reasons. When thermosetting resins, preferably of the phenol-formaldehyde type, are ready for use as a glue they are said to have a certain "advancement," which in one sense means that the chemical changes that cause complete setting of the glue to an insoluble solid have progressed more or less but have not been completed. The farther the "advancement" the higher the temperature at which the resins soften. The term "advancement" is also employed in referring to the size of the molecules in the resin. If the molecules are small the resin is said to be less advanced than it is where the molecules are large. However, the size of the molecules does not depend upon the other kind of "advancement" mentioned above for, if the resin is heated very quickly, it may be completely set and the molecules be of a certain size; whereas if the heating is done more slowly it can be completely set but the molecules will be much larger.

A film made with resin in the form of large molecules is likely to be much stronger than a film made with resin in the form of smaller molecules. Therefore, in order to make it more likely that the molecules will be large, it is preferable slowly to heat the panels to be glued rather than to cause the temperature thereof to rise rapidly.

One of the serious problems in gluing with thermosetting resins is to insure that the resins will soften sufficiently, but not too much to permit a good joint to be made. If the resins become too liquid they will be absorbed by the wood, with the result that the joints will be weak; and, if they do not become soft enough, they will not penetrate sufficiently into the wood to produce a strong joint. The presence of moisture lowers the softening point of the resin and also retards the setting thereof. This sensitiveness of the resin to moisture is very evident if the resin is heated rapidly. It is obvious that under certain conditions, with respect to the stage of advancement of the resin and moisture content, rapid heating will cause the resins to become too liquid. The presence of moisture lowers the softening point of the resin, thereby counteracting the effect of heating a panel more slowly in the center thereof than in the outer portions. Since the "advancement" of resins intended for use as a glue varies greatly, and since the "advancement" progresses from the beginning of every heating operation, it is wholly impracticable to insure good commercial gluing, particularly in the case of panels of more than three plies, unless expedients are adopted to offset the vagaries of resins in different stages of advancement. I have found that the only expedients that will serve this purpose are a reasonably high moisture content in the wood and slow heating of the panels.

It is not enough that the operation of making good glue joints in a panel be successful, but the panel must be removed from the press in a sound condition. Some of the steam generated in the panels during the gluing process escapes; but, at the end of the process, the internal pressure in the panel caused by the remaining steam and the vapor pressure of the gaseous reaction products is still considerable. Then, when the pressure on the panel is relieved, the panel is subjected to internal expansion forces which may be great enough to blister the panel and even tear it apart. The slower the heating of the panel, the greater will be the leakage of steam and vapor and the lower will be the internal pressure in the panel.

I have discovered that if the external pressure on the panel be relieved very slowly, the remaining steam and vapors will gradually work their way out of the panel without injury to the latter. If only the pressure of the steam were involved, the pressure could be lowered quickly from the gluing pressure of about two hundred fifty pounds to about sixty pounds and then the reduction to atmospheric pressure could proceed slowly. However, because of the presence of the vapor pressure of the gaseous reaction products within the panel, the safest way to proceed is to cause a gradual lowering of the pressure from the beginning. In actual practice I have found that panels will leave the press in a sound, undamaged condition when a period of about five minutes is allowed for the gradual release of the pressure down to atmospheric pressure.

It will thus be seen that my improved process consists in the preparation of the assembled plies

with the resin between them, in such a condition that the rudimentary panel assembly be not too dry nor too wet; and the subsequent pressing of the assembly and the slow heating thereof. Furthermore, because of the time factor in commercial operations it is necessary to remove the panel or panels from the press without undue delay, the full advantages of my invention or discovery are not obtained unless there be, also, a slow release of the pressure on the glued panel. It will be understood that by slow release I do not mean that the rate of release must be uniform and gradual, but that it need simply be such that the steam pressure or the pressure of the steam and vapor may subside before any damage can be done thereby to the panel upon opening the press.

I claim:

1. The method of gluing a plywood panel with thermosetting resin in a reactive state, which consists in assembling plies with the resin interposed between adjacent plies, the whole being in such a condition that the moisture content is considerable, applying heat and pressure, and then slowly releasing the pressure.

2. The method of gluing a plywood panel with thermosetting resin still in a fusible condition, which consists in assembling plies containing considerable moisture with dry resin interposed between adjacent plies, applying heat and pressure, and then slowly releasing the pressure.

3. The method of gluing a plywood panel with resin of the thermosetting type, which consists in assembling plies having a considerable moisture content with dry resin interposed between adjacent plies, then applying pressure to and slowly heating the assembly, and then releasing the pressure so slowly that several minutes are consumed in bringing it down to atmospheric pressure.

4. The method of gluing a plywood panel with resin of the thermosetting type, which consists in assembling a rudimentary panel having a moisture content of from seven to twelve per cent. and consisting of plies of wood alternating with layers or coatings of resin, applying heavy pressure to and slowly heating the panel, and then releasing the pressure so slowly that several minutes are consumed in bringing it down to atmospheric pressure.

5. The method of gluing a plywood panel with resin of the thermo-setting type, which consists in assembling a rudimentary panel having a moisture content of from 7% to 12% and consisting of more than three plies of wood, alternating with dry layers or coatings of resin, and subjecting the rudimentary panel to a pressure of less than 400 pounds per square inch between heating elements whose temperature, at the beginning, is about the same as that of the panel and is thereafter gradually raised until it exceeds 300° F.

CHARLES B. NORRIS.