A plank is described wherein the plank comprises a core, and optionally, a print layer, and optionally an overlay. The core includes from about 30 wt % to about 95 wt % at least one polymeric material, by weight of the core, and from about 5 wt % to about 70 wt % of least one natural fiber or flour, by weight of the core, wherein the core includes a top surface and a bottom surface, and opposing sides, wherein said plank is substantially moisture resistant, having a swelling property of from about 0.5% to about 5% by NALFA Thickness Test Section 3.2 LF 01-2003 standard, and wherein said plank includes a bow of from about 0.5% to about 4%. In addition, a method of making the plank is further described.
Supplied Core

Finish Sand

Wrapper

Profile

FIG. 6
FLOORING PRODUCTS AND METHODS OF MAKING THE SAME


[0002] The present invention relates to wood/polymer composite products, such as flooring products and methods to make the same. The present invention particularly relates to a plank or tile core that is structurally durable in providing excellent wear and durability properties as well as water resistance. The methods to make the product offer design versatility with superior sustainability by optionally incorporating high amounts of post consumer or post industrial recycled material into the flooring products without compromising the performance and aesthetics. Also, proper selections of the wear surface material for the product can greatly reduce the life-cycle cost by minimizing the frequency of maintenance.

BACKGROUND OF THE INVENTION

[0003] Commercially available floorings, such as laminate flooring (using high or medium density fiberboard or particle board as the core layer), have gained overwhelming success in the flooring market. The growth rate of the laminate flooring has remained in the double digits since the product was introduced in the United States market. The success of this product is credited to certain properties such as stain resistance, wear resistance, fire resistance, good cleanliness, and the ability to use just about any type of printed design. In addition, the overall emission of organic compound vapor is low and the laminate flooring is considered color stable and environmentally friendly over other competing flooring products.

[0004] One concern with commercially available laminate flooring is the moisture resistance of the finished product and the sensitivity of the raw materials (high or medium density fiberboard, paper, and particle board) to moisture during the manufacturing process. In some instances, the moisture can lead to some serious quality control issues and application restraints. For instance, and just to name a few, the higher moisture content in the product, such as in the particle board or fiberboard, can cause blistering and adhesion failure of the melamine surface to the core. Also, excessive moisture contents can create edge peaking due to the swelling of the product and such edge peaking can result in edge chip-off or premature wear-out or can soil more quickly. The susceptibility to moisture content also leads to some installers not wishing to place such laminate flooring in areas which are subject to having water on the surface of the floor, such as in the kitchen and bathroom areas.

[0005] The suppliers of such laminate flooring have appreciated the problems associated with their products and have attempted to overcome these problems by developing laminate flooring having better moisture resistance by using melamine, phenolic, or isocyanate binders to partially replace urea resins present in the laminate flooring. While this improvement has made the product more moisture resistant, the current commercially available laminate floorings are still prone to moisture damage. For instance, laminate floor thickness can swell by more than 10% and water absorbency can exceed more than 15% according to the 24 hours water absorption test. Another attempted solution at the moisture resistance weaknesses of current laminate flooring has led some manufacturers to apply a water repellent material on the upper edges of the tongue and groove areas which further serve to resist any moisture penetration through joints. Still another attempted solution involves applying silicone caulk to seal the edges and voids of the laminate perimeter where the laminate flooring meets the wall. However, if very stringent installation instructions are not followed, the laminate flooring will still be subjected to moisture damage.

[0006] Another weakness of laminate flooring is its susceptibility to break or chip at the corners of edges and the tongue and the groove profile because fibers in the high density fiber board are not cohesively bonded together with chemicals. Rather, they are pressed together primarily by tremendous pressure and heat.

[0007] Commercially available flooring that is an acrylic impregnated wood flooring is available. A typical acrylic impregnated wood flooring is produced by: 1) impregnating liquid acrylic monomer or other suitable monomers into raw wood veneer, wherein the liquid monomer is forced into the pores of the wood; 2) followed by polymerizing or hardening the acrylic monomer by thermal or free radical polymerization such as gamma radiation or heat; 3) bonding the impregnated veneer with polyurethane adhesive to the wood veneer base to form the finished product; and 4) optionally choosing a glass fiber layer in between the top surface and the base to produce a more dimensionally stable product. Typical acrylic impregnated wood flooring is not an environmental and operational friendly product. It takes a long time to impregnate the liquid acrylic monomer into pores of the wood veneer. It is often difficult or impossible to penetrate the liquid fully to the desirable depth or to penetrate uniformly into the pores of the wood. In addition, operators need to exercise tremendous caution for safely handling noxious liquid acrylic monomer and pay attention to the environmental consideration and government regulations. Due to such a time consuming and a labor intensive process, the product normally is very expensive. Consequently, only limited buyers can afford to use it. However, the acrylic impregnated wood layer offers excellent moisture resistance properties, has minimal indentation, and good wear, and durability properties. It is ideally used in high traffic areas.

[0008] Accordingly, there is a need to develop a new category of flooring which overcomes the above weaknesses and disadvantages of current commercially available floorings.

SUMMARY OF THE INVENTION

[0009] A feature of the present invention is to provide a plank which can be used in a surface covering system. The plank is based on a wood/plastic composite as the core, wherein fiber or flour portions in the core are preferably encapsulated by the polymer portion, and which provides improved moisture resistance, and is not susceptible to damage caused by moisture.
Another feature of the present invention is to provide a plank and surface covering system which is versatile for many decorative and wear surfaces (e.g., veneers—oak, maple, ash, beech, cherry, hickory, and other wood styles, and e.g., laminate overlay, direct print, transfer printing, vulcanized paper, and the like) depending upon the needs of markets.

A further feature of the present invention is to provide a flooring system that has beneficial sustainability and life cycle cost.

An additional feature of the present invention is to provide a surface covering system having flexibility in shape, size, and joint systems depending upon customer preference, installation ease and familiarity, and maintenance ease.

Still another feature of the present invention is to provide a surface covering system which has significant improvements in wear, rupture, chipping and breakage resistant properties, such as indentation, abrasion, appearance retention and chemical and stain resistance and the like.

Another feature of the present invention is to provide a surface covering system which is a higher value (better performance and lower cost) than the impregnated wood flooring.

Another feature of the present invention is to provide a flooring system that has great flexibility in choosing the type of woods and polymers and its ratio of mixture.

Another feature of the present invention is to provide a flooring system that can alleviate the requirement of a balance layer on the back of the product.

Also, a feature of the present invention is to provide a surface covering system which has the ability to tolerate some imperfections in the sub-floor or substrate and thus avoid telegraphing the imperfections on the surface covering itself.

A further feature of the present invention is to provide a surface covering system which has excellent dimensional stability and flammability resistance and the like.

Additional features and advantages of the present invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the present invention. The features and other advantages of the present invention will be realized and attained by means of the elements and combinations particularly pointed out in the written description and appended claims.

To achieve these and other advantages and in accordance with the purposes of the present invention, as embodied and broadly described herein, the present invention relates to a plank, wherein the plank has a core comprising at least one polymeric material, at least one type of natural fiber or flour, wherein the core has a top surface and a bottom surface, wherein the core is substantially moisture resistant, having a swelled property (based on thickness) of from about 0.5% to about 3%, wherein the core includes a downward bow of from about 0.5% to about 3.5% of the length of the plank. Optionally, the core includes a lubricant and/or a compatibilizer/coupling agent. Furthermore, optionally, affixed to the top surface of the core can be a print layer, wherein the print layer has a top surface and a bottom surface. Also, a protective layer can be affixed to the top surface of the print layer. The plank can optionally contain an underlay layer located and affixed between the bottom surface of the print layer and the top surface of the core. Furthermore, wood veneers such as oak, maple, ash, pine, cherry, hickory, and the like can be affixed as a top layer to the top surface of the core, wherein the top layer has a top surface and a bottom surface. Also, a radiation cured urethane acrylate coating or other wear resistant layer can be affixed to the top surface of the top layer. Furthermore, a direct digital design of any natural product or art work can be printed to the top surface of the core, wherein the radiation cured (or e-beam cured) urethane acrylate coating(s) or other wear resistant layer(s) can be affixed to the top surface of the top layer. The present invention further relates to a method of making a plank and can involve the step of extruding at least one polymeric material, at least one type of natural fiber or flour, and optionally, a lubricant and/or a compatibilizer/coupling agent into the shape of a core and optionally affixing a laminate on the core, wherein the laminate comprises an overlayer affixed to the top surface of a print layer and optionally an underlay layer affixed to the bottom surface of the print layer.

Also, the present invention relates to a method of making a plank by printing a design directly on the top surface of the plank using any number of printing techniques, such as embossing gravure printing, transfer printing, digital printing, flexo printing, and the like. The method includes applying a protective coating on top of the printed design, such as a polyurethane type coating with or without wear resistant particles in the coating.

A further embodiment of the present invention relates to making a plank for flooring by co-extrusion techniques, which involves extruding at least one polymeric material, at least one type of natural fiber or flour, and optionally a lubricant and/or a compatibilizer/coupling agent into the shape of the core and also extruding a layer containing at least one thermoplastic material with one or more pigmented compounds on top of the extruded core, wherein the layer simulates a design, such as wood grain.

The present invention also relates to planks having the above-described characteristics.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are intended to provide a further explanation of the present invention, as claimed.

The accompanying drawings, which are incorporated in and constitute a part of this application, illustrate several embodiments of the present invention and together with the description serve to explain the principles of the present invention.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**FIG. 1** is a schematic diagram showing a side view of one embodiment of the plank of the present invention.

**FIG. 2** is a schematic diagram showing a side view of a spline design which can be used in the present invention.

**FIG. 3** is a schematic diagram of a sectional view showing another embodiment of the plank of the present invention.
FIG. 4 is a schematic diagram showing a groove design for a plank of the present invention.

FIG. 5 is a partial side view of one type of tongue and groove system that can be used in the planks of the present application.

FIG. 6 shows a side view of a plank which is finished sanded, then wrapped with a laminate layer or layers and then cut to have a tongue and groove system.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

For purposes of the present invention, a floor panel, or plank includes, is not limited to, any shape or size floor panel. In other words, the floor panel can be rectangular, triangular, square, hexagonal, and octagonal or have any number of sides. Also, the floor panel can have other geometrical designs, such as curves and the like. As long as the floor panels can be joined together in some fashion, the present invention can be used. Thus, for purposes of the present invention, floor panel includes these various shapes and designs. In general, the present invention relates to a plank which contains a core including from about 30 wt % to about 95 wt % of at least one polymeric material, by weight of the core, and from about 5 wt % to about 80 wt % of at least one natural fiber or flour, by weight of the core. The core of the present invention is substantially moisture resistant, having a swelling property of from 0.5% to about 5%, by NALFA Thickness Swell Test (Section 3.2 LF 01-2003 Standard) (other ranges for moisture resistance as determined by the swelling property are from 1.0% to 4%, or from 2.0% to 4%), and wherein the core includes a downward bow of from about 0.5% to about 3.5% of the length of the plank. Other ranges for the downward bow are from 1.0% to 3%, or 1.5% to 3%, or 2.0% to 3%.

The planks of the present invention can have a density of from about 58 lbs./ft³ to about 73 lbs./ft³. Preferably, the planks of the present invention include a density of from about 60 lbs./ft³ to about 70 lbs./ft³. The density of the planks of the present invention is measured by Method 1: measurement of weight of a given volume of the product. Weight is measured using a balance reading to 0.0001 gram. Volume is determined by measurement of dimensions using calipers reading to 0.001, or Method 2: calculation using specific gravity of HDPE=0.93 g/cc and PP=0.91 g/cc with wood density=cellulose=1.27 g/cc and lubricant package at 1.1 g/cc.

In one example, the plank of the present invention does not include a backing layer. The permanent downward bow of from about 0.5% to about 3.5% of the length of the plank can counteract for having no backing layer. This bowing can be achieved, for instance, by heat-treating the plank (e.g., heat treating the bottom surface of the plank) in order to provide a sufficient bow (camber or dome) to counteract any dimensional change of a top layer (if any) on the core from temperature and humidity in the environment. The heat treatment, for example, can be at a temperature of from about 250° F to 1,000° F (e.g., 300° F to 800° F or 300° F to 500° F) for a time, such as 3 seconds to 1 minute (e.g., 3 seconds to 25 seconds).

The planks of the present invention can have a glass transition temperature (Tg) of greater than about –50° C. Preferably, the glass transition temperature of the plank is from about –45° C to about –15° C. (High Density Polyethylene) from about –50° C to about +20° C (Polypropylene) or from about 75° C to about 105° C (Polyvinyl chloride). The glass transition temperature can be from about –45° C to about 105° C. The polymeric material of the present invention can be present in an amount of from about 30 wt % to about 95 wt % of the weight of the core. The polymeric material can have a melt index of from about 0.4 to about 20 grams. Preferably, the polymeric material has a melt index of from 0.8 to about 3 grams. The amount of polymeric material can be from about 40 wt % to about 90 wt % or from about 50 wt % to about 80 wt %, based on the weight of the core.

The polymeric material of the present invention can be one or more polymers having a polyolefin group, such as polyethylene. Other exemplary polymers include, but are not limited to, polypropylene, polyvinyl chloride, copolymer of PVC, and also other suitable thermoplastics.

In more detail, the polymeric material in the core can be at least one thermoplastic material. Generally, any polymeric material, combinations thereof, alloys thereof, or mixtures of two or more polymeric materials can be used for the polymeric material of the core. Generally, the polymeric materials are thermoplastic materials that include, but are not limited to, vinyl containing thermoplastics such as polyvinyl chloride, polyvinyl acetate, polyvinyl alcohol, and other vinyl and vinylidene resins and copolymers thereof; polyolefins such as low density polyethylene and high density polyethylenes and copolymers thereof; styrene such as ABS, SAN, and styrenes and copolymers thereof; polyparaphylene and copolymers thereof; saturated and unsaturated polyesters; acrylics; polyamides such as nylon containing types; engineering plastics such as acetyl, polycarbonate, polyamide, polysulfide, and polyphenylene oxide and sulfide resins and the like. One or more conductive polymers can be used to form polymeric material of the plank, which has applications in conductive flooring and the like. The thermoplastic polymers set forth in Kirk-Othmer (3rd Edition, 1981) at pp. 328 to 848 of Vol. 18 and pp. 385-498 of Vol. 16, (incorporated in their entirety by reference herein) can also be used as long as the resulting plank has sufficient strength for its intended purpose.

Preferably, the thermoplastic material is a polyolefin including polyethylene or propylene, and rigid polyvinyl chloride (PVC), semi-rigid or flexible polyvinyl chloride may also be used. Preferably, the olefins or the rigid PVC possesses good impact strength, ease of processing, high extrusion rate, good surface properties, excellent dimensional stability, and indentation resistance. The flexibility of the thermoplastic material can be imparted by using at least one liquid or solid plasticizer which is, preferably, present in an amount of less than about 20 phr, and, more preferably, less than 1 phr (e.g., less than 20% by weight of the core), especially in the case of PVC. A typical rigid rigid PVC compound used in the present invention to form the polymeric material of the core can also include, but is not limited to, pigments, impact modifiers, stabilizers, processing aids, lubricants, fillers, other conventional additives, and the like.
The polymeric material to be processed can be in powder, liquid, cubed, pelletized form and/or any other extrudable form. Also, the polymeric material can be virgin, recycled, or a mixture of both. Furthermore, the polymeric material can be incorporated with a blowing agent(s) or a mechanically injected gas during the extrusion process to make a cellular foam structure core.

The polymeric materials used to form part of the core can be polyolefin and polyvinyl chloride. Polyolefin is preferably, High Density Polyethylene or Polypropylene. PETROTHENE LB 0100-00 can be used and is a high density polyethylene reactor powder. LB0100-00 provides excellent polymer dispersion, lower extruder amperage, and increased extruder output rates versus pellets of equivalent melt index and density in wood plastic composites.

Physical Properties for LB 0100-00

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Units</th>
<th>ASTM Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melt Index</td>
<td>0.50</td>
<td>g/10 min</td>
<td>D 1238</td>
</tr>
<tr>
<td>Density</td>
<td>0.952</td>
<td>g/cc</td>
<td>D 1505</td>
</tr>
<tr>
<td>Tensile Strength @ Break</td>
<td>3,980</td>
<td>psi</td>
<td>D 638</td>
</tr>
<tr>
<td>Elongation @ Break</td>
<td>&gt;600</td>
<td>%</td>
<td>D 638</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>185,000</td>
<td>psi</td>
<td>D 790</td>
</tr>
<tr>
<td>Tensile Impact</td>
<td>120</td>
<td>lb/in.</td>
<td>D 1822</td>
</tr>
<tr>
<td>Low Temperature Brittleness, Fty</td>
<td>&lt;76</td>
<td>°C</td>
<td>D 746</td>
</tr>
<tr>
<td>Heat Deflection Temperature @</td>
<td>75</td>
<td>°C</td>
<td>D 648</td>
</tr>
<tr>
<td>66 psi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicat Softening Point</td>
<td>125</td>
<td>°C</td>
<td>D 1525</td>
</tr>
<tr>
<td>Hardness, Shore D</td>
<td>66</td>
<td></td>
<td>D 2240</td>
</tr>
<tr>
<td>Environmental Stress Crack</td>
<td>25</td>
<td>hrs</td>
<td>D 1693</td>
</tr>
<tr>
<td>Resistance, Fsv</td>
<td>500</td>
<td>hrs</td>
<td>D 2561</td>
</tr>
</tbody>
</table>

Exxon Mobil PLTD 1765 Homo-polymer can be used and is a medium melt flow rate polypropylene homopolymer.

Physical Properties PLTD 1765

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Units</th>
<th>ASTM Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melt Index</td>
<td>4.0</td>
<td>g/10 min</td>
<td>D 1238</td>
</tr>
<tr>
<td>Density</td>
<td>0.9</td>
<td>g/cc</td>
<td>D 792</td>
</tr>
<tr>
<td>Tensile Strength @ Yield</td>
<td>4,930</td>
<td>psi</td>
<td>D 638</td>
</tr>
<tr>
<td>Elongation @ Yield</td>
<td>10</td>
<td>%</td>
<td>D 638</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>220,000</td>
<td>psi</td>
<td>D 790</td>
</tr>
<tr>
<td>Izod Impact</td>
<td>0.8</td>
<td>ft-lb/in.</td>
<td>D 256</td>
</tr>
<tr>
<td>Low Temperature Brittleness, Fty</td>
<td>&lt;76</td>
<td>°C</td>
<td>D 746</td>
</tr>
<tr>
<td>Heat Deflection Temperature @</td>
<td>91</td>
<td>°C</td>
<td>D 648</td>
</tr>
</tbody>
</table>

PVC resin can be used and is a suspension grade or mass polymerization grade homopolymer resin having a preferred molecular weight as reflected by an inherent viscosity of from about 0.88 to about 1.0 inherent viscosity. In general, a higher molecular weight polymer is preferred from the standpoint of processing stability and, preferably, the molecular weight distribution and particle size distribution are narrow in order to provide a good balance between processability and properties. Also, a high, uniform porosity of the resin particles are preferred to optimize compounding and processing aspects, including the fast and uniform absorption of any stabilizer that is present as well as other ingredients during compounding.

The polyvinyl chloride can have the following properties:

<table>
<thead>
<tr>
<th>GEON COMPOUND</th>
<th>ASTM METHOD</th>
<th>Property Value Units Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Cube</td>
<td></td>
</tr>
<tr>
<td>Cell Classification</td>
<td>D1784</td>
<td>13344·C</td>
</tr>
<tr>
<td>Specific Gravity 0.2</td>
<td>D792</td>
<td>1.45</td>
</tr>
<tr>
<td>Hardness-Durometer Shore D 3</td>
<td>D2240</td>
<td>92</td>
</tr>
<tr>
<td>Tensile Properties - Strength Psi</td>
<td>D638</td>
<td>6000</td>
</tr>
<tr>
<td>Tensile Properties - Modulus Psi</td>
<td>D638</td>
<td>390000</td>
</tr>
<tr>
<td>Flexural Properties - Strength Psi</td>
<td>D790</td>
<td>11000</td>
</tr>
<tr>
<td>Flexural Properties - Modulus Psi</td>
<td>D790</td>
<td>370000</td>
</tr>
<tr>
<td>Heat Deflection Temperature F.</td>
<td>D648</td>
<td>160</td>
</tr>
<tr>
<td>Unannealed @ 1.82 MPa (254 PSI)</td>
<td>D069</td>
<td>3.4 x 10-5</td>
</tr>
<tr>
<td>Coefficient of Linear Expansion</td>
<td>in./in. F.</td>
<td>D256</td>
</tr>
<tr>
<td>Notched Izod Flub./in. of notch @</td>
<td>23 C. (73 F)</td>
<td>3</td>
</tr>
<tr>
<td>Impact Properties - Drop Impact in./lb/in @ 375 F. melt T.</td>
<td>D4226</td>
<td>2.0</td>
</tr>
<tr>
<td>1⁄4&quot; Dur. H.250 Method A</td>
<td>D256</td>
<td>1.0</td>
</tr>
<tr>
<td>1⁄4&quot; Dur. H.250 Method B</td>
<td>D256</td>
<td>1.0</td>
</tr>
<tr>
<td>1⁄4&quot; Dur. H.125 Method A</td>
<td>D256</td>
<td>1.0</td>
</tr>
<tr>
<td>1⁄4&quot; Dur. H.125 Method B</td>
<td>D256</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Generally, this compound can have a melt temperature of from about 360 to about 390°F. Also, a stabilizer can be present in the polymeric formulation that forms part of the core. A preferred stabilizer is a butyl tin mercaptide stabilizer. In addition, an impact modifier can also be present. Preferred impact modifiers are acrylic-based from Rohm and Haas, an EVA-based impact modifier known as Elvaloy™ from DuPont; and others such as chlorinated polyethylene and acrylonitrile butadiene styrene, and the like.

With respect to the above various tables and properties, generally, the core can have any one or more of these properties or can have any one or more of these properties that are within 25% or within 10% of the stated property values provided. In addition, the polymeric formulation can contain at least one processing aid, which is, preferably, an acrylic based low molecular weight resin such as Acryloid K-125 or K-175 from Rohm and Haas.

With respect to the natural fibers or flour, the natural fibers or flour in the core is preferably present in an amount of from about 5% to about 75% or to about 80 wt %, by weight of the core. Preferably, the natural fibers have a reduced particle size. This can be achieved, for instance, by pulverizing and classifying the particle sizes. Generally, this pulverizing and the like forms a wood flour. The natural fibers or wood flour can have a particle size of about 50 mil or less and, more preferably, about 30 mil or less. In one embodiment, the particle size is no less than about 7 mil or no less than 5 mil. In one embodiment, the particle size of the natural fibers that are present are based on a particle size distribution. In one embodiment, about 10 wt % to 40 wt % of the particles have a particle size of from about 20 mil to 30 mil, about 10 wt % to 30 wt % of the particles have a particle size of from about 15 mil to 20 mil, about 10 wt % to 30 wt % of the particles have a particle size of from about
5 mil to 15 mil, and about 0 wt % to 20 wt % of the particles have a particle size of about 5 mil or less. With respect to these particle sizes, it would be difficult to have the size ranges as absolute values. Thus, there may be particles outside these size ranges to a small extent, such as less than 15% by weight of all particles, and more preferably less than 10% by weight or less than 5% by weight of the particles present.

[0049] The following particle size distribution can be used as an example:

<table>
<thead>
<tr>
<th>Mesh Size</th>
<th>Retained</th>
<th>mil</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>35%</td>
<td>23</td>
<td>0.58</td>
</tr>
<tr>
<td>40</td>
<td>30%</td>
<td>16.5</td>
<td>0.42</td>
</tr>
<tr>
<td>50-60</td>
<td>30%</td>
<td>11.7-9.8</td>
<td>0.30-0.25</td>
</tr>
<tr>
<td>80</td>
<td>5%</td>
<td>7</td>
<td>0.18</td>
</tr>
</tbody>
</table>

[0050] As another example, the wood flour/fibers can have a particle size ranging from that passing through 20 mesh screen to that retained on 80 mesh screens. This 20/80 size fraction corresponds to 180 microns to 850 microns particle size. More preferably, the size range corresponds to the fraction passing through a 20 mesh screen to that retained on a 60 mesh screen. This size 20/60 size fraction corresponds to 250 microns to 850 microns.

[0051] Other weight percentages and particle size distributions or any combination thereof can also be utilized.

[0052] The natural fibers or flour preferably have a moisture content of about 1% or lower (by weight of fiber or flour). The natural fiber or wood flour most preferably has a moisture content of less than 0.5 wt %. The natural fibers can be from any wood source, cellulose source, other natural sources, or any combination thereof. Examples include, but are not limited to, wood (e.g., maple, oak, pine, cedar, hickory, spruce, poplar, ash, and the like), bamboo, kenaf, jute, hemp, flax, sisal, cotton, coconut flour, rice hull, and the like. As stated, generally, any natural fiber can be used which is from trees, plants, parts thereof and the like. For purposes of the present invention, natural fiber and flour include the above in fiber form or flour form (i.e., particle size). Synthetic fibers may also be used to enhance mechanical properties such as flexural and tensile modulus of the product. The higher aspect ratio (ratio of length to diameter), the better enhancement of the properties. In addition to natural fibers and flour, fillers that are not natural fiber or flour can be added to the core formulation to further reduce product cost and to improve impact properties. While any filler can be used as long as it is compatible with the polymeric material and natural fiber or flour, typical fillers include, but are not limited to, calcium carbonate.

[0053] The natural fiber or flour can be virgin, recycled, or a mixture of both. Furthermore, the natural fiber or flour can be incorporated with a foaming agent(s) or a mechanically-injected gas during the extrusion process to make a cellular foam structure core.

[0054] In one example, the planks of the present invention can have a thickness swelling property of about 3% or less, and, more preferably, from about 0.5 to about 3% swelling. This is significantly less than conventional laminates which have a swelling of from 12 to 14%. The swelling property is measured by immersing the sample in water for 24 hours according to the test method NALFA Thickness Swell Test Section 3.2 LF 01-2003, incorporated by reference herein.

[0055] The plank of the present invention, preferably, has a bow to counteract any dimensional change of the top layer, such as a laminate, on the core from temperature and humidity in the environment. Preferably, the planks of the present invention, especially those without a backing layer, are domed in order to create an arch for purposes of achieving desired dimensional stability.

[0056] The amount of dome can be dependent on the type of surface layer utilized and the moisture content of the surface layer at the time of wrapping. The amount of dome of the plank should accordingly be adjusted so that the plank has its ability to maintain flatness in its service environment. For instance, in one example where a laminate overlay is utilized as the surface layer, the plank can include a downward dome of from about 0.25 inch to about 2.9 inches and preferably, from about 0.30 inches to about 2.5 inches. For a thin veneer (e.g., 0.006 inches) laminated to a polyester backing system, the plank can have a bow of from about 1 inch to about 2 inches before being placed in the box. The bow described above is measured vertically at the center of the plank along a long straight edge that touches both ends. Preferably, the plank of the present invention includes a bow of from about 1% to about 4% of the length of the plank, based on 0% having no bow and 100% being perpendicular to the center.

[0057] In another embodiment of the present invention, the planks of the present invention have favorable flexibility which is very suitable for laying the planks together on a floor since such flexibility will conform to sub-floors more easily even with imperfections in the sub-floor. In the present invention, in a preferred embodiment, the planks of the present invention have a plank sag of at least 25 inches and more preferably at least 30 inches. A suitable range for the plank sag is from about 25 inches to about 45 inches. The plank sag is determined by a plank sag test which determines how the plank will conform under gravity. The test is conducted by using 6 foot long planks of the core without a finished top layer (e.g., no laminate layer). The plank core is clamped with C-clamps to a edge of a horizontal platform (e.g., a table). The plank core is clamped so that as much of the 6 foot length can hang as possible. The amount that the plank sags at the unclamped end from a horizontal plane is measured. As indicated, this shows the flexibility of the product. The planks of the present invention preferably have this plank flexibility in association with the other properties set forth above. The planks of the present invention have this preferred flexibility either with a dome as described above or without a dome.

[0058] At least one lubricant can be present in the formulation. The amount of lubricant can be any suitable amount, such as, for example, from about 1 wt % to about 5 wt % or more, by weight of the formulation. One example of such a lubricant is from Struktol (Struktol TPW104). A lubricant such as a polyester lubricant can be used.

[0059] The lubricant can include an internal lubricant and an external lubricant. Preferred internal lubricants, which act internally to alter the cohesive forces amongst the polymer chains that result in lower melt viscosity without reducing
the strength properties of the resin, are metallic stearates such as calcium and zinc salts of stearic acid. External lubricants, which act externally to prevent resins from sticking to hot metal processing machinery by reducing friction between the surfaces, are preferably low-melting paraffin. Other examples of lubricants include polyolefin wax, fatty acid amides, fatty acid esters, metal soaps and salts of stearic acid and other organic acids, and the like.

[0060] The core can include at least one compatibilizer/coupling agent for improving impact strength, heat distortion temperature, tensile and elongation characteristics and modulus of elasticity and lastly reducing moisture sensitivity. The amount of compatibilizer can be from about 0.5% to about 5% by weight. An example of a compatibilizer/coupling agent that can be used in the present invention is maleic anhydride.

[0061] Preferably, the core is rigid in nature and includes the following range of preferred properties: impact resistance, static load resistance, indentation resistance, moisture insensitivity, pre-profiled configuration, and the like.

[0062] The dimensions of the core can practically be any shape (e.g., square, rectangle, curved, and the like) or size as long as such material can be extruded as one piece or multiple pieces. For instance, the core can include a thickness of from about 3 mm to about 50 mm, a width of from about 2 cm to about 60 cm, and a length of from about 30 cm to about 215 cm. Also, the top surface of the core can, optionally, have a textured surface on the top surface as part of the core which is extruded through the die. A mechanical embossing row can be located behind the cooling calibrator and after the extrusion die to achieve surface texturing of the extruded core. Any variety of textures can be created by this method on the core such as wood grains and the like.

[0063] Also, as an option, the core can be 100% solid or can have one or more cavities or cells which are located between the upper and lower surfaces of the core. The solid core is preferred since it enhances the impact strength and the indentation property of the product. The extruded core preferably has the thickness from about 3 mm to about 25 mm, preferably, about 6 mm to about 10 mm. The width of the plank has the dimension of 50 mm to 500 mm, preferably has the width about 75 mm to 305 mm. While the cavities or cells are optional, the extruded core can have cavities having dimensions of 3 mm to about 16 mm in height, preferably, about 7.6 mm in height by about 6 mm by about 20 mm in width, preferably, about 7.6 mm in width, and can be separated by a wall, preferably, a solid thermoplastic material, having a thickness of from about 1.0 mm to about 3.02 mm, preferably from about 1.27 mm to about 1.8 mm. The optimal dimension of cavities is dependent upon the requirement of the product withstand the potential impact force of falling objects. The cavities which are preferably present can be in any shape such as rounded, oval, or rectangular. These cavities or cells, preferably, exist across the entire distance of the core as shown in FIG. 1. Another advantage is that wires, cables, fiber optics, and/or piping can be run through the cavities which makes installation of wiring and piping quite easy without the necessity of putting holes through walls, or running wires underneath the floor or in the ceiling. Further, if necessary, holes can be drilled through the polymeric material and the natural fiber that separate one cavity from another in order to have the wire or piping go in a perpendicular direction when necessary. Alternatively, for certain polymeric and natural fiber core pieces, the cavities can be run in a perpendicular direction from the remaining pieces in order to accommodate the direction that wiring or piping may take when being placed in a room.

[0064] The cores which form the plank are preferably all made from the same die design and thus they are uniform in appearance. Also, the cavities which are preferably present in the core align with the cavities in respective core pieces. Dowels, biscuits or other equivalent material can be inserted into the cavities at the short end of the plank in order to join an adjacent plank to create a tight seal at each seam. This type of coupling system, though optional, can further insures a very secure tight fitting floating floor or other surface covering.

[0065] Though not necessary, the ends of the plank as well as the tongue and/or groove can have a bonding agent applied to these locations in order to seal or bond the planks together. Sealant compositions such as tetrahydrofuran have the ability to work as a bonding agent to join the planks of wood/PVC composition together. In one of the examples that follow, the results show that by using tetrahydrofuran or compositions like tetrahydrofuran, the joints of the planks which have been attached with the use of this composition leads to the formation of a bond between the planks. This increases the overall bond strength of two adjoining boards significantly. This bonding agent can be used not only with the planks described above. One advantage of using a bonding agent like tetrahydrofuran is that it is simple to use, and leaves no residue on the surface after evaporation. Thus, no adhesive marks are left on the surface of the planks. In addition, applying such bonding agents like tetrahydrofuran is quite easy since it can be applied by brush or spray or applicator tip using gravity or other force such as squeezing an applicator bottle, and any excess is easily removed unlike the application of some adhesives for tiles and the like. Other examples of suitable bonding agents which have the ability to bond the thermoplastic planks (e.g., PVC) include, but are not limited to, mylene chloride and ketones and the like. Examples of ketones include, but are not limited to, methyl ethyl ketone, methyl amyl ketone, dipropyl ketone, methyl isobutyl ketone, a-n-methyl pyrrolidone, dimethyl formamide, cyclohexanol, nitrobenzene, and the like.

[0066] Another option is to use waterborne adhesive such as polyvinyl acetate type to bond the faces of the exposed wood fiber after the plank was machined with a tongue and groove joint system.

[0067] Another optional aspect of the core is the presence of a groove and/or a tongue design on preferably at least two sides or edges of the core wherein the sides or edges are opposite to each other. For instance, the core design can have a tongue design on one edge and a groove design on the opposite edge, and it is possible to extrude the core with a tongue and a groove configuration on two edges and then machine the dimension of the tongue and the groove to the tight tolerance of the joint system required for easing connection. The typical dimensional tolerance for the extrusion process is around 15-20 mils (0.015-0.020 inches), ranges which can be considered too broad for the connection system. The subsequent machining process can bring the tongue and the groove dimension within the tolerance of
adequate fit. It is also possible for machining both edges which are opposite to each other having a groove design. The tongue or groove can have a variety of dimensions, but, preferably, the groove which is present on two opposite edges has an internal depth dimension of from about 5 mm to about 12 mm and a height of from about 3 mm to about 5 mm. The bottom width of the side having the groove is slightly shorter than the upper width of the same side to ensure no gap exists between planks after butting together. With respect to the edges of the floor panels, which are joined together in some fashion, the floor panels can have straight edges or can have a tongue and groove design or there can be some intermediate connecting system used to join the floor panels together such as a spline or other connecting device. Again, any manner in which floor panels can be joined together is embodied by the present application. For purposes of the present invention, the floor panel can have a tongue and groove design or similar connecting design on the side edges of the floor panel. Examples of floor panel designs, shapes, and the like that can be used herein include, but are not limited to, the floor panels described in U.S. Pat. Nos.: 6,101,778; 6,023,907; 5,860,267; 6,006,466; 5,797,237; 5,348,778; 5,706,621; 6,094,862; 6,182,410; 6,205,639; 5,200,553; 1,764,331; 1,808,591; 2,004,193; 2,152,694; 2,852,815; 2,882,560; 3,623,288; 3,437,300; 3,731,445; 4,095,913; 4,471,012; 4,695,502; 4,807,416; 4,953,335; 5,283,102; 5,295,341; 5,437,934; 5,618,602; 5,694,730; 5,736,227; and 4,426,820 and U.S. Published Patent Application Nos. 20020031646 and 20010021431 and U.S. patent application Ser. No. 09/460,928, and all are incorporated in their entirety by reference herein.

In one embodiment, a floor panel can have at least two side edges wherein one side edge has a tongue design and the opposite side having a groove design, and wherein the tongue and groove are designed to have a mechanical locking system. These two edges are preferably the longer of the four side edges. The remaining two edges, preferably the short joints, can also have a mechanical locking system, such as the tongue and groove design, or the short joints can have a standard tongue and groove design, wherein one edge has a standard tongue design and the other edge has a standard groove design. The standard design is a design wherein the tongue and groove is not a mechanical locking system but is generally a tongue having a straight tongue design in the middle of the edge and the groove design has the counterpart groove to receive this tongue. Such a design has many advantages wherein a mechanical locking system can be used to connect the long sides of the plank, typically by tilting the tongue into the groove of a previously laid down plank. Then, the standard tongue and groove design on the short edges permits the connecting of the short edge of the plank to the previously laid plank without any tilting motion or lifting of the previous laid planks. The adhesive can be applied to all edges or just to the standard tongue and groove edges. The present invention encompasses any type of joint or connecting system that adjoins edges of floor panels together in some fashion with the use of straight edges, grooves, channels, tongues, splines, and other connecting systems. Optionally, the planks can be joined together wherein at least a portion of the planks are joined together at least in part by an adhesive. An example of such a system is described in U.S. patent application Ser. No. 10/205,408, which is incorporated herein in its entirety.

Also, as an option, any edge of the plank can be straight or bevel. Preferably the edges tapered or beveled so that when two cores are brought together for attachment, a valley or V-shaped valley is formed. Preferably, the tapered or beveled edges are at an angle of from about 5° to about 55°, and, more preferably, at about a 15°-45° angle. Also, the length of the beveled or tapered edge can be from about 1.0 mm to about 7.0 mm on each core piece. A preferred design is set forth in FIG. 3.

The planks of the present invention can include a top layer on the core. For example, the top layer can include (a) a high pressure laminate construction that is comprised of an impregnated underlayer Kraft paper, a printed decorative layer, and an impregnated protective overlay compressed together with heat and pressure to become one single layer; (b) a wood veneer; or (c) a vulcanized cellulose layer that is made from a number of plies of paper treated with zinc chloride, acid to make the surfaces of the paper gummy and sticky, wherein the gummy plies are then pressed together. The planks of the present invention does not require a backing layer, but can optionally have a backing layer. Preferably, the planks have no backing layer.

In addition, the decorative element(s) such as wood grains and/or knots texture can be embossed (e.g., mechanical or chemical embossing), wherein the design can then be directly printed on the surface using, for example, a non-contact type digital printing technology. Another option is to incorporate the pigments into extrusion operation to create wood grain look on the surface of the planks by disturbing the material flow in the extruder. The decorative element can be any design, like natural appearances, stone, brick, ceramic, wood, marble, and the like or can be other designs common to or used by the floor industry. The design and overall upper layers can be textured, such as embossed in register with the design.

In one example, the top layer is a laminate on top of the core; a print layer can be affixed to the top surface of the core, wherein the print layer has a top surface and a bottom surface. The print layer, preferably, is an aminoplast resin impregnated printed paper. Preferably, the print layer has a printed design. The printed design can be any design which is capable of being printed onto the print layer. The print layer is also known as a decor print layer. Generally, the print layer can be prepared by rotogravure printing techniques or other printing means such as digital printing. Once a design is printed on the paper, the paper can then be impregnated with an aminoplast resin or mixtures thereof. Preferably, the aminoplast resin is a blend of urea formaldehyde and melamine formaldehyde.

The print paper, also known as the Deco paper, preferably, should have the ability to have liquids penetrate the paper such as a melamine liquid penetrating in about 3 to 4 seconds and also maintain a wet strength and even fiber orientation to provide good reinforcement in all directions. Preferably, the resin used for the impregnation is a mixture of urea formaldehyde and melamine formaldehyde resins. Urea formaldehyde can contribute to the cloudiness of the film that is formed and thus is not preferred for dark colors and the melamine resin imparts transparency, high hardness, scratch resistance, chemical resistance, and good formation, but may have high shrinkage values. Combining urea resins with melamine resins in a mixture or using a double impreg-
nation (i.e., applying one resin after another sequentially) provides a positive interaction in controlling shrinkage and reducing cloudiness. Any type of paper can be used in the present invention. Preferably, the type of paper used is 80 g/m² weight and includes a thickness of 0.16 mm.

Located optionally on the top surface of the print layer is an overlay. The overlay which can also be known as the wear layer is an overlay paper, which upon being affixed onto the print layer, is clear in appearance.

The overlay paper is, preferably, a high abrasive overlay which, preferably, has aluminum oxide embedded in the surface of the paper. In addition, the paper can be impregnated with an aminoplast resin just as with the print overlay. Various commercial grades of high abrasive overlays are preferably used such as those from Mead Specialty Paper with the product numbers TMO 361, 461 (70 g/m² premium overlay from Mead), and 561, wherein these products have a range of Taber values of 4000 to 6000 cycles according to NALFA Standard LF-01 3.7. Preferably, the type of paper used is about 46 g/m² and has a thickness of about 0.15 mm.

With respect to the print layer and the overlay, any amount of aminoplast can be used. Preferably, the amount of aminoplast resin is from about 60 to about 140 g/m² and, more preferably, from about 100 to about 120 g/m².

A multilayered overlay can be used to provide printed decoration and protection for the product. This overlay can have a printed paper as a decorative layer. On the top surface of the printed paper can be a layer of urethane acrylate containing aluminum oxide for enhanced abrasion resistance. Above this layer can be another layer of urethane acrylate without aluminum oxide for improved surface visuals. Below the print layer can be a primer to enhance the bond to the core material. The multilayered overlay can be produced by building layers of the primer liquid, and the two acrylic layers as liquid onto the print layer and then e-beam curing to produce the solid cured product.

As an option, an underlay can be located and affixed between the bottom surface of the print layer and the top surface of the core. Preferably, the underlay is present and is paper impregnated with an aminoplast resin as described above with respect to the print layer and overlay. Preferably, the underlay is Kraft paper impregnated with aminoplast resins or phenolics and, more preferably, phenolic formaldehyde resin or melamine formaldehyde resin which is present in an amount of from about 60 g/m² to about 145 g/m² and, more preferably, from about 100 g/m² to about 120 g/m² paper. Any type of paper can be used. Preferably, the type of paper used is about 145 g/m² and includes a thickness of about 0.25 mm. The underlay is especially preferred when extra impact strength resistance is required.

Other types of layers, which can be used in the present invention, such as wood veneer and vulcanized cellulose layers, can include the same components described above with respect to the laminate. Wood veneers used as the top layer can be any type of species such as oak, maple, cherry, hickory, beech, pine, walnut, mahogany, chestnut, and teak and the like. The thickness of the veneer can be in the range of 0.005 inch to 0.250 inch. Preferably, the thickness of the veneer is in the ranges of 0.080 inches to 0.160 inches. The veneer on the top can be decorated with a printed design to highlight the grains or knots or to mimic certain wood species or to emboss the surface to create vintage appearance and the like.

As a protective layer, a radiation curing or e-beam curing urethane acrylate coating(s) can be applied on the surface of any previous layer or on the core upper surface to provide the required surface properties such as scratch and wear resistance, scuff resistance, stain and chemical resistance and the foremost importance is the appearance retention. The coating(s) can incorporate the abrasive resistance particles in the urethane for better surface protection that typically has abrasion level of 300-500 cycles per NALFA test.

While the core can be made in a number of ways, preferably, the core is formed by an extrusion process wherein the polymeric material, natural fiber, along with any other optional ingredients are blended together and are then fed into an extruder by a feeder, wherein the extruder, preferably, uniformly mixes the polymeric material with the natural fiber and the application of heat and auger action can melt the polymeric material to the extent that it is eventually fed through a die, wherein the die can be in the shape of the core. Preferably, the fiber or flour is uniformly distributed and encapsulated throughout the polymeric material. Preferably, the fiber or flour is substantially encapsulated or coated individually by the polymeric material when formed into the core.

In forming the core of the present invention, the ingredients making up the formulation can be mixed prior to introducing the ingredients into an extruder or can be mixed by way of the extruder.

In making the planks of the present invention, the starting polymer, which is preferably a thermoplastic, can typically, be in the form of a powder that is mixed with the natural fibers inside the extruder without going through the pre-mixing process.

As an alternative, the ingredients, including the starting polymer(s), and the natural fiber/flour can be intimately mixed together under heat and/or pressure to form pellets of the material. These pellets can then be introduced into an extruder for formation of the desired shape of the core. The pellets can have any size suitable for use in an extruder.

The natural fibers can be reduced to the desired particle size by any reducing technique, such as using a pulverizer, mill, and the like. In addition, to obtain the desired moisture content in the natural fibers, any drying technique can be utilized such as conductive, convective, and radiation heating means.

In more detail, the extrusion process permits a) an economically feasible design by designing a profile with cavities inside the structure and b) a highly versatile method of achieving the complicated profile design of the preferred plank in conjunction with additional machining afterwards for the tongue and groove, for instance. Generally, the extruder can be designed to uniformly mix the various ingredients together to extrude, using a die, in the form of a core. While any extruder can be used which can extrude the desired design of the plank for polymeric and natural fiber materials, preferably, the extruder is a twin screw extruder, such as one from American Maplan Corporation, such as
The TS-88 includes the ability to process polymeric profiles with a maximum output capacity of about 900 lb/hr, based upon a compound bulk density of 37 lb/ft³. The TS-88 is a twin screw extruder which includes a barrel heating section and a cooling section as well as a vacuum system. In the extruder, there can be 12 temperature zones with 6 for cooling and a temperature control system.

Preferably, the plank can be prepared by extruding the core as described above and forming a top layer, such as a wood veneer or laminate or vulcanized cellulose layer. The laminate can comprise the overlay affixed to the top surface of the print layer and, optionally, the underlay layer which is affixed to the bottom surface of the print layer. In one example, wherein the top layer is a laminate, the laminate can be prepared by, for instance, any process customarily used to manufacture laminate films such as a continuous double belt press. In general, if an underlay is used, the phenolic impregnated kraft backer, the print layer and the overlay can be fed into a continuous double belt press that serves as a laminating calendar. Preferably, the continuous operation is an isobaric system wherein pressures can go as high as 30 bars and the line speed can be up to 20 meters per minute. The pressure zone length is about 2 to 3 meters. In this continuous double belt press system, the isobaric system provides a steady uniform pressure effect on each point of the treated surface of the laminate. Embossing of the laminate can be accomplished by embossed release paper or the belt of the double belt press can be embossed to produce surface textures. In a continuous double belt press, the simultaneous heating of the laminate with proper dwell time and pressure forms the laminate film which can then be rolled up for subsequent application. Once the laminate is formed it can be applied onto the core and is preferably affixed by any means, such as with an adhesive. Preferably the adhesive is a hot melt adhesive such as hot melt glue like hot melt polyurethane glue.

The hot melt adhesive, such as the hot melt polyurethane adhesive, is preferably applied to the back surface of the laminate film at a preferred temperature of from about 250°F to about 300°F, preferably from about 250°F to about 275°F. These temperatures may vary slightly depending upon the adhesive. The application of the hot melt adhesive to the laminate can be done by a direct roll coater. The laminate with the adhesive on the back surface can then be heated to an adequate temperature to soften the laminate and allow the laminate to form to the profile of the thermoplastic core and thus be affixed permanently. The typical wrapping machine is designed to hold the laminate to the contour of the thermoplastic plank as it is being cooled to below about 90°F. To about 100°F. The thickness of the application of the adhesive can have an effect on the impact resistance of the laminate. The impact of the adhesive is too thick, an impact may cause the laminate to become brittle and crack. A thin application enables the laminate to flex less during impact and minimize the damage. Application of the adhesive is preferably from about 5 to about 15 g/ft² and more preferably from about 6 to about 12 g/ft².

A preferred hot melt adhesive is EverLock® 2U145/2U230 modified polyurethane adhesive reactive hot melt from Reinhold Chemicals, Inc.

Wood veneer and vulcanized cellulose can be laminated in a similar manner. These products may be provided as coils or as individual strips. In either case, the hot melt adhesive which is heated to the temperatures described above can be applied to the back of the overlay material to be laminated onto the base plank. The overlay with adhesive is then mated to the base plank under heat and the pressure of multiple rollers. The heat used needs to be sufficient to re-soften the hot melt and if necessary to soften the overlay until it bends and conforms to the surface onto which it is being laminated. In the case of certain laminate overlay products to bend the overlay around a bevel edge, the temperature may need to be 300-320 degrees F. If no bending is needed, and re-softening the adhesive will suffice, the temperature can be lower, preferably to 230-260 degrees F. The cooling process begins until at the end of the line the temperature of the product is between about 90-100°F.

As described above, the various planks of the present invention can be connected together by a tongue and groove system with a mechanical locking profile, or using full spread adhesive to glue the planks together or using spline or snap connector. A separate spline or snap connector is a separate piece and is especially effective when a groove is present on two, opposite sides or edges of the plank. The snap or tongue piece can be inserted into one groove and is long enough to extend outside the groove and fit into a respective groove of another plank in order to connect the two pieces together. The tongue piece or spline connector can be a co-extruded material whose core is made of a rigid thermoplastic material such as polyvinyl chloride and whose outer co-extruded top and bottom shell is made of a soft thermoplastic material such as plasticized polyvinyl chloride or polyvinyl chloride/rubber blends. The hard inner core allows some rigidity for positioning and installation ease. The soft outer shell on top and bottom surface allow compressibility for easy fit into the plank groove. In addition, due to topographical features such as teeth on the spline, an improved grab onto the teeth of the plank groove can be obtained. In another example, the tongue piece or snap connector can be a co-extruded material that is made of at least one polymeric material and at least one natural fiber.

In the present invention, while each of the planks can be affixed to the subfloor or substrate, it is preferred that the planks be attached only to each other through a connector system such that there is a floating floor system. This promotes fast and easy laying of the floor system.

With the planks of the present invention, the present invention achieves many benefits and advantages such as low cost, moisture resistance and mechanical properties such as impact strength, resistance to indentation and gouges, and beneficial acoustical properties. Further, the laminate plank system of the present invention can be used in any environment, dry, wet, indoor, or outdoor, since it is not susceptible to moisture. In an embodiment of the present invention, the planks are less sensitive to the combined effects of temperature and humidity than is the standard laminate product. As a result, the need for T-moldings to act as expansion and contraction areas of the floor can generally be eliminated. These T-moldings are not only unsightly, but can act as tripping hazards. By the elimination of T-moldings/expansion joints in the walkway, the present invention allows the use of the floor in commercial applications. In an embodiment, the present invention expanded only one fifth as much as a standard laminate product under identical conditions. These conditions take the product from ambient room conditions to conditions of 90% relative humidity and
90° F. Standard expansion joints for laminates are typically placed every 30 feet. Thus, a hallway of 150 feet would be feasible without an expansion joint with the present invention.

[0094] In the preferred embodiment of the present invention, the installation method utilizes the unique design of the product to eliminate the need for glue used in tongue and groove connections.

[0095] Furthermore, the installer has options for installing the plank product. In one method, a floating floor installation method can be utilized with a floating floor, applying glue to a tongue and groove joining system can be used. Such glues as waterborne polyvinyl acetate, two part epoxy or urethane systems or one part moisture cure polyurethane adhesive can be used. In this method, no adhesive is applied to bond the product to the subfloor surface. The benefits of this method have been described earlier.

[0096] In a second method, a full-spread adhesive is applied between the underside of the product and the subfloor surface. This provides the advantages of added dimensional stabilization and sound deadening. Both of these properties would be beneficial in commercial applications. Glues that can be used include reactive type systems such as moisture cure urethanes or two part epoxies or urethanes.

[0097] In a third method, a click mechanical locking system can also be possible.

[0098] In a fourth method, the combination of a mechanical lock system with adhesive together can be an option as well.

[0099] In addition, the excellent moisture resistance and sound deadening qualities of this product can eliminate the need for underpaddings, though use of underpaddings is an option.

[0100] A further embodiment of the present invention relates to a plank which comprises the same plank described above but, in lieu of a top layer on top of the plank, a design is printed directly on the top surface of the plank using any number of printing techniques such as gravure printing, transfer printing, digital printing, flexo printing, and the like. Or, a printed thermoplastic film (e.g., PVC) or a wood veneer and the like can be laminated to a thermoplastic plank. Protective coating can then be placed on top of the printed design. Any type of protective coating or wear layer can be used, such as a polyurethane type coating with or without wear resistant particles in the coating. Thus, a plank would have a core, where the core has a top surface and bottom surface as well as opposing sides and a printed design directly on the top surface of the plank and optionally at least one protective coating on top of the printed design. The top surface of the plank as described earlier can have a textured surface as described above.

[0101] This type of plank can be made by extruding at least one polymeric material and at least one natural fiber into the shape of the core and then printing a design directly on the top surface of the plank and then, optionally, applying at least one protective coating on top of the printed design and curing the protective coating. The protective coating can be applied by conventional techniques, such as with a curtain coater, direct roll coater, vacuum coater, differential roll coater, air knife coater, or spray apparatus.

[0102] In another embodiment of the present invention, a plank for surface coverings, such as flooring, has a core and an extruded layer on the top surface of the core, wherein the extruded layer includes at least one thermoplastic material with one or more pigmented compounds. The extruded layer on top of the extruded core can simulate various designs such as wood grain and the like.

[0103] The plank in this embodiment can be made by co-extrusion techniques which involve extruding the core and extruding either simultaneously or subsequently a layer containing at least one thermoplastic material with one or more pigmented compounds on top of the extruded core.

[0104] Another embodiment involves a plank having the same design as described above with a printed polymeric film, such as a PVC film placed on the top surface of the extruded core. The printed polymeric film can be a polymeric film having a printed design on the film wherein the film would preferably be from about 10 to about 20 mil thick. One or more wear layers or protective coatings can be placed on top of the printed polymeric film. The polymeric film can be placed on top of the extruded core by typical lamination techniques, such as heating the printed film, then pressing the film to the extruded core to bond them together, or using glue to bond them together.

[0105] With reference to the Figures, the Figures show various aspects of several embodiments of the present invention. For instance, FIG. 1 represents a schematic diagram of a side view of one embodiment of the plank. The particular Figure is with the perspective view of looking at the front edge of the plastic wood composite plank wherein the groove (76) would run along each edge of the plank. The spline or tongue (64) is inserted along the length of each groove (76). Indicia (72) points to the edges of the spline having the groove whereas the indicia (68) points to the lower or bottom surface of the spline and the indicia (70) points to the top surface of the surface that typically, but optionally, receives the print layer and the like. As illustrated, the feet or strips (62) of post-extruded material extend along the bottom surface of the core from the front edge to the back edge. As can be seen in FIG. 1, typically these post extruded lines of material act as a support mechanism and typically run parallel in the same parallel direction as the cavities (60). Preferably, and as shown in the exemplary embodiments in FIG. 1, the side of the plank which has a groove is typically tapered or beveled and is shown by indicia (78).

[0106] FIG. 2 is an exemplary representation of one type of spline or tongue (64) that can be used in one embodiment of the present invention. As can be seen in FIG. 2, the preferably soft material (82), such as plasticized PVC, is located on the top and bottom surface of the spline or tongue in order to ensure a tighter fit with the groove of the plank. The spline can be made of the same material as the core such as PVC, or the spline can be made of a different material. The spline design, preferably, includes a thickness of from about 3 mls to 5 mls thicker than the groove of the plank (for a solid spline design). The spline will have a thickness of from about 24 mls to 42 mls thicker than the groove in the plank for the double tooth (top and bottom) design. If the spline is too thick, it can open the groove and cause edge peaking. If the spline is too thin, it does not effectively engage the groups with the teeth in the groove. The edges of
the spline or tongue (64) are tapered or beveled (80) in order to ensure that the tongue can be inserted into the groove.

[0107] FIG. 3 makes a reference to a spline (64) which includes teeth (90) on the surfaces which engage the groove (76) of the plank. Further, as can be seen in FIG. 3, the top surfaces of the plank form a V shape valley (88) and the edge of the plank touches each other whereas the bottom portions of each respective plank are cut in order to have a slightly shorter length in order to form a gap (86) which ensures that the top ends (88) touch each other and do not leave any gaps on the walking surface of the planks. The top layer(s) (84) can be a print layer and the like.

[0108] Referring to FIG. 4, FIG. 4 is a depiction of a tongue (76) which has receiving teeth (92) for a spline or tongue of the design shown in FIG. 3 (90). FIG. 4 further shows the post extruded lines on the bottom surface of the extrusion plank (62) as well as the various angles and cuts of the cavity (60) as well as the receiving groove (76). Further, the beveled or tapered edge (78) is shown in FIG. 4.

[0109] Referring to FIG. 5, a flat spline without co-extrusion top and bottom surface can be inserted into groove and bonded with waterborne adhesive such as polyvinyl acetate as the glue.

[0110] Furthermore, a regular tongue and groove configuration used on most of the engineered wood flooring or solid wood flooring, or click joint systems that are widely used as a connection system for laminate flooring can also be possible to join the planks together with or without a waterborne adhesive.

[0111] Furthermore, it is also possible to weld the joint together by an ultrasonic welding machine in a tongue and groove configuration.

[0112] The planks of the present invention can be used in a variety of applications including, but not limited to, wall panels, ceiling panels, flooring surfaces, decks, patios, furniture surfaces, shelving, and other surface coverings or parts thereof.

[0113] The present invention will be further clarified by the following examples, which are intended to be purely exemplary of the present invention.

EXAMPLES

Example 1

Laminated Overlay (T-11) on Wood Composite Base with a Hot Melt Polyurethane Adhesive.

[0114] The laminated overlay layer utilized included a top layer that was 0.004 inches thick and was composed of a cross-linked melamine-impregnated paper containing aluminum oxide. The top layer was designed to be clear and to protect the decorative print layer below it. The second layer, which was located under the top layer, was a gravure-printed paper for decorative purposes. The third layer (bottom layer), which was located under the second layer, was composed of cross-linked phenolic impregnated Kraft paper. The purpose for the bottom layer was to provide support and stability for the top two layers during processing.

[0115] The three layers that made the laminated overlay were consolidated under heat and pressure in a continuous consolidation procedure performed on a Grecon unit.

Section A

[0116] The core of the plank was extruded wood fiber composite having the following formulation:

<table>
<thead>
<tr>
<th>Component</th>
<th>% by wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maple Wood Fibers</td>
<td>55%</td>
</tr>
<tr>
<td>Exxon Mobile Polyethylene LB 0100-00</td>
<td>40%</td>
</tr>
<tr>
<td>Polyester lubricant (Struktol TPW 104)</td>
<td>5%</td>
</tr>
</tbody>
</table>

[0117] A small amount (less than or equal to 1%) of color concentrate was included to tint the base extrusion. The mesh size distribution of the maple wood fibers was as follows:

<table>
<thead>
<tr>
<th>Mesh Size</th>
<th>Particle Size (inch)</th>
<th>% by wt. Retained on Mesh</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>0.023</td>
<td>30</td>
</tr>
<tr>
<td>40</td>
<td>0.016</td>
<td>30</td>
</tr>
<tr>
<td>60</td>
<td>0.0098</td>
<td>30</td>
</tr>
<tr>
<td>&lt;60 fines</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

[0118] The extrusion was performed using an American Maplan (division of Battenfeld International) TS-110 counter-rotating twin screw extruder. The zone temperatures as well as the monitored temperature and pressure readings were recorded and are listed below in Table I.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone Temperatures</td>
<td></td>
</tr>
<tr>
<td>Zone 1</td>
<td>399.7°F</td>
</tr>
<tr>
<td>Zone 2</td>
<td>384.7°F</td>
</tr>
<tr>
<td>Zone 3</td>
<td>350.0°F</td>
</tr>
<tr>
<td>Zone 4</td>
<td>350.0°F</td>
</tr>
<tr>
<td>Zone 5</td>
<td>299.8°F</td>
</tr>
<tr>
<td>Melt Temperature (between Zone 5 and die)</td>
<td>380.4°F</td>
</tr>
<tr>
<td>Melt Pressure (between Zone 5 and die)</td>
<td>2176.5 psi</td>
</tr>
<tr>
<td>Main Motor rpm</td>
<td>944.5</td>
</tr>
<tr>
<td>Main Motor % load</td>
<td>54%</td>
</tr>
<tr>
<td>Screw Oil Temp</td>
<td>300°F</td>
</tr>
<tr>
<td>Screw Oil Core</td>
<td>326.4°F</td>
</tr>
</tbody>
</table>

[0119] The extruder included a five-inch wide rectangular shaped profile with a thickness of 0.345±0.003 inches.

Section B

[0120] The laminate overlay was adhered to the core by a hot melt cross-linked polyurethane adhesive. In particular, the adhesive was Forbo (Reichhold) 2U-316. This adhesive was heated to 250°F and applied to the phenolic back of the three-layered laminate which was slightly preheated to 135°F.

[0121] The laminate was then joined to the core. This was then briefly heated to 250-270°F for re-softening the adhesive. Immediately after the softening heat was applied,
a roller pressed the laminate firmly onto the core. The product was then cooled with water to below 90°F.

[0122] In the rectangular construction with a flat top, high heat and heat of excess 310°F was not used because the laminate overlay was not shaped to include a beveled edge, for example. The application of higher heat to the edge may be useful if the laminate overlay needs to be softened and shaped around a bend or bend portion of the profile.

[0123] When heat is applied to the top of the product or the top layer of the product (top heat), a sufficient amount of heat is also, preferably, applied to the bottom of the product (back heat) to bring the product into a thermally balanced state. The amount of back heat applied, generally, depends on the moisture content of the T-11 three-layered laminate, the product stiffness, and the weight of the base plank. The preferred moisture contents of overlay as measured by weight loss for 24 hours at 162°F is 3%-4%. If the T-11 laminate overlay contains 3.5 wt % moisture, a plank should be set with a positive dome of 250-300 mls over six feet for being able to remain its flatness in variable environments.

Example 2

Wood Veneer Overlay on Wood Composite Base

[0124] The core was prepared as described above in Example 1, Section A, using the TS-110 extruder from American Maplan Company. However, the decorative element adhered to the top of the core was an actual wood veneer. The wood veneer included polyester back with a thin (0.006 inches thickness) red oak veneer adhered to the top of the polyester. The polyester was used to hold the thin veneer to be processed as a continuous coil when it was wrapped onto the extruded wood composite base. The veneer overlay was adhered to the wood composite base with a hot melt polyurethane adhesive Forbo (Reichhold) 20-316.

[0125] The temperature and other conditions at which the veneer was wrapped and the method of laminating the veneer to the wood composite were the same as the conditions and method described in Example 1, Section B, with the exception that cooling water was not in contact with the face of the wood veneer.

[0126] To protect the red oak veneer from wear and tear, various fillers, sealers, and a polyurethane liquid layer, all of which were properly cured, were applied to the red oak veneer on the process line.

[0127] The steps and materials used in this processing were as follows:

<table>
<thead>
<tr>
<th>Process Step</th>
<th>Materials</th>
<th>Quantity Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stain</td>
<td>UV Curable Auburn Tint</td>
<td>0.21 g/36 in²</td>
</tr>
<tr>
<td>Denib</td>
<td>Filler</td>
<td>0.50 g/36 in²</td>
</tr>
<tr>
<td>Filler-1</td>
<td>Filler</td>
<td>0.20 g/36 in²</td>
</tr>
<tr>
<td>Denib</td>
<td>Standard Sealer</td>
<td>0.45 g/36 in²</td>
</tr>
<tr>
<td>Sealer (standard)-1</td>
<td>Filler with Alum Oxide</td>
<td>0.40 g/36 in²</td>
</tr>
</tbody>
</table>

[0128] The stain used to tint the red oak veneer was the auburn tint stain. All the process steps described above were in a continuous line. The line gradually increased speed to eliminate any back-up and congestion problems. All of the application heads in the process were roll applicators. After the UV curable stain weight was applied and cured, the plank traveled under denibbing rolls, wherein the raised grains in the staining process were removed.

[0129] Next, a clear UV curable filler was applied and cured. The plank was again denibbed, followed by a second filler application weight and denibbing.

[0130] A clear UV curable sealer weight and a curing agent were applied to the plaque with an application head. This was followed by applying a UV curable aluminum oxide sealer and curing the sealer. The plank was then denibbed and a standard UV curable sealer weight was applied and cured. Finally, two wet applications of the 50 gloss Valspar UV curable coating were applied, weighted, and cured.

Example 3

Vulcanized Cellulose on Wood Composite Base

[0131] The core was prepared as described above in Example 1, Section A, using the TS-110 extruder from American Maplan Company. However, the decorative element adhered to the top of the plank was a vulcanized cellulose layer with a printed wood grain design. The vulcanized cellulose layer was supplied by NVF Company and is known as Yorkite Vulcanized Fiber (YVF). The vulcanized cellulose layer was prepared by soaking cellulose fibers in CaCl2. The fibers were then compacted and heated to form a cross-linked cellulose layer. The vulcanized cellulose layer used in this example was 0.020 inches thick.

[0132] The YVF overlay was adhered to the wood composite base with a hot melt polyurethane adhesive, such as Forbo/Swift 20-316. The temperature and other conditions at which the YVF was wrapped and the method of laminating of the YVF to the wood composite base were the same as the conditions and method described in Example 1, with the exception that cooling water was not in contact with the face of the wood veneer. The YVF was also protected from wear by a coating. To protect the YVF, a UV curable coating or a melamine-impregnated overlay was applied to the YVF before YVF was laminated to the wood composite base.

Example 4

[0133] A pelletized blend of HDPE, pine wood fibers, and coupling agents was added with a lubricant at the extruder such that the final formulation was:
<table>
<thead>
<tr>
<th>(wt %)</th>
<th>Wood Fiber</th>
<th>70%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HDPE</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Coupling Agent</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Lubricant</td>
<td>6</td>
</tr>
</tbody>
</table>

[0134] This was extruded on an American Maplan TS 110 twin screw extruder into a rectangular plank 5 inches wide and 0.340 inches thick. Zone temperatures were set at 320 F-330 F, die set at 410-420 F, Melt temp=350-355 F.

[0135] The plank was tested for percent thickness swell when submersed in water for 24 hours yielding a value of 2.8+/−0.5%. The plank had a static load indent of 0.0005+/−0.0001 inch. The static load indentation test was run by placing 1160 psi pressure on the product for 24 hours, removing the pressure, allowing rebound for 24 hours and then measuring indent.

Example 5

[0136] A blend of purchased maple wood fibers 30-60 mesh size was mixed with HDPE and agglomerated into pellets on a Pallmann Palltruder®. The weight ratio of wood fibers to HDPE was 1.4:1. These pellets were extruded with lubricant added at the extruder. The extruder used was an American Maplan TS 110 twin screw extruder and the pellets were extruded into planks of dimensions described in Example 4. The extruder temperatures were similar to those in Example 4.

[0137] The final extruded formulation was

<table>
<thead>
<tr>
<th>(wt %)</th>
<th>Wood fiber</th>
<th>54%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exxon Mobil EA 55-003 (HDPE)</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Lubricant</td>
<td>4</td>
</tr>
</tbody>
</table>

[0142] The plank was tested for water swell and static load indentation as described in Example 4. The values measured were: 24 hour water thickness swell was 3.1+/−0.4%. Static load 1160 psi was 0.0012+/−0.0006 inch.

Example 7

[0143] A blend of purchased maple wood fibers 30-60 mesh size was extruded directly with HDPE and lubricant on an American Maplan TS 110 twin screw extruder into planks of dimensions described in Example 4. The extruder temperatures were similar to those in Example 4.

[0144] The final extruded formulation was

<table>
<thead>
<tr>
<th>(wt %)</th>
<th>Wood fiber</th>
<th>54%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exxon Mobil EA 55-003 (HDPE)</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Lubricant</td>
<td>4</td>
</tr>
</tbody>
</table>

[0145] The plank was tested for water swell and static load indentation as described in Example 4. The values measured were: 24 hour water thickness swell was 4.4+/−0.8%. Static load 1160 psi was 0.0010+/−0.0005 inch.

Example 8

[0146] Wood composite planks with Elesgo 350 gram overlay and T-11 Overlay were prepared by adhering the respective overlays to a wood composite planks comprised of 55 wt % maple wood fibers, 40 wt % HDPE resin and 5 wt % lubricant.

[0147] Bow—refers to vertical movement of plank ends in relation to the plank center down the length of the plank.

[0148] A position where the ends are above the center is called "horns up" or positive bow.

[0149] A position where the center is above the ends is called horns down or negative bow. This may also be referred to as dome.

[0150] Cup—refers to vertical movement across the plank. Where the sides are above the center in the z-direction, the cup is called positive cup. Where the center is above the sides is called negative cup.

[0151] The negative bow (dome) was induced by setting an infrared heater at 1000 degrees F. set point. Actual thermocouple temperature in the infrared oven was 815 degree F. The planks were run under the heater with the bottom side of the plank facing the heater. The speed of the sample under the oven and distance from the IR heater to the back of the plank were varied. The speed was varied.
between 5 and 9 feet per minute and distances were varied between 6 and 9 inches. Raytek temperature measurements were taken as the sample exited from the oven. Essentially, back heat temperatures in the 300-500° F. range can induce a negative bow (dome) of 1 to 1½ inch.

[0152] Applicants specifically incorporate the entire contents of all cited references in this disclosure. Further, when an amount, concentration, or other value or parameter is given as either a range, preferred range, or a list of upper preferable values and lower preferable values, this is to be understood as specifically disclosing all ranges formed from any pair of any upper range limit or preferred value and any lower range limit or preferred value, regardless of whether ranges are separately disclosed. Where a range of numerical values is recited herein, unless otherwise stated, the range is intended to include the endpoints thereof, and all integers and fractions within the range. It is not intended that the scope of the invention be limited to the specific values recited when defining a range.

[0153] Other embodiments of the present invention will be apparent to those skilled in the art from consideration of the specification and practice of the present invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with the true scope and spirit of the present invention being indicated by the following claims and equivalents thereof.

1. A plank comprising:
   a core comprising from about 30 wt % to about 95 wt % of at least one polymeric material, by weight of said core, and from about 5 wt % to about 80 wt % of at least one natural fiber or flour, by weight of said core, wherein said core has a top surface and a bottom surface, and opposing sides, wherein plank is substantially moisture resistant, having a swelling property of from 0.5% to about 5%, by NALFA Thickness Test Section 3.2 LF 01-2003 standard, and wherein plank includes a downward bow or dome of from about 0.5% to about 4%.
   2. The plank of claim 1, wherein said plank has a density of from about 60 lbs/ft³ to about 85 lbs/ft³.
   3. The plank of claim 1, wherein said plank has a glass transition temperature of about ~50° C. or higher.
   4. The plank of claim 3, wherein said glass transition temperature is from about ~45° C. to about 105° C.
   5. The plank of claim 1, wherein said core has a thickness of from about 5 mm to about 20 mm, a width of from about 2 cm to about 30 cm, and a length of from about 30 cm to about 130 cm.
   6. The plank of claim 1, wherein said core has a plurality of cavities.
   7. The plank of claim 1, wherein two sides of said core are tapered or have beveled edges, wherein said sides are opposite to each other.
   8. The plank of claim 1, wherein said polymeric material comprises a melt index of from about 0.4 to about 20 grams/10 minutes.
   9. The plank of claim 1, wherein said polymeric material includes a melt index of from about 0.8 to about 3 grams/10 minutes.
   10. The plank of claim 1, wherein said polymeric material comprises a polyolefin group.
   11. The plank of claim 10, wherein said polyolefin group comprises a polyethylene.
   12. The plank of claim 1, wherein said polymeric material comprises a polypropylene, a polyvinyl chloride, a copolymer of PVC, or a combination thereof.
   13. The plank of claim 1, wherein said polymeric material comprises at least one thermoplastic material, at least one plasticizer, and at least one coupling agent.
   14. The plank of claim 13, wherein said plasticizer is present in an amount of less than about 20% by weight of said core.
   15. The plank of claim 1, wherein said natural fiber or flour includes a particle size of from about 50 mil or less.
   16. The plank of claim 1, wherein said natural fiber or flour has a particle size of from about 30 mil or less.
   17. The plank of claim 1, wherein said natural fiber or flour includes from about 10 wt % to about 40 wt % of a fiber or flour having a size of from about 20 mil to about 30 mil; from about 10 wt % to about 30 wt % of a fiber or flour having a size of from about 15 mil to about 20 mil; from about 10 wt % to about 30 wt % of a fiber or flour having a size of from about 5 mil to about 15 mil, and from about 0 wt % to about 20 wt % of a fiber or flour having a size of about 5 mil or less.
   18. The plank of claim 1, wherein said natural fiber or flour comprises a moisture content of about 1 wt % or less.
   19. The plank of claim 1, wherein said natural fiber or flour comprises wood, a cellulose source other than wood, or a combination thereof.
   20. The plank of claim 1, wherein said plank has a swelling property of from 0.5% to about 3% by NALFA Thickness Test Section 3.2 LF 01-2003 standard.
   21. The plank of claim 1, wherein said plank comprises a bow of from about 0.5 inch to about 3.5 inches.
   22. The plank of claim 1 further comprising at least one lubricant.
   23. The plank of claim 22, wherein said lubricant is present in an amount of from about 1% to about 5% or more, by weight of said core.
   24. The plank of claim 22, wherein said lubricant comprises a polyester lubricant.
   25. The plank of claim 22, wherein said lubricant comprises a polyolefin wax, an amide wax, a montan wax ester, a metallic stearate, a calcium stearate, a zinc stearate, a metal salt of a long chain carboxylic acid, a paraffin, or any combination thereof.
   26. The plank of claim 1 further comprising at least one compatibilizer or coupling agent.
   27. The plank of claim 26, wherein said compatibilizer or coupling agent is present in an amount of from about 0.5 wt % to about 5 wt %, by weight of said core.
   28. The plank of claim 26, wherein said compatibilizer or coupling agent comprises a maleic anhydride.
   29. The plank of claim 1, further comprising a laminate, wood veneer, vulcanized cellulose layer, or a combination thereof on said top surface.
   30. The plank of claim 1, further comprising an underlay layer located and affixed between bottom surfaces of a top layer and said top surface of said core.
   31. The plank of claim 30, wherein said underlay comprises an aminoplast resin impregnated paper.
   32. The plank of claim 30, wherein said underlay comprises Kraft paper impregnated with an aminoplast resin.
33. The plank of claim 30, wherein an adhesive is present between said cores and said underlay layer in order to affix said underlay layer to said core.
34. The plank of claim 30, further comprising a printed design.
35. The plank of claim 30, further comprising a protective layer affixed to said top surface of said top layer.
36. The plank of claim 35, wherein said protective layer comprises an aminoplast resin impregnated overlay paper and aluminum oxide imbedded on the top surface of said paper.
37. The plank of claim 35, wherein said protective layer comprises an aminoplast resin impregnated overlay paper.
38. The plank of claim 30, wherein said plank includes a bow of from about 2.5 inches to about 3.2 inches.
39. The plank of claim 30, wherein said top layer comprises a decorative element.
40. The plank of claim 30, wherein said top layer is embossed with a design.
41. The plank of claim 1, wherein said bottom surface of said core is thermally treated.
42. The plank of claim 1, further comprising at least one design layer.
43. The plank of claim 42, wherein said design layer has the design of natural wood, stone, ceramic, brick, or tile.
44. The plank of claim 42, wherein said plank further comprises a layer that has texture or said top surface of core has a textured surface or both.
45. The plank of claim 44, wherein said design on said design layer and said texture are in register.
46. The plank of claim 44, wherein said texture simulates the texture present in natural wood, stone, ceramic, brick, or tile.
47. A floor comprising a plurality of the planks of claim 1 joined together.
48. The floor of claim 47, wherein the planks are joined together by a mechanical locking system.
49. The floor of claim 47, wherein the planks are joined together by a bonding agent.
50. The floor of claim 47, wherein the planks are joined together by a tongue and groove connection.
51. The floor of claim 47, wherein the planks are joined together by a groove and spline system.
52. The floor of claim 47, wherein said floor is a floating floor.

* * * * *