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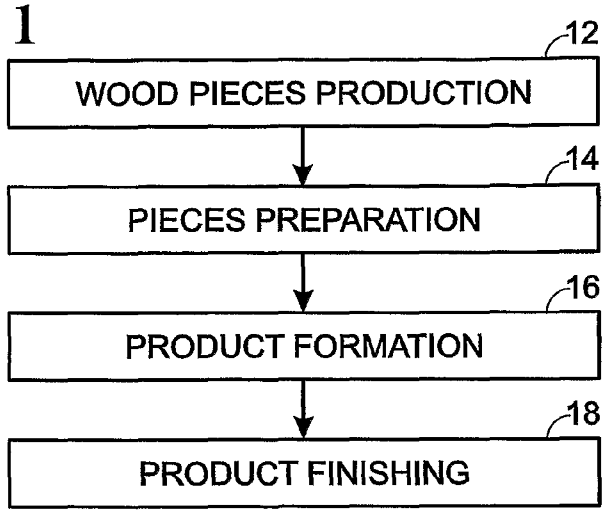
(54) Title: METHODS OF MANUFACTURING ENGINEERED WOOD PRODUCTS

Fig. 1



(57) Abstract: Methods for manufacturing an engineered wood product are disclosed. The method may include orienting two or more sets of wood pieces to provide a blanket of oriented pieces, the blanket of oriented pieces including a core layer sandwiched between a pair of face layers, wherein at least one of the sets of wood pieces includes at least one phenol- formaldehyde (PF) resin; steam preheating at least a portion of the blanket of oriented pieces; and curing the at least one PF resin, wherein the curing includes exposing at least a part of the blanket of oriented pieces to at least one of an elevated temperature, an elevated pressure, and radiant energy, and wherein the exposing is partially performed while at least some steam from the steam preheating is within the core layer.

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Methods of Manufacturing Engineered Wood Products

Background of the Disclosure

Engineered wood products have become more popular because those products typically make better use of available forest resources. For example, products may be produced from smaller and lower quality trees, as compared to conventional wood products. Engineered wood products have been used in several applications, such as panels, boards, timber, beams, headers, columns, studs, wood I-joists, and various other applications.

Engineered wood products typically are manufactured by bonding together wood strands, veneers, lumber, particles, and/or other forms of wood pieces to produce a larger composite material. Wood pieces may be blended with one or more resins, arranged in particular configuration(s), and then exposed to elevated temperatures, elevated pressures, and/or radiant energy to cure the resins. To facilitate the curing of the resins, the wood pieces may be preheated before being exposed to the elevated temperatures, elevated pressures, and/or radiant energy. For example, the arranged wood pieces may be preheated with steam, radio frequency, and/or microwave.

The use of steam for preheating may, however, cause washout of the resin and/or otherwise prevent the resins from curing. Washout resistant resins may be used to minimize washout. MDI (methylene diphenyl diisocyanate) resins are commonly used for producing strand-based composites and/or products, such as Oriented Strand Board (OSB), Oriented Strand Lumber (OSL), and Laminated Strand Lumber (LSL), using steam pressing or steam pre-heating because MDI resins react with water and are resistant to moisture. Release agent(s) typically must be used with the washout resistant resins because those resins may cause the wood pieces to adhere to the equipment used. Alternatively, the manufacturing process may be optimized in one or more other ways to minimize washout of the resin(s).

Examples of manufacturing processes are provided in U.S. Patents Nos. 6,818,317; 6,800,352; 6,767,490; 6,136,408; 6,098,679; 5,718,786; 5,525,394; 5,470,631; 5,443,894; 5,425,976; 5,379,027; 4,364,984; 4,893,415; 4,751,131; 4,517,147; 4,364,984; 4,361,612; 4,198,763; 4,194,296; 4,068,991; 4,061,819; 4,058,906; 4,017,980; 3,811,200; 3,685,959; 3,308,013; 3,173,460; 3,164,511; 3,098,781; 2,343,740; and 1,023,606, European Patent No. 0172930, and U.S. Patent Application Publication Nos. 2006/0102278 and 2005/0082709. The complete disclosures of those patents and patent applications are herein incorporated by reference for all purposes.

Summary of the Disclosure

Some embodiments provide a method for manufacturing an engineered wood product. In some embodiments, the method may include orienting two or more sets of wood pieces to provide a blanket of oriented pieces, the blanket of oriented pieces including a core layer sandwiched between a pair of face layers, wherein at least one of the sets of wood pieces includes at least one phenol-formaldehyde (PF) resin; steam preheating at least a portion of the blanket of oriented pieces; and curing the at least one PF resin, wherein the curing includes exposing at least a part of the blanket of oriented pieces to at least one of an elevated temperature, an elevated pressure, and radiant energy, and wherein the exposing is partially performed while at least some steam from the steam preheating is within the core layer.

In some embodiments, the method may include orienting two or more sets of wood pieces to provide a blanket of oriented pieces, the blanket of oriented pieces including a core layer sandwiched between a pair of face layers, wherein at least one of the sets of wood pieces includes at least one PF resin and at least the other of the sets of wood pieces includes at least one MDI resin; steam preheating at least a portion of the blanket of oriented pieces; and curing the at least one PF resin and the at least one MDI resin, wherein curing includes exposing at least a part of the blanket of oriented pieces to at least one of an elevated temperature, an elevated pressure, and radiant energy at least partially while at least some steam from the steam preheating is within the core layer.

In some embodiments, the method may include orienting lengthwise two or more sets of wood strands to provide a blanket of oriented strands, the blanket of oriented strands including a core layer sandwiched between a pair of face layers, wherein at least one of the sets of wood strands includes at least one PF resin and at least the other of the sets of wood strands includes at least one MDI resin; steam preheating at least a portion of the blanket of oriented strands; and curing the at least one PF resin and the at least one MDI resin, wherein the curing includes exposing at least a part of the blanket of oriented strands to at least one of an elevated temperature, an elevated pressure, and radiant energy, and wherein the exposing is partially performed while at least some steam from the steam preheating is within the core layer.

Brief Description of the Drawings

Fig. 1 is a flow diagram of an example of a method of manufacturing engineered wood products.

Fig. 2 is a more detailed flow diagram of the method of Fig. 1.

Figs. 3-4 are flow diagrams of other examples of a method of manufacturing engineered wood products.

Detailed Description of the Disclosure

Figs. 1-2 provide an example of a method for manufacturing engineered wood products, which is generally indicated at 10. The method may include any suitable steps configured to manufacture one or more types of engineered wood products. For example, method 10 may include the steps of wood pieces production at 12, pieces preparation at 14, product formation at 16, and product finishing at 18. The steps may be performed in different sequences and in different combinations, not all steps being required for all embodiments of method 10. Additionally, two or more steps may be performed simultaneously and/or may overlap. For example, a step may be at least started before completing the prior step.

Wood pieces production at 12 may include one or more steps configured to produce the desired type of wood pieces from wood raw material(s), such as from any suitable type(s) of species of logs. For example, wood pieces production may include the steps of sorting at 20, soaking at 22, preparation at 24, and cutting at 26. The step of sorting may be configured to sort usable raw material(s) from unusable raw material(s). For example, log sorters may be used to sort out usable logs from unusable logs.

The step of soaking may be configured to soak raw material(s) to deice, heat, and/or prepare the wood, such as when the logs are below about 50 °F. For example, logs may be heated in soaking or thaw ponds and/or via any suitable structure or equipment. The soaking or thaw pond(s) may be at any suitable temperature(s). For example, the logs may be heated in a pond of water having a temperature of up to about 176 °F, up to about 140 °F, or up to about 104 °F. Specifically, the logs may be heated in the thaw pond having a temperature of about 86 °F to about 110 °F. Additionally, the logs may be heated for more than about one hour. Specifically, the logs may be heated for about one hour to about forty-eight hours.

The step of preparation may be configured to prepare raw material(s) for the step of cutting, such as removing unusable parts of the raw material(s). For example, logs may be debarked in any suitable debarker(s), such as ring and drum debarkers. The step of cutting may be configured to cut or slice the prepared raw material(s) into the desired wood pieces. Flakers (such as disk flakers and ring flakers), stranders, and/or any other suitable equipment may be used to perform the step of cutting. As used herein, "wood pieces" may include flakes, strands, veneers, pieces, fines, and/or any suitable pieces sliced or otherwise cut from wood raw material(s), such as logs.

The wood pieces may be any suitable size(s). For example, when the desired wood pieces are flakes for strand-based products, then those flakes may have lengths (y-dimension) of up to about 12 inches or about 4.5 inches to about 6.0 inches, and may have widths (x-dimension) of up to about 12 inches or about 0.75 inches to about 2.5 inches. Similarly, those flakes may have a thickness (z-dimension) of about 0.001 inches to about 0.060 inches, or about 0.020 inches to about 0.030 inches. The width of the flakes may be a function of the length of the flakes. For example, the length of the flakes may be at least about three times greater than the width of the flakes, which may provide for proper flake orientation and acceptable physical properties for the engineered wood product.

Additionally, if the desired pieces are strands for OSL or LSL billets, then those strands may have lengths (y-dimension) of about 6 inches or about 0.5 inches to about 7 inches, and may have widths (x-dimension) of about 0.75 inch or about 0.04 inches to about 2.5 inches. Similarly, those strands may have a thickness (z-dimension) of about 0.031 inches, or about 0.01 inches to about 0.08 inches. The width of the strands may be a function of the length of the strands. For example, the length of the strands may be at least about three times to at least about six times greater than the width of the flakes. ASTM D5456 – 05 (sections 3.2.2.1 and 3.2.2.3), the complete disclosure of which is herein incorporated by reference for all purposes, defines LSL and OSL as a composite of wood strand elements with wood fibers primarily oriented along the length of the member with a least dimension (such as the lesser of a thickness or a width) of the strands of LSL and OSL not to exceed 0.10 inches. The average length of LSL shall be a minimum of 150 times the least dimension, and the average length of OSL shall be a minimum of 75 times the least dimension.

Although the wood pieces are described to have certain dimension ranges, those wood pieces may have any suitable dimensions. Additionally, although the step of wood pieces production is described to have certain steps, the step of wood pieces production may include any suitable steps configured to produce the desired type of wood pieces from raw material(s), such as from any suitable type(s) of species of logs. Moreover, the steps discussed above may be performed in different sequences and in different combinations, not all steps being required for all embodiments of method 10.

The step of pieces preparation at 14 may include one or more steps configured to prepare the wood pieces for producing the engineered wood product(s). For example, the step of pieces preparation may include the step of moisture adjustment at 28 and screening at 29. Any suitable dryer(s) may be used for the step of moisture adjustment, such as a tumble dryer, triple-pass dryer, a single-pass dryer, a combination triple-pass/single-pass dryer, and/or a three-section conveyor dryer. Another example of a suitable dryer is one in which the wood pieces are laid on a chain mat and the wood pieces are held in place as they move through the dryer. The wood pieces may be dried under any suitable conditions (e.g., at a temperature of about 104 °F for about ten seconds or more), provided at least some of the water present is removed. Specifically, the wood pieces may be dried at about 150 °F to about 225 °F for about eight to ten minutes.

Although the step of moisture adjustment is described to include the use of one or more dryers, any suitable equipment may be used to adjust the moisture of the wood pieces. For example, the step may additionally, or alternatively, include the use of one or more moisture addition equipment.

Any suitable type of equipment may be used for the step of screening at 29. For example, rotating disk screens (triangular, square, and/or rectangular shaped disks), rotary screens and inclined vibrating conveyors with screened sections may be used. Although the step of pieces preparation is shown to include the step of moisture adjustment and the step of screening, the step of pieces preparation may include any suitable step(s) configured to prepare the wood pieces for producing the engineered wood product. The steps of pieces preparation may be performed in different sequences and in different combinations, not all steps being required for all embodiments of method 10.

The step of product formation at 16 may include one or more steps configured to produce an engineered wood product from the prepared wood pieces. For example, the step of product formation may include the steps of blending at 30, orienting at 32, preheating at 34, and curing at 36. The step of blending may be configured to contact at least part of one or more sets of the prepared wood pieces with one or more resins. For example, the step of blending at 30 may include the step of separating the wood pieces into two sets, the step of contacting at least part of a first set of wood pieces with a first resin, and the step of contacting at least part of a second set of wood pieces with a second resin. The first and/or second sets of wood pieces may include any suitable wood pieces. For example, the first and/or second set of wood pieces may include wood strands and/or wood flakes. Any suitable equipment may be used to perform the step of blending, such as separate rotating blenders for the first and second sets of wood pieces and spinning disk resin applicators and/or other resin applicators.

As used herein, "resin" may include an adhesive polymer of natural and/or synthetic origin. Any suitable resin(s) may be used in the blending step. For example, the resins may be thermoplastic polymers or thermosetting polymers. As used herein, "thermoplastic polymers" may include long-chain polymers that soften and flow on heating, and then harden again by cooling. Those polymers may generally have less resistance to heat, moisture, and long-term static loading than thermosetting polymers. Examples of resins that are based on thermoplastic polymers may include polyvinyl acetate emulsions, elastomerics, contacts, and hot-melts. As used herein, "thermosetting polymers" may undergo irreversible chemical change, and on reheating, may not soften and flow again. Those polymers may form crosslinked polymers that may have strength, may have resistance to moisture and other chemicals, and may be rigid enough to support high, long-term static loads without deforming. Examples of resins that are based on thermosetting polymers may include phenolic, resorcinolic, melamine, isocyanate, urea, and epoxy.

The resins may be of natural origin, synthetic origin, or may include a combination thereof. Resins of natural origin may include animal protein, blood protein, casein protein, soybean protein, lignocellulostic residue and extracts, bark-based resins, and combinations thereof. Resins of synthetic origin may include cross-linkable polyvinyl acetate emulsion, elastomeric contact, elastomeric mastic, emulsion polymer/isocyanate, epoxy, hot melt, isocyanate, formaldehyde, melamine and melamine urea, phenolic, polyurethane, resorcinol and phenol resorcinol, urea, and combinations thereof.

Specifically, the resins may include an isocyanate resin, a melamine resin, a phenol-formaldehyde (PF) resin, a melamine-formaldehyde (MF) resin, a phenol-melamine-formaldehyde (PMF) resin, a melamine-urea-formaldehyde (MUF) resin, a phenol-melamine-urea-formaldehyde (PMUF) resin, or a combination thereof. Examples of suitable isocyanate resins may include PMDI (polymethylene diphenyl diisocyanate); MDI (methylene diphenyl diisocyanate), or a combination thereof.

The phenols of the above resins may be substituted. Examples of suitable substituted phenols may include alkyl substituted phenols, aryl substituted phenols, cycloalkyl substituted phenols, alkenyl substituted phenols, alkoxy substituted phenols, aryloxy substituted phenols, and halogen substituted phenols, as disclosed in U.S. Patent No. 5,700,587, the complete disclosure of which is hereby incorporated by reference for all purposes. Additional examples of suitable substituted phenols are disclosed in U.S. Patent No. 6,132,549, the complete disclosure of which is hereby incorporated by reference for all purposes.

Additionally, or alternatively, the formaldehyde of the above resins may be replaced with another suitable aldehyde. Examples of suitable aldehydes include acetaldehyde, propionaldehyde, furfuraldehyde, and benzaldehyde. In general, the aldehyde employed may have the formula R'CHO wherein R' is a hydrogen or a hydrocarbon radical of 1 to about 12 carbon atoms. Other examples of suitable aldehydes are disclosed in U.S. Patent No. 5,700,587, the complete disclosure of which has been incorporated by reference for all purposes.

The resin may be a solid, such as a powder, a liquid, or a combination thereof. For example, the resin may be in at least substantially liquid form or the resin may be in at least substantially solid form. If the resin is a liquid, the liquid resin may be relatively viscous, relatively nonviscous, or somewhere in between. If the resin is a liquid and is a relatively viscous, then the resin may be diluted with one or more carriers to render the resin relatively nonviscous. Examples of suitable carriers may include water, organic hydrocarbons, or a combination thereof.

Some of the resins described above may be more washout resistant than other resins. Thus, a blanket of oriented pieces formed from the wood pieces may be configured to at least substantially minimize washout of the resin by, at least in part, using resins that are more washout resistant than other resins. As used herein, "washout" may refer to loss of at least a portion of the resin during one or more steps of method 10 before the resin is cured, such as the preheating step at 34. As used herein, "washout resistant" or "washout resistance" may refer to characteristic(s) of the resin to remain at least in partial contact with the wood pieces and/or to resist washout before the resin is cured.

When steam is used during at least part of the preheating step, an isocyanate resin (such as MDI) may be more washout resistant than a PF resin. When MDI is used, one or more release agents may be used to minimize adherence of the wood pieces having MDI to one or more portions of the equipment used in method 10, such as the steel used in the presses of the step of curing. The release agent(s) may be mixed with the MDI and/or applied to surface(s) of the equipment.

Some of the resins described above may react with water and may thus be more washout resistant than other resins that do not react with water. For example, when steam is used during at least part of the preheating step, isocyanate resins may react with water, while PF resins may not react with water. Although isocyanate resins are discussed to be more washout resistant than PF resins, other resins also may be more washout resistant than PF resins and/or less washout resistant than isocyanate resins. Additionally, although isocyanate resins are discussed to react with water and PF resins are discussed to not react with water, other resins also may react with water and other resins may not react with water.

Additional examples of suitable resins may be found in the *Handbook of Thermoset Plastics; Wood Handbook*, sections 9-16, 9-9, 10-3, and 10-4; *Forest Products Society Publications* (http://www.forestprod.org); *Wood Adhesives 2000*, extended abstracts cat. No. 7260; *International Contributions to Wood Adhesion Research*, cat No. 7267; *Wood Adhesives 1999*, cat No. 7266; *1998 Resin Binding Seminar Proceedings*, cat No. 7266; *Handbook of Pressure Sensitive Adhesive Technology*, 3rd edition by Donatas Satas, Hardcover; *Handbook of Adhesive Technology*, by A. Pizzi, K.L. Mittal, Hardcover; *Resin Transfer Moulding*, by Kevin Potter, Hardcover; and *Cyanoacrylate Resins: The Instant Adhesives*, by Henry L. Lee, Paperback, T/C Press, January 1986; and references cited therein. The complete disclosures of the above references are hereby incorporated by reference for all purposes.

Additional examples of suitable resins may be found in U.S. Patent Nos. 6,136,408; 6,132,885; 6,132,549; 6,028,133; 5,974,760; 5,951,795; 5,861,119; 5,714,099; 5,700,587; 5,635,118; 5,554,429; 5,552,095; 5,425,908; 4,758,478; 4,514,532; 4,407,999; 4,364,984;

and references cited therein. The complete disclosures of the above patents are hereby incorporated by reference for all purposes.

In the example discussed above, at least part of the first set of wood pieces may be contacted with at least one PF resin, while at least part of the second set of wood pieces may be contacted with at least one isocyanate resin (or at least one MDI resin). The at least one PF resin may be in at least substantially liquid form or at least substantially solid form. Alternatively, the at least one PF resin may include one or more PF resins in at least substantially liquid form and one or more PF resins in at least substantially solid form.

Additionally, the first and/or second sets of wood pieces may be contacted with wax and/or other additives during the step of blending. For example, wax may be added to improve the efficiency of the resin(s) used and/or enhance the resistance of the blanket of oriented pieces to moisture and water absorption. Other additive(s) may additionally, or alternatively, be used to provide the engineered wood product with particular characteristics. For example, pesticides and/or fungicides may be used to provide engineered wood products that are resistant to pests, such as termites, and/or fungus, as described in U.S. Patent No. 6,818,317. The complete disclosure of that patent has been incorporated by reference for all purposes.

Although the first set of wood pieces is described to be contacted with at least one PF resin and the second set of wood pieces is described to be contacted with at least one isocyanate resin, the first and/or second sets of wood pieces may alternatively, or additionally, be contacted with one or more other suitable resins. Additionally, although the first and second sets of wood pieces are discussed to be contacted with different resins, both sets of wood pieces may be contacted with the same resin.

Moreover, although the prepared wood pieces are discussed to be separated into two sets of wood pieces, the prepared wood pieces may be separated into three or more sets of wood pieces, with those sets of wood pieces being contacted with one or more resins. For example, the prepared wood pieces may be separated into three, four, five, or six sets of wood pieces, which may be used to form a blanket of oriented pieces with any suitable number of layers, such as three, four, five, or six layers.

The step of orienting the wood pieces at 32 may be configured to provide or form a mat or blanket of oriented pieces. The blanket of oriented pieces may have any suitable numbers and/or types of layers. For example, the blanket of oriented pieces may include a core layer sandwiched between a pair of face layers.

"Sandwiched," as used herein to describe the core layer, refers to the core layer being positioned between a pair of face layers within the blanket of oriented pieces, regardless or independent of the existence of one or more layers between the core layer and one or both of the face layers. In some embodiments, the core layer may be adjacent to one or both of the face layers. Alternatively, or additionally, one or more layers may be positioned between the core layer and one or both of the face layers. Those layers positioned between the core layer and face layers may sometimes be referred to as "intermediate layers." Additionally, or alternatively, the blanket of oriented pieces may include two or more core layers positioned between a pair of face layers.

Any suitable set or combination of sets of wood pieces from the blending step may be used to form one or more of the layers of the blanket of oriented pieces. For example, the core layer may be formed of the second set of wood pieces, while the pair of face layers may be formed of the first set of wood pieces.

Additionally, the wood pieces may be oriented in any suitable direction in each of the layers. For example, at least a substantial portion of the wood pieces of the core layer and the face layers may be oriented at least substantially lengthwise (or along the length of the engineered wood product). Alternatively, at least a substantial portion of the wood pieces of the core layer may be oriented at least substantially perpendicular to at least a substantial portion of the wood pieces of the face layers.

Moreover, the layers of the blanket of oriented pieces may have any suitable weight ratios to at least substantially minimize washout of the one or more resins, such as any suitable face-layers-to-core-layer weight ratio before the step of preheating. For example, the face-layers-to-core-layer weight ratio before the step of preheating may be based, at least in part, on a target thickness for the engineered wood product, a target density for the engineered wood product, preheating time, washout resistance of the resin used for the core layer, washout resistance of the resin used for the face layer(s), and/or other suitable factors. In some engineered wood products (such as oriented strand lumber and laminated strand lumber), the face-layers-to-core-layer weight ratio before steam preheating may range from about 5% to 95%, to about 40% to 60% to at least substantially minimize washout of the one or more resins. In some engineered wood products (such as oriented strand lumber and laminated strand lumber), the face-layers-to-core-layer weight ratio before steam preheating may range from about 11.4% to 88.6%, to about 21.2% to 78.8% to at least substantially minimize washout of the one or more resins.

Similarly, the layers of the blanket of oriented pieces may have any suitable weight per unit area to at least substantially minimize washout of the one or more resins, such as any suitable weight per unit area before the step of preheating. For example, one or both of the face layers may have a weight per unit area before the step of preheating based, at least in part, on a target thickness for the engineered wood product, a target density for the engineered wood product, preheating time, washout resistance of the resin used for the core layer, washout resistance of the resin used for the face layer(s), and/or other suitable factors. In some engineered wood products (such as oriented strand lumber and laminated strand lumber), the weight per unit area of one or each of the face layers may be about 0.2 to about

1.2 pounds per square foot (lbs/ft^2) before the step of steam preheating to at least substantially minimize washout of the one or more resins. In some engineered wood products (such as oriented strand lumber and laminated strand lumber), the weight per unit area of one or each of the face layers may be about 0.27 to about 0.7 lbs/ft^2 before the step of steam preheating to at least substantially minimize washout of the one or more resins.

Any suitable equipment may be used for the step of orienting or forming the wood pieces. For example, orienting equipment may include disk-type and star-type orienters, and may range from electrostatic equipment to mechanical devices containing spinning disks, orienting disks, and/or other types of equipment to align wood pieces. Some equipment may use the dimensional characteristics of the wood pieces to achieve the desired alignment onto a moving caul plate or conveyor belt below forming heads. Oriented layers of wood pieces within the blanket may be dropped sequentially, each with a different forming head. Some equipment may use wire screens and/or conveyor belts to carry the blanket into the press, such as a multi-opening press or a continuous press.

Although the blanket of oriented pieces is described to include a core layer sandwiched between a pair of face layers, the blanket of oriented pieces may include any suitable number of layers. For example, the blanket of oriented pieces may include two or more core layers. Alternatively, or additionally, the blanket of oriented pieces may include one or more intermediate layers between a core layer and one or both of the face layers. For example, the blanket of oriented pieces may include a single core layer sandwiched between a pair of face layers with an intermediate layer between the core layer and each of the face layers. Alternatively, the blanket of oriented pieces may include two core layers sandwiched between a pair of face layers with an intermediate layer between the core layers and each of the face layers.

Additionally, although the blanket of oriented pieces is discussed to have certain face-layers-to-core-layer weight ratios or have layers with certain weight per unit area, the blanket of oriented pieces may have any suitable face-layers-to-core-layer weight ratio or have layers with any suitable weight per unit area configured to at least substantially minimize washout of the first resin. For example, the use of resin(s) in solid form and/or resin(s) that are more washout resistant may allow the blanket of oriented pieces to have one or both face layers with higher weights per unit area then described above. Moreover, although the layers of the blanket of oriented pieces is described to have at least a substantial portion of wood pieces oriented in specific orientations, those layers may include any suitable portion(s) of wood pieces oriented in any suitable orientation(s).

The step of preheating at 34 may be configured to preheat at least a portion of the blanket of oriented pieces. Preheating may facilitate or shorten time required for the step of curing, particularly for thicker engineered wood products, such as oriented strand lumber (OSL) and laminated strand lumber (LSL). Any suitable portion(s) of the blanket of oriented pieces may be preheated. For example, at least a substantial portion of the core layer may be preheated. Alternatively, at least a substantial portion of one or both of the face layers may be preheated. Alternatively, at least a substantial portion of the blanket of oriented pieces may be preheated.

Any suitable material(s) and/or equipment may be used to preheat. For example, steam at any suitable concentration may be injected and/or otherwise introduced to one or more layers of the blanket of oriented pieces. In some embodiments, steam may be injected into the core and/or face layer(s) of the blanket of oriented pieces. Preheating with steam (or steam preheating) may be performed for any suitable period of time to at least substantially minimize washout of the one or more resins. For example, the steam preheating may be performed for a sufficient period of time to raise the temperature of at least a substantial portion of the core layer to a target core temperature.

The target core temperature may be based, at least in part, on a target thickness for the engineered wood product, a target density for the engineered wood product, washout resistance of the resin used for the core layer (such as the first resin in the example described above), washout resistance of the resin used for the face layer (such as the second resin in the example described above), and/or other suitable factors. For example, a target core temperature may be about 212 °F to about 221 °F.

In some blankets of oriented pieces, a sufficient period of time for the steam preheating may be about 20 seconds to about 70 seconds for the core layer to reach a target core temperature of about 212 °F to about 221 °F to at least substantially minimize washout of the one or more resins. In some blankets of oriented pieces, a sufficient period of time for the steam preheating may be about 30 seconds to about 32 seconds for the core layer to reach a target core temperature of about 212 °F to about 221 °F to at least substantially minimize washout of the one or more resins.

Any suitable equipment may be used to preheat the blanket of oriented pieces. For example, the preheating may at least substantially be performed in a continuous press where the step of curing also is performed. Alternatively, or additionally, the preheating may be performed in a separate preheater, and/or other suitable equipment.

Although the step of preheating is discussed to include steam injection or steam preheating, the step of preheating may include any suitable step(s) and/or any suitable equipment configured to preheat at least a portion of the blanket of oriented pieces. For example, hot air, radio frequency and/or microwave equipment may alternatively, or additionally, be used for the step of preheating. Additionally, although the step of preheating is discussed to include steam, the step of preheating may include any suitable material(s).

For example, air and/or electromagnetic radiation may additionally, or alternatively, be used for the step of preheating.

Moreover, although the step of preheating is discussed to have particular target core temperatures and steam preheating times are discussed, the step of preheating may include any suitable target core temperature(s) and steam preheating time(s) to at least substantially minimize washout of the one or more resins. For example, varying one or more parameters of the method, such as the speed of the continuous press, may allow steam preheating times of less than 20 seconds or more than 70 seconds. Furthermore, although the step of preheating is described to be performed in a continuous press, the step of preheating may be performed via any suitable equipment, including any suitable type(s) of batch equipment.

The step of curing at 36 may include any suitable step(s) configured to cure the one or more resins, such as exposing at least a part of the blanket of oriented pieces to an elevated temperature, an elevated pressure, and/or radiant energy to cure the first and second resins. For example, hot pressing may be used to compress the blanket of oriented pieces under elevated temperature and elevated pressure to cure the one or more resins. Any suitable equipment may be used, such as multiple-opening or continuous presses, such as steam injection presses. For example, the step of curing may at least substantially be performed in a continuous press.

As used herein, "elevated temperature" may include any temperature above room temperature of 77 °F. The elevated temperature may be above about 212 °F, above about 302 °F, above about 392 °F, or up to about 482 °F. Specifically, the elevated temperature may be about 77 °F to about 599 °F, about 77 °F to 425 °F, about 212 °F to about 425 °F, or about 374 °F to about 425 °F. More specifically, when the desired engineered wood product is an oriented strand board (OSB), the elevated temperature may be about 325 °F to about 475 °F, may be about 350 °F to about 450 °F, or about 375 °F to about 425 °F. More specifically, when the desired engineered wood product is plywood, elevated temperature may be about 225 °F to about 425 °F, about 250 °F to about 400 °F, or about 275 °F to about 375 °F. More specifically, when the desired engineered wood product is oriented strand lumber (OSL) or laminated strand lumber (LSL), elevated temperature may be about 257 °F, or about 248 °F to 266 °F.

As used herein, "elevated pressure" may include any pressure above standard pressure of 1 atmosphere (atm). Elevated pressure may be above about 5.0 atm, above about 10.0 atm, above about 20.0 atm, above about 40.0 atm, or above about 80.0 atm. Specifically, the elevated pressure may be about 60.0 atm to about 85.0 atm. More specifically, when the desired engineered wood product is OSB, then the elevated pressure may be about 25 atm to about 55 atm, about 30 atm to about 50 atm, about 34 atm to about 48 atm, or about 35 atm to about 45 atm. More specifically, when the desired engineered wood product is plywood, then the elevated pressure may be about 8.0 atm to about 21 atm or about 10.0 atm to about 17 atm. More specifically, when the desired engineered wood product is OSL or LSL, elevated pressure may be about 21.1 atm to about 40.8 atm, or about 8.2 atm to about 9.5 atm.

In some embodiments, the curing step may be at least partially performed during and/or shortly after the preheating step, such as while at least some steam from steam preheating is within one or more layers of the blanket of oriented pieces. For example, the curing step may be partially performed while at least some steam from steam preheating is within the core layer. Examples of curing at least partially while at least some stream from steam preheating is within the core layer of the blanket of oriented pieces are described in one or more of the examples provided below, such as Example 2.

In some embodiments, the curing step may be configured to draw steam from at least one of the pair of face layers of the blanket of oriented pieces to the core layer of that blanket. For example, the curing step may include pressing the blanket of oriented pieces to a thickness smaller than a target thickness (may also be referred to as "overpressing"). In some embodiments, overpressing may compact the blanket of oriented pieces to improve heat transfer and/or may create a vacuum in the mat to draw steam into the core layer from at least one of the pair of face layers (which may improve heating). Examples of curing with overpressing are described in one or more of the examples provided below, such as Example 2.

Alternatively, or additionally, at least some steam from steam preheating may be vented or exhausted. The venting or exhausting of steam may be performed actively with any suitable venting or exhausting equipment, and/or passively by allowing at least some of the steam to escape from the blanket of oriented pieces. Additionally, the venting or exhausting of steam may be performed during the preheating step, after the preheating step, before the curing step, during the curing step, and/or after the curing step. In some embodiments, the venting or exhausting step does not remove all of the steam within one or more layers of the blanket of oriented pieces.

Although the step of curing is discussed to include the step exposing at least part of the blanket of oriented pieces to an elevated temperature, elevated pressure, and/or radiant energy, the step of curing may include any suitable step(s) configured to cure the one or more resins. Additionally, although specific elevated temperature and pressure ranges are provided, any suitable elevated temperatures and pressures may be used. Moreover, although specific elevated temperatures and pressure ranges are provided for OSB, plywood, OSL, and LSL, suitable elevated temperature and pressure ranges, which may be the same or different from the ranges discussed for OSB, plywood, OSL, and LSL, may be used for other desired engineered wood products.

Although the step of product formation at 16 is shown to include the steps of blending, forming, preheating, and curing, the step of product formation may include any suitable step(s) configured to form the desired engineered wood product from the prepared wood pieces. Additionally, the steps discussed above may be performed in different sequences and in different combinations, not all steps being required for all embodiments of method 10.

Product finishing at 18 may include one or more steps configured to finish the engineered wood product. For example, the product finishing may include the steps of cooling at 44, cutting to desired size(s) at 46, grade stamping at 48, stacking at 50. Although the step of product finishing at 18 is discussed to include particular step(s), the step of product finishing may include any suitable step(s) configured to finish the desired engineered wood product. For example, the step of product finishing may additionally, or alternatively, include grade stamping and/or edge coating. Additionally, the steps discussed above may be performed in different sequences and in different combinations, not all steps being required for all embodiments of method 10.

Although method 10 is shown to include specific steps, the method may include any suitable step(s) configured to manufacture engineered wood product(s). Additional examples of method 10 are shown in Figs. 3-4 and are generally indicated at 100 and 200, respectively. Other examples also are provided below.

Control Example A: Pressing of 1" Thick OSL/LSL Panel without Steam Preheating

Strands were cut using custom-made knife holders. Each strander knife was set up to cut two 7" strands and two 6" strands. Strand analysis showed the following results for the mass weighted averages: thickness = 0.77 mm (0.030"); length = 153 mm (6.024"); and width = 64.2 mm (2.528"). General observations indicated that the strands had a high percentage of wide width strands prior to blending/forming and the strands appeared to break up to narrower widths after blending and forming.

Control panel A without steam pre-heating was pressed. The following pressing parameters and targets were used: press platen temperature = 125°C; strand moisture content = 7%; MDI = 6% and e-wax = 1.2%; and target out of press density = 45 lbs/cu ft; target oven dried density = 43 lbs/cu ft.

The time to form the mat was 1.25 hours versus 3 hours at a previous trial; the shorter forming time was mainly attributed to the shorter and narrower strands. The orienter disk diameter was 22" and the disk spacing was 2". The rotational speed of the orienting rolls was 21 rpm. The average stand alignment was 23.6° and the percentage of strands greater than 42° was 17.4%. The strands over 42° was suspected to be the strands carried over from the orienter rolls and deposited on the mat through the gap between the plywood bin designed for capturing the carried over strands and the last roll of orienting disks.

The panel was pressed to 650 psi pressure to a target thickness of 12% below the nominal thickness to allow for spring back. Once the target thickness was achieved, pressure was maintained to keep this thickness. The pressure was observed to decrease gradually, and asymptotic to above 150 psi at 30 minutes. The panel was under pressure for about 35 minutes and the core temperature reached about 240°F (115°C). Pressure was released gradually in the beginning of the degassing cycle with no significant increase of gas pressure. The press was then opened up and the panel was found to be solid. The moisture content of the panel was estimated at 5.4 % based on the mat weight and panel weight measurements. Based on oven dry specimens, the moisture content was 4.6% (based on oven dry).

Specimens were cut from the edge trims for testing edge bending MOE & MOR, internal bond (I.B.), specific gravity (S.G.), moisture content and density profile. The hot test results showed: average I.B. (based on six specimens taken from an edge trim) = 144.7 psi; average MOE = 1.286 million psi; average MOR = 8,930 psi; and average out-of-press density of the MOE/MOR samples = 43.3 lbs/cu ft.

The average density of the IB samples was 0.798 S.G. (49.8 lbs/cu ft). These reported density values appeared to be high and could be attributed to the higher density in the trim edges. Samples taken from a panel edge trim were measured for density profile. The batch average density was 0.768 S.G. (47.9 lbs/cu ft) and the minimum density was 0.626 S.G. (39 lbs/ cu ft). The ratio of the core density (center 1/3rd of thickness) to the average density was 0.91.

Example 1: Pressing of 1" Thick OSL/LSL Panel with Steam Pre-Heating

Upon the successful production of Control Panel A, the team agreed to produce the 1st panel with steam pre-heating. The pressing parameters of the control panel were used except for the following:

- The press was closed to an opening of 3" or 300% of the nominal panel thickness for steam pre-heating. The steam supply at the generator was at 400 psi and 210°C. The steam passed through a small accumulator and then through the manifolds to the top and bottom platens of the steam press. The steam pressure and temperature at the steam press were determined to be 30 psi and 121°C at the press based on the steam table. The bulk density of the slightly compressed mat was at about 240 kg/m^3.
- Used a steam time of 30 seconds and immediate activated the closing of the press after steam pre-heating as the closing of the lab press was slow.
- Overpressed the panel by 0.5mm for 45 seconds beyond the target thickness of 0.88", which was already 12% below the nominal 1" thickness.
- Used only one pressure probe close to the mid point of the panel. Used two thermal couples close to the top face (~ three strand layers below the top surface) and two other temperature measurements (including the one with the pressure probe) for the panel core.

The gas pressure was observed to be very low and the press pressure also diminished very quickly after the press reached the target thickness. The total press time before degassing and opening of press was 7 minutes. The panel was sound but the thickness was about 5 mm greater than target. After some investigations, it was discovered that the press platen inserts were removed to allow for steam pre-heating and the press program was not adjusted for the thickness of the platen inserts. Thus, the panel was pressed to a target thickness approximately 5 mm greater than the target thickness. Therefore, this panel was of low density and the low density contributed to the low gas pressure & low press pressure. The spring back of this panel was estimated at 1.9 mm (0.076").

During the steam pre-heating phase, the thermal couple readings (both at the surface and core) indicated a temperature of just below 100°C with no sign of super heated steam. At the end of the steaming cycle and beginning of the closing of the press, the two core thermal couple readings showed a sharp increase of temperature. The cause of this phenomenon was not known and would be further investigated (for example the delay of closing of steam valve after closing of the press).

Edge trims of the panel were tested for IB, S.G., moisture content, density profile and edge bending properties. The average I.B. value of six samples was 92.7 psi. The out-of-press density was 38 lbs/cu ft based on the I.B. samples. The average edge bending MOE (based on center point loading and average of three specimens) was 938,000 psi and the average edge bending MOR was 5,460 psi. Strand alignment measurements were taken during forming. The average strand alignment of this panel was 26.4° and the % over 42° was 23.5%.

The conservation of heat theory applies for steam preheating. The heat gained by a given mass of blended wood strands = the heat given up by the steam through condensation. See the following equation:

$$Q = M_{wood} (\Delta T) S_{wood} = M_{steam} (S_{steam})$$

Where M_{wood} is the mass of the blended wood strands

ΔT is the difference of 100°C and the temperature of the blended wood strands

S_{Wood} is the specific heat of the blended wood strands (~1.42)

M_{steam} is the mass of steam required to bring the wood mass up to 100°C

S_{steam} is the specific heat for condensation (~2.263).

The above equation was used to determine the depth of the wood strands that would be heated.

Example 2: Pressing of 1" Thick OSL/LSL Panel with Steam Pre-Heating

As the strands before blending appeared to have a high percentage of wide width strands, strands were collected after blending & forming for length, width and thickness measurements. The results of the analysts showed the following mass weighted mean values: length = 124.7 mm (4.9"); width = 22 mm (0.866"); and thickness = 0.81 mm (0.032"). An average strand alignment angle of 24° was determined using a simplistic mathematic model for determining the strand alignment angle based on the 4.9" mass weighted strand length average and 2" gap spacing of the orienting disks.

The mat was formed with the slotted OSB board in place to capture the carried over strands; any visible cross oriented strands on the mat were eliminated. The average strand alignment was 23.4° with 17.1% of the strands above 42°. The improvement of the strand alignment from the implementation of the slotted OSB board was minimal. The mat height was 230 mm and the mat weight was 74 kg. The mat was pre-compressed to 3" (instead of the target 4" due to a programing error). The steaming time was 30 seconds and the press was closed immediately after steaming. The target press thickness was 0.88" to allow for spring back. A 0.5 mm (0.020") over-pressing over 45 seconds was implemented before holding the press opening at 0.88". The rationales for the over-pressing were:

- To allow for wood relaxation
- To briefly compact the panel for improved heat transfer (from higher density and lower thickness)

- To create a vacuum in the mat to draw steam into the core to improve heating when the press was returned to 0.88" opening.

The press time was about 6 minutes and the panel was solid. There was one high spot on the surface of the panel. A small hole was drilled at this spot and no delamination was detected at this location. The high spot was caused by high localized density. The panel thickness was 0.983" with an out-of-press density of 47.5 lbs/cu ft. The moisture content was estimated at 9.9% and the oven dry density was estimated at 42.8 lbs/cu ft. The hot test results showed: average I.B. of six specimens taken from the edge trim = 127.1 psi; average density of the I.B. specimens = 47.5 lbs/cu ft (out of press density); the density profile scans showed uniform density; average MOE = 1.42 million psi; and average MOR = 9,750 psi.

The consistency of the mat distribution was measured by cutting small specimens (3.67" by 5" with the 5" length along the width and along the length) and weighing the specimens. The width measurements showed an average weight of 0.4364 lbs, a maximum weight of 0.4692 lbs and a minimum weight of 0.4095 lbs. The range was about ± 0.03 lbs or ± 6.8%. The length measurements showed an average weight of 0.5557 lbs, a maximum weight of 0.6088 lbs and a minimum weight of 0.4725 lbs (ignoring the last specimen at one end). The range was about ± 0.068 lbs or ± 12%. The weight variations were high, perhaps due to the specimens taken from the end and edge trims.

<u>Example 3: Pressing of 1” Thick OSL/LSL Panel with Steam Pre-Heating</u>

The mat weight was ~73.8 kg (162.7 lbs) and the mat height was 230 mm (9.06"). The steam ports were shut off after steaming. Please note that the steam ports had been left open for previous runs and trial prior to this panel. The press cycle was essentially the same as that for the previous example except that the mat was pressed to 105 mm (4.134") for steam pre-heating. The bulk density of the pre-compressed mat was ~173.9 kg/m^3 (10.9 lbs/cu ft). For the previous two steam pre-heated panels, a temperature rise was observed from 212°F

(100°C) after the steam shut-off and at the start of the press closing. It was suspected that there is a delay reaction of the steam shut-off. Therefore, a delay of 2 seconds was implemented after steam shut-off and before closing of press to account for the delay of the steam shut-off. The sharp temperature rise disappeared with the implementation of the 2 second delay.

The panel thickness was 0.985" with a density of 47.5 lbs/cu ft. The moisture content was estimated at 9.1% and the oven dry density was estimated at 43.1 lbs/cu ft. The panel was solid with some minor surface bumps due to high localized density spots. The hot test results showed: average edge MOE = 1.286 million psi; average edge MOR = 9,230 psi; and average I.B. = 144.5 psi. The density profile indicated the following density zone ratios to the average density: zone 1 =1.02, zone 2 = 0.97 and zone 3 = 1.05. Zone 2 (core) appeared to be lower in density than the face layers. This is perhaps an effect of the higher platen temperature (135°C versus 125°C).

Example 4: Pressing of 1" Thick OSL/LSL Panel with Steam Pre-Heating

The panel was formed with a target oven-dry density of 45 lbs/cu ft. The target mat weight for this density was 77 kg. The mat was pre-compressed to 110 mm (4.33") for steam pre-heating and the bulk density of the mat was determined to be 173 kg/m^3 (10.9 lbs/cu ft). The press cycle of the previous example was used with the exception that the platen temperature was reduced to 125°C. The top platen temperature was 264.4°F (129°C) and the bottom platen temperature was 253.7°F (123°C) based on the information on the display console during pressing. The press was opened gradually to 20 psi press pressure and then 10 psi press pressure after 6.5 minutes of press time. The panel appeared to be solid with no sign of delaminations. The hot test results showed: average I.B. = 125.4 psi; average MOE = 1.305 million psi; average MOR = 9,660 psi; average out-of-press density for MOE/MOR samples = 48.4 lbs/cu ft; and a uniform density profile.

Example 5: Pressing of 1-3/4" Thick OSL/LSL Panel with Steam Pre-Heating

The panel was formed with a target oven-dry density of 43 lbs/cu ft. The target platen temperature was 130°C. The mat height was 33 cm (13"). The press cycle was about 9.5 minutes and the press was opened slowly to a press pressure of 20 psi and then 10 psi prior to opening of the press completely. Three pressure probes were used and one pressure probe showed a peak gas pressure of 50 psi. The press factor was estimated at about 14.5 sec/mm. The panel appeared to be solid and smooth on the surface. The spring back was about 2.5 to 3 mm. The hot test results showed: average MOE = 1.213 million psi; average MOR = 8,390 psi; average I.B. = 128.6 psi; and a uniform density profile.

Example 6: Pressing of 1" Thick OSL/LSL Panel with Steam Pre-Heating

This panel was a repeat of the panel from Example 4, except with a fast degassing cycle. The panel was solid and did not have any blows. The panel surface had small dumps (or waviness as a result of poor forming distribution or high density spots). The hot test results showed: average MOE = 1.267 million psi; average MOR = 9,400 psi; average I.B. = 134.3 psi; and a uniform density profile.

Example 7: Pressing of 1" OSL/LSL Panel with Steam Pre-Heating

The Liquid PF/Powder PF resin system was used for the face layers. This panel was formed with a reduced thickness of the face layers. The face layer weight was 0.33 lbs of strands per square foot. The target density of this panel was 43 lbs/cu ft. The face to core ratio for the 1" thick panel was 18% to 82%.

The platen temperature of 130°C was used and the press time was seven minutes. A slow open degassing cycle was used. The press was opened up after the highest gas pressure came down to 6 psi. The board appeared to be solid with no sign of delamination. This strategy would allow us to produce OSL/LSL panels without the need to use MDI release agent.

A box of strands used in the above examples was screened using a bulk deck screening device. A 1-3/4" mesh was used for the top deck and a 3/16" mesh was used for the bottom deck. The results showed: strands over 1-3/4" mesh = 102.95 kg (64.2%); strands under 1-3/4" and over 3/16" = 50.3 kg (31.3%); strands under 3/16" = 7.2 kg (4.5%).

The dimensions and steam hole spacing of the steam injection platen used in the above examples are platen size = 60" by 108"; steam hole end distance (to end of platen) = 6"; steam hole edge distance (to edge of platen) = 9"; steam hole spacing along the platen width = 1.75"; steam hole spacing along the platen length = 1.778"; steam hole diameter = 5/64".

Control Example B: Pressing of 1" Thick OSL/LSL Panel without Steam Pre-Heating

Using the same 6" & 7" strand length combination produced for the examples above, we started with a 1.5" disk spacing with the shaft to shaft disk alignment "centered" giving and effective disk spacing of 0.75". We also added plastic picks above the last roll, on a 3 disk spacing, to help align the strands. Two passes were done with this configuration and it was decided that there was too much carry over and the shaft to shaft alignment should be adjusted to align the disks on each roll with the ones next to it. This increased the disk spacing to 1.5" and reduced the potential alignment of the strands but improved the throughput.

Three thin mats were produced with the "centered alignment", one with the fingers over the last roll and two with the fingers between the last and second to last roll. Strand alignment measurements showed an 18 degree (18.4, 17.6) average alignment in the first case. There was a measured gain of 0.8 and 1.2 degrees of alignment in moving the picks and the throughput appeared to improve in the latter case. The average alignment of the third mat was 16.8 degrees.

It was agreed at this point to measure the carry over and then re-adjust the shaft to shaft alignment to a centered configuration to see if a significant improvement in alignment was possible. The carry over was measured again to see if a significant loss in throughput occurred. The average alignment with the orientation rolls centered was 17.5 degrees (20.2, 15.9, and 16.3). One of the measurements was quite high and may not be representative. If we exclude this possible outlier then the orientation angle is 16.1 degrees. We concluded that this was the optimum configuration for the trial this week and proceeded to produce the Control Panel B.

Control Panel B (with all MDI) was produced with no delaminations. Cook time was slightly longer due to a higher board pressure and internal gas pressure. Press platen temperature was at 263/253 degrees F (top/bottom). MDI addition was 6% as before as was Wax at 1.2%. Furnish MC was targeted at 7%. A 48 lb/ft^3 out of press density was targeted. Press thickness of 4.134" for steaming was used for 32s then a 50s over press of 0.020" with a total press cycle of 11min. Maximum internal gas pressure was ~30psi. Minimum internal gas pressure was achieved after 60 seconds of degas at 7.4psi.

The panel had an average IB of 142 psi (Break locations 2,3,3,3,3,5) with an MOE average of 1.392 million psi. This average MOE value included a low density replicate (43.2 lb/ft^3) due to edge sampling. Excluding this outlier the MOE average of the two remaining replicates was 1.501 million psi at an average density of 49 lb/ft^3. Strand alignment on this panel was measured at 15.7 degrees (15.4, 14.0, 14.6 and 18.9).

Example 8: Pressing of 1" Thick OSL/LSL Panel with Steam Pre-Heating

The same parameters were used with this panel as previous except for Resin Addition rates and furnish MC. Resin addition for this panel was 8% face PF, 6% Core MDI. Furnish moisture content for the PF resin panels was 2.0 Face and 4.5 Core before blending. The post blending Face moisture content was 8.0%. The wax addition was the same as previous panels.

The 1" Hexion LPF Face/MDI Core Panel was produced with a 10% (0.4lb/sft) face layer. This panel was produced with no delaminations. All parameters were the same with the exception of a slight face layer thickness correction (i.e. 10% by weight). The maximum pressure for this pressing was ~500 psi with a peak internal gas pressure of 35psi. Minimum internal gas pressure of 9psi was achieved after 60 seconds of degas. This panel had an Internal Bond of 104.0psi (Break locations 2,2,1,1,2,2) with an MOE value of 1.281 million psi also somewhat lower than the MDI control panel. The MOE values were again affected by an outlier due to a lower density replicate from the panel edge. The MOE value with the outlier removed was 1.335 million psi (1.320 and 1.349) with an average density of 48.6 lb/ft^3 (49.4 and 47.8). The average strand alignment was ~18.6°.

Example 9: Pressing of 1" Thick OSL/LSL Panel with Steam Pre-Heating

We decided to reduce the face layer from 10% to 7% (0.28lbs/sf) for the next Dynea LPF Face/MDI Core Panel. This panel was produced with no delaminations. Maximum pressure for this pressing was ~500psi with a peak internal gas pressure of 9psi. Minimum internal gas pressure of 3-4psi was achieved prior to degas but the same degas method was used to remain consistent. The average internal bond for this panel was 112.9psi (Break locations 1,1,5,4,5,4). The average hot MOE value was 1.576 million psi with replicate densities slightly below target (47.7, 45.6 and 47.3). Average panel density was 48.7 lbs/ft^3. The average strand alignment was ~16.8°. The improved strand alignment was attained by paying closer attention to minimize the daylight or distance between the orienters and the mat. The improved strand alignment led to a significant improvement in the edge bending MOE.

Example 10: Pressing of 1-3/4" Thick OSL/LSL Panel with Steam Pre-Heating

We began with blending of furnish for making a 1 3/4" thick OSL panel using the Hexion LPF for Face with a 10% by weight or 0.7ib/sqft per face layer and MDI for Core. As we ran out of the previous strands, we switched to use the 7" length Aspen strands cut using the lab strander. Based on previous strand analyses results, the mass weighted strand length of the strands would be about 6" to 6.25" while the previous strands would be about 5". The average strand alignment was 13.9°, which was the best of all the panels that had been produced to this point in time. The longer strands would contribute to the better strand alignment. The pressing strategy follows the same method as our previous trial. A 30 second steam pre-heating is simulated in the daylight press by compressing the mat to 11.5lb/ft^3 and injecting steam. A simple pressure curve is used to close quickly to 0.070" below thickness and then back off to target thickness after 60 seconds. A manual venting cycle of ~60 seconds was used as before to reduce internal gas pressure to a safe level before opening.

The panel was a repeat of the previous panel using the Hexion LPF for face (at 5.7% or 0.4 lbs/ft ^2 per face layer) and 6% MDI for the core layer. The panel surface after pressing was smooth and the panel was sound with no signs of delamination.

Although the methods of manufacturing engineered wood products and features of those methods have been shown and described with reference to the foregoing operational principles and preferred embodiments, those skilled in the art will find apparent that various changes in form and detail may be made without departing from the spirit and scope of the claims. The present disclosure is intended to embrace all such alternatives, modifications, and variances that fall within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A method of manufacturing an engineered wood product, comprising:

orienting two or more sets of wood pieces to provide a blanket of oriented pieces, the blanket of oriented pieces including a core layer sandwiched between a pair of face layers, wherein at least one of the sets of wood pieces includes at least one phenol-formaldehyde (PF) resin;

steam preheating at least a portion of the blanket of oriented pieces; and

curing the at least one PF resin, wherein the curing includes exposing at least a part of the blanket of oriented pieces to at least one of an elevated temperature, an elevated pressure, and radiant energy, and wherein the exposing is partially performed while at least some steam from the steam preheating is within the core layer.

2. The method of claim 1, wherein the core layer includes the at least one PF resin.

3. The method of claim 1, wherein at least one of the sets of wood pieces includes wood strands.

4. The method of claim 3, wherein the wood strands include strands with a least dimension of at most 0.1 inches and a length of at least 150 times the least dimension.

5. The method of claim 4, wherein the least dimension is a thickness of the strands.

6. The method of claim 3, wherein the wood strands include strands with a least dimension of at most 0.1 inches and a length of at least 75 times the least dimension.

7. The method of claim 6, wherein the least dimension is a thickness of the strands.

8. The method of claim 1, wherein at least a substantial portion of the wood pieces of at least one of the layers are oriented at least substantially in a first direction and at least a substantial portion of the wood pieces of the at least one of the other layers are oriented at least substantially in a second direction.

9. The method of claim 8, wherein the first direction is at least substantially parallel to the second direction.

10. The method of claim 8, wherein the first direction is at least substantially perpendicular to the second direction.

11. The method of claim 1, wherein the at least one PF resin is in at least substantially liquid form.

12. The method of claim 1, wherein the at least one PF resin is in at least substantially solid form.

13. The method of claim 1, wherein the at least one PF resin includes one or more PF resins in at least substantially liquid form and one or more PF resins in at least substantially solid form.

14. The method of claim 1, wherein at least the other of the sets of wood pieces includes at least one methylene diphenyl diisocyanate (MDI) resin.

15. The method of claim 14, wherein the face layers include the at least one MDI resin.

16. The method of claim 1, wherein at least one of the layers has a weight per unit area before the steam preheating based, at least in part, on at least one of a target thickness for the product, a target density for the product, steam preheating time, and washout resistance of the at least one PF resin.

17. The method of claim 16, wherein the weight per unit area of at least one of the layers is about 0.2 to about 1.2 pounds per square foot (lbs/ft2) before the steam preheating.

18. The method of claim 1, wherein the steam preheating is for a sufficient period of time to raise the temperature of at least a substantial portion of at least one the layers to a target temperature based, at least in part, on at least one of a target thickness for the product, a target density for the product, and washout resistance of the at least one PF resin.

19. The method of claim 18, wherein the sufficient period of time for the preheating is about 20 seconds to about 70 seconds.

20. A method of manufacturing an engineered wood product, comprising:

orienting two or more sets of wood pieces to provide a blanket of oriented pieces, the blanket of oriented pieces including a core layer sandwiched between a pair of face layers, wherein at least one of the sets of wood pieces includes at least one PF resin and at least the other of the sets of wood pieces includes at least one MDI resin;

steam preheating at least a portion of the blanket of oriented pieces; and

curing the at least one PF resin and the at least one MDI resin, wherein curing includes exposing at least a part of the blanket of oriented pieces to at least one of an elevated temperature, an elevated pressure, and radiant energy at least partially while at least some steam from the steam preheating is within the core layer.

21. The method of claim 20, wherein at least a substantial portion of the wood pieces of the layers are oriented at least substantially lengthwise.

22. A method of manufacturing strand-based lumber, comprising:

orienting lengthwise two or more sets of wood strands to provide a blanket of oriented strands, the blanket of oriented strands including a core layer sandwiched between a pair of face layers, wherein at least one of the sets of wood strands includes at least one PF resin and at least the other of the sets of wood strands includes at least one MDI resin;

steam preheating at least a portion of the blanket of oriented strands; and

curing the at least one PF resin and the at least one MDI resin, wherein the curing includes exposing at least a part of the blanket of oriented strands to at least one of an elevated temperature, an elevated pressure, and radiant energy, and wherein the exposing is partially performed while at least some steam from the steam preheating is within the core layer.

23. The method of claim 22, wherein the core layer includes the at least one PF resin.

24. The method of claim 23, wherein the face layers include the at least one MDI resin.

Fig. 1

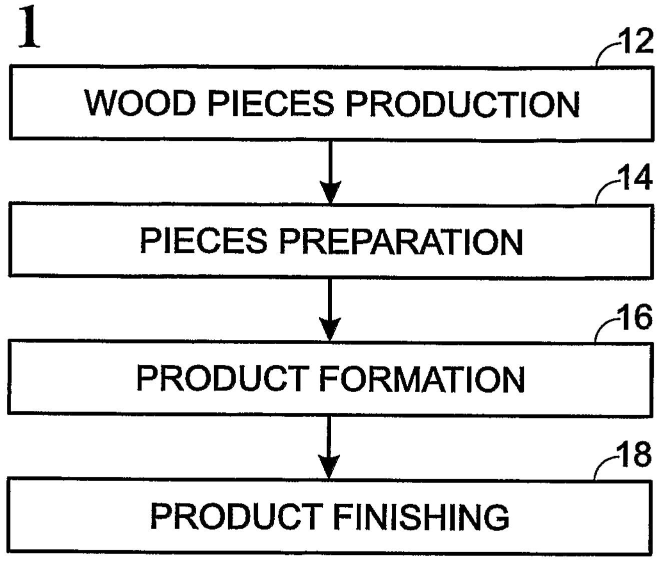
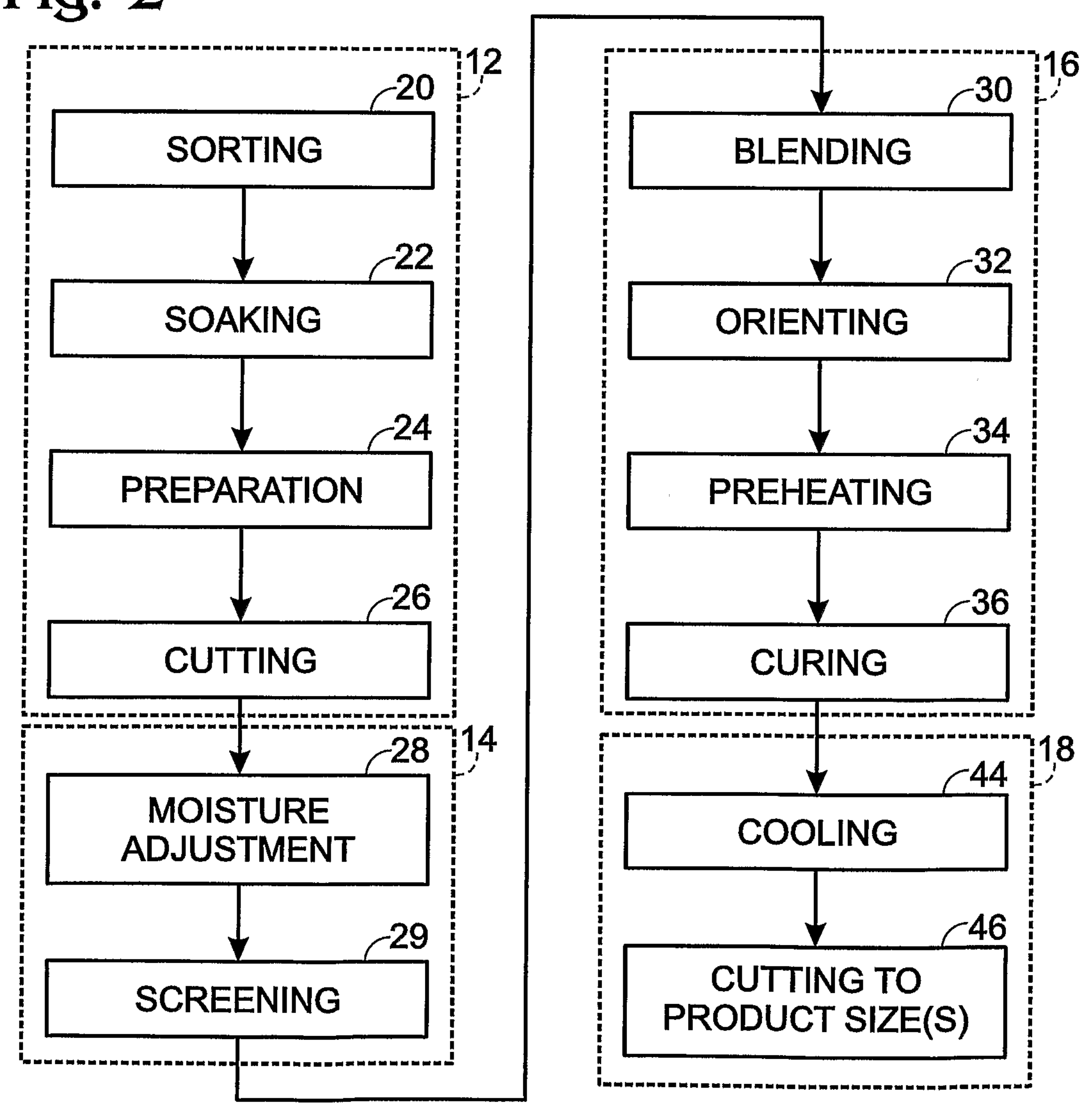
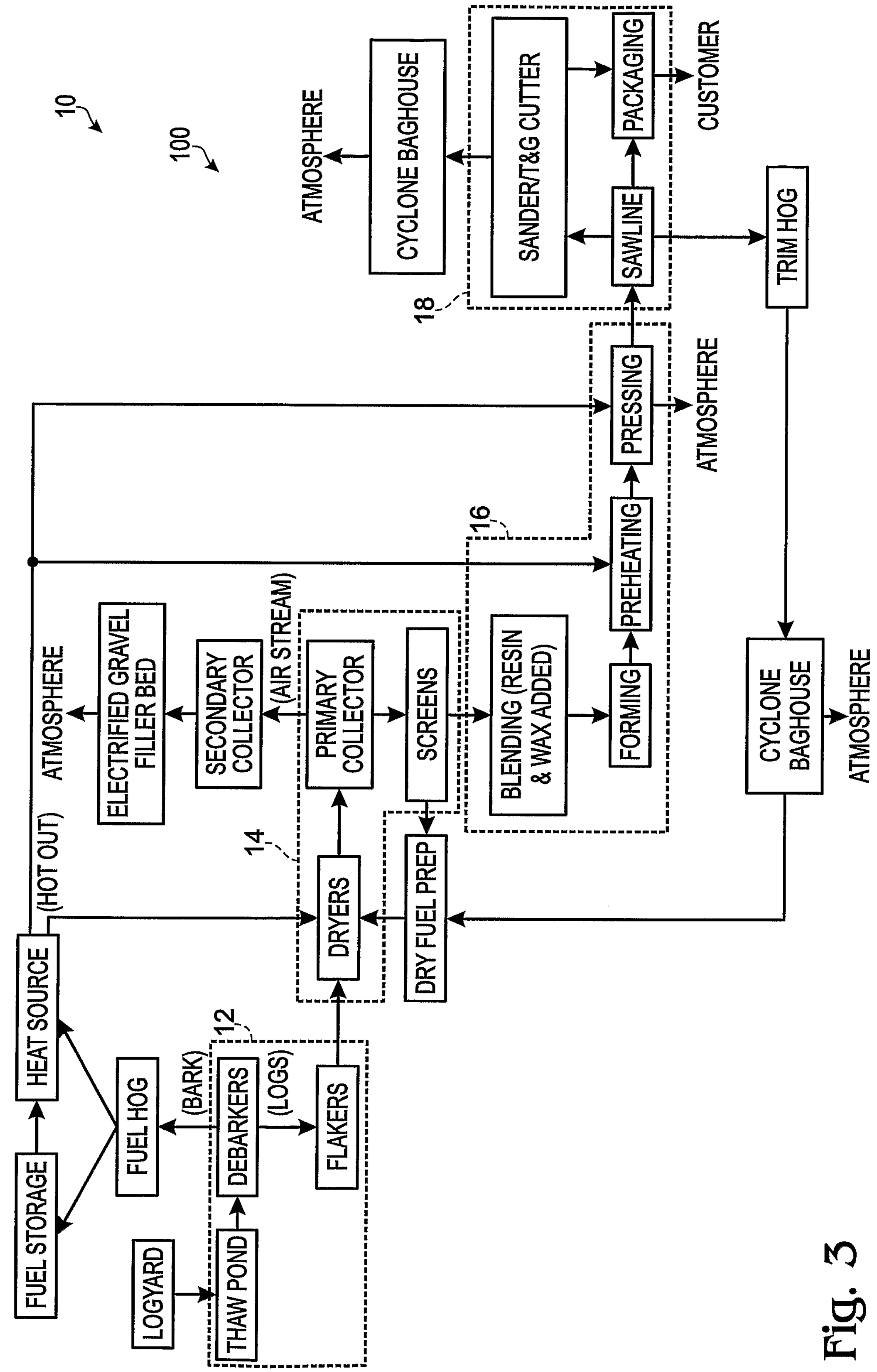

12
WOOD PIECES PRODUCTION
14
PIECES PREPARATION
16
PRODUCT FORMATION
18
PRODUCT FINISHING

Fig. 2


12
20
SORTING
22
SOAKING
24
PREPARATION
26
CUTTING
14
28
MOISTURE ADJUSTMENT
29
SCREENING
16
30
BLENDING
32
ORIENTING
34
PREHEATING
36
CURING
18
44
COOLING
46
CUTTING TO PRODUCT SIZE(S)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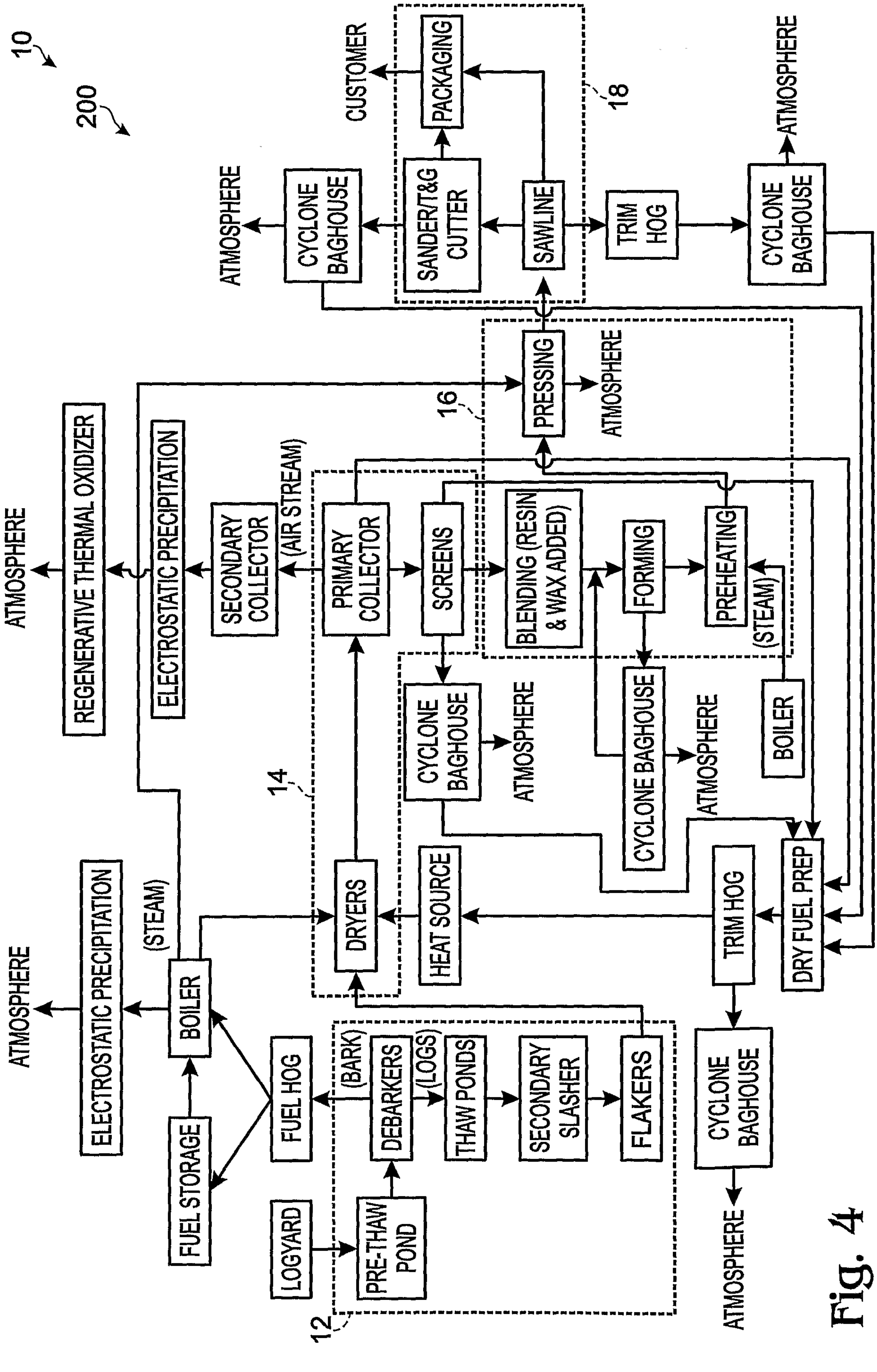
HEAT SOURCE
(HOT OUT)
LOGYARD
FUEL HOG
THAW POND
DEBARKERS
(BARK)
(LOGS)
FLAKERS
12
DRYERS
14
PRIMARY COLLECTOR
SCREENS
DRY FUEL PREP
SECONDARY COLLECTOR
(AIR STREAM)
ELECTRIFIED GRAVEL FILLER BED
ATMOSPHERE
BLENDING (RESIN & WAX ADDED)
FORMING
PREHEATING
PRESSING
16
ATMOSPHERE
18
SAWLINE
SANDER/T&G CUTTER
PACKAGING
CUSTOMER
CYCLONE BAGHOUSE
ATMOSPHERE
TRIM HOG
CYCLONE BAGHOUSE
ATMOSPHERE

Fig. 3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PRE-THAW POND
DEBARKERS
(BARK)
(LOGS)
THAW PONDS
SECONDARY SLASHER
FLAKERS
12
FUEL HOG
FUEL STORAGE
BOILER
(STEAM)
ELECTROSTATIC PRECIPITATION
ATMOSPHERE
DRYERS
HEAT SOURCE
14
PRIMARY COLLECTOR
SECONDARY COLLECTOR
(AIR STREAM)
ELECTROSTATIC PRECIPITATION
REGENERATIVE THERMAL OXIDIZER
ATMOSPHERE
SCREENS
CYCLONE BAGHOUSE
ATMOSPHERE
BLENDING (RESIN & WAX ADDED)
FORMING
CYCLONE BAGHOUSE
ATMOSPHERE
PREHEATING
(STEAM)
BOILER
16
PRESSING
ATMOSPHERE
SAWLINE
SANDER/T&G CUTTER
PACKAGING
CUSTOMER
18
CYCLONE BAGHOUSE
ATMOSPHERE
TRIM HOG
CYCLONE BAGHOUSE
ATMOSPHERE
TRIM HOG
DRY FUEL PREP
CYCLONE BAGHOUSE
ATMOSPHERE

Fig. 4