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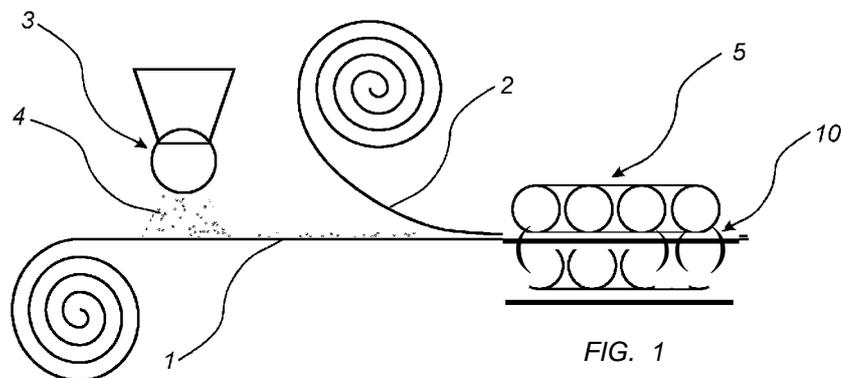


FIG. 1

(57) Abstract: The present invention relates to a method to produce a wear resistant foil, comprising providing a first foil comprising a first thermoplastic material, applying wear resistant particles on the first foil, applying a second foil comprising a second thermoplastic material on the first foil, and adhering the first foil and the second foil to each other to form a wear resistant foil.

METHOD TO PRODUCE A THERMOPLASTIC WEAR RESISTANT FOIL

Field of the invention

The present invention relates to a method to produce a thermoplastic wear resistant foil, a method to produce a building panel including such a thermoplastic wear resistant foil and a building panel.

5

Technical background

In recent years, so-called Luxury Vinyl Tiles and Planks (LVT) have gained increasing success. These types of floor panels usually comprise a thermoplastic core, a thermoplastic decor layer arranged on the core, a transparent wear layer on the decor layer, and a coating applied on the wear layer. The thermoplastic material is often PVC. The wear layer is conventionally a PVC foil, for example, having a thickness of 0.2-0.7 mm. The coating applied on the wear layer is conventionally a UV curing polyurethane coating. The wear layer together with the coating provides the wear resistance of the floor panel and protects the decor layer.

However, when subjecting floor panels to wear, it has been shown that the coating and the wear layer are relatively easily worn down, or at least worn such that the appearance of the wear layer is affected, such as having scratches and/or not being transparent any longer. Compared to a conventional laminate floor panel, the wear resistance of a LVT floor panel is inferior. However, LVT floors offer several advantages over, for example, laminate floors, such as deep embossing, dimensional stability related to humidity, moisture resistance and sound absorbing properties.

It is therefore desirable to provide a LVT product having improved wear resistance. It is also desirable to simplify the build up of LVT product.

It is known from US 2008/0063844 to apply a surface coating including aluminium oxide on a resilient floor covering. The coating is a wet coating.

WO 2013/079950 discloses an anti-skid floor covering comprising at least two transparent polymer layers, wherein particles of an aggregate material having an average particle size of between about 0.05 mm to about 0.8 mm are located between and/or within the two or more polymer layers. The particles improve the slip resistance of the floor covering.

30

Summary

It is an object of at least embodiments of the present invention to provide an improvement over the above described techniques and known art.

5 A further object of at least embodiments of the present invention is to improve the wear resistance of LVT floorings.

A further object of at least embodiments of the present invention is to simplify the build up of LVT floorings.

10 At least some of these and other objects and advantages that will be apparent from the description have been achieved by a method to produce a wear resistant foil according to a first aspect. The method includes providing a first foil comprising a first thermoplastic material, applying a second foil comprising a second thermoplastic material on the first foil, applying wear resistant particles on the first foil and/or on the second foil prior to applying the second foil on the first foil, and adhering the first foil and to the second foil
15 with the wear resistant particles there between for forming a wear resistant foil.

The first and the second foil may comprise different thermoplastic material, or may comprise thermoplastic material of the same type.

The wear resistant particles may be applied on the first foil.

20 The first and the second foil may be adhered by pressing the first foil and the second foil together.

An advantage of at least embodiments of the present invention is that a wear resistant foil having improved wear resistance is provided. By including wear resistant particles in the wear resistant foil, the wear resistant particles
25 provide additional wear resistance to the thermoplastic materials of the first and the second foil. The wear resistance of the foil is improved compared to a conventional wear layer of LVT products.

Furthermore, conventional coatings, for example a UV curable polyurethane (PU) coating conventionally applied on the wear layer, may be
30 replaced by using the wear resistant foil according to the invention instead. A conventional coating step may be replaced by arranging a single foil. Thereby, the production process is simplified and the number of steps in the production process is reduced by arranging a wear resistant foil having improved wear resistant properties instead of several layers or coatings.

35 By using different thermoplastic material in the first and the second foil, it is possible to benefit from different thermoplastic material having different properties. The desired properties of the material of the first foil may differ

from the desired properties of the second foil. For the second foil, properties such as stain resistance and scratch resistance are important, and the material of the second foil can be chosen to match these criteria. Usually, suitable thermoplastic material for the second foil may be more expensive compared to thermoplastic material used as, for example, in printed film or as core material. By only using such thermoplastic material in the second foil, the cost of the wear resistant foil can be controlled. Further, the second foil can have a layer thickness being less than a layer thickness of the first foil. By choosing different thermoplastic materials for the first and second foil, the thermoplastic materials can be used in an efficient and cost effective manner. By adjusting the layer thickness of the first and second foil, the materials can be used in an even more efficient manner.

The object of the wear resistant particles is to provide wear resistance of the foil when being worn, not to provide slip resistance.

The wear resistant foil is preferably transparent, or at least substantially transparent, for example, having a light transmittance index exceeding 80%, preferably exceeding 90%. Thereby, any decorative layer or decorative print is visible through the wear resistant foil. Preferably, the wear resistant foil does not influence of the impression of any decorative layer or decorative print arranged beneath the wear resistant foil. The wear resistant foil is preferably non-pigmented.

The wear resistant particles may be enclosed, preferably completely enclosed, by the first and the second foil after being adhered to each other. The wear resistant particles may be encapsulated by the second foil. Preferably, the wear resistant particles do not protrude from a surface of the second foil being opposite the first foil. If the wear resistant particles protrude beyond the surface of the second foil, the wear resistance foil will cause wear on items placed on the wear resistance foil. For example, when the wear resistant foil is used a top surface of a flooring, protruding wear resistant particles will cause wear on socks, shoes, etc. Further, protruding wear resistant particles would cause a rough and/or harsh surface of the wear resistant foil, as provided by a slip resistant surface. The aim of the wear resistant particles enclosed by the foils is to provide wear resistance when the second foil is worn, not to provide slip resistance.

The first thermoplastic material may be or comprise polyvinyl chloride (PVC).

The second thermoplastic material may be or comprise polyurethane (PU). By arranging a second foil comprising polyurethane, no additional polyurethane containing coating has to be provided on top of the wear resistant foil. Thereby, the layered structure of a LVT product may be simplified. Furthermore, compared to for example a conventional wear layer substantially consisting of PVC, a wear resistant foil comprising an upper portion of polyurethane (PU) obtains improved chemical resistance. Its scuff resistance and micro scratch resistance are also improved. An upper layer of polyurethane (PU) also provides improved resistance against black heel marks. An additional advantage is that curable polyurethane, such as UV curable polyurethane, shrinks when curing. By pressing a thermoplastic polyurethane (PU) material, no, or at least reduced, such shrinking occurs.

The first foil may substantially consist of the thermoplastic material, preferably polyvinyl chloride, and optionally additives. Additives may be plasticizers, stabilizers, lubricants, degassing agents, coupling agents, compatibilizers, crosslinking agents, etc.

The first foil may be a decorative foil. The first foil may be printed, for example by digital printing, direct printing, rotogravure printing, etc.

The second foil may substantially consist of the thermoplastic material, preferably polyurethane, and optionally additives. Additives may be plasticizers, stabilizers, lubricants, degassing agents, coupling agents, compatibilizers, crosslinking agents, etc.

In one embodiment, the first thermoplastic material may be or comprise polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof.

In one embodiment, the second thermoplastic material may be or comprise polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof.

The wear resistant particles may preferably comprise aluminium oxide. The wear resistant particles may comprise aluminium oxide such as corundum, carborundum, quartz, silica, glass, glass beads, glass spheres, silicon carbide, diamond particles, hard plastics, reinforced polymers and organics, or a combination thereof.

The wear resistant particles may have an average particle size of less than 45 μm .

The wear resistant particles may have a refractive index similar to the refractive index of the second foil. The wear resistant particles may have a refractive index of 1.4-1.7. In one embodiment, the wear resistant particle may have a refractive index of 1.4-1.9, preferably 1.5-1.8, for example, 1.7-1.8. The refractive index of the wear resistant particles may not differ from the refractive index of the second foil more than $\pm 20\%$.

A thickness of the second foil may be less than 75 μm , for example, such as about 50 μm , after the wear resistant foil has been formed, such as after pressing.

The wear resistant particles may have an average particle size being less than the thickness of the second foil. The wear resistant particles may have an average particle size being larger than the thickness of the second foil. However, during pressing, the wear resistant particles are pressed into the first foil such that the wear resistant particles do not protrude beyond an upper surface of the second foil after pressing, although the wear resistant particles having an average particle size exceeding the thickness of the second foil.

The ratio between the size of the wear resistant particles and the thickness of the second foil may be less than 1.5:1.

The thickness of the second foil may be less than the thickness of the first foil.

The method may further comprise applying scratch resistant particles on the second foil and/or the first foil. The scratch resistant particles may be or comprise nano-sized silica particles, preferably fused silica particles. The scratch resistant particles may be or comprise aluminium oxide.

Pressing the first and second foils together may comprise calendering the first and the second foil together.

The second foil may be formed by an extrusion process such as extrusion coating or extrusion lamination, preferably in connection with forming the wear resistant foil. The first foil may be formed by an extrusion process such as extrusion coating or extrusion coating.

According to a second aspect, a method of forming a building panel is provided. The method comprises applying a wear resistant foil produced according to the first aspect on a core, and adhering the wear resistant foil to the core for forming a building panel.

The wear resistant foil may be adhered to the core by pressing the wear resistant foil and the core together.

The core may be provided with a decorative layer. The core may be provided with a print on a surface of the core. The wear resistant foil is
5 arranged on the decorative layer, or on the print.

The core may comprise a third thermoplastic material. The core may be a thermoplastic core, a WPC (Wood Plastic Composite), etc. The third thermoplastic material may be or comprise polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS),
10 polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polyvinyl butyral, or a combination thereof. The core may be provided with several layers. The core may be foamed.

According to a third aspect, a method to produce a building panel is provided. The method includes providing a core, applying a first foil
15 comprising a first thermoplastic material on the core, applying a second foil comprising a second thermoplastic material on the first foil, applying wear resistant particles on the first foil and/or on the second foil prior to applying the second foil on the first foil, and adhering the core, the first foil, and the second foil to each other to form a building panel.

20 The first and the second foil may comprise different thermoplastic material, or may comprise thermoplastic material of the same type.

In one embodiment, the wear resistant foil is produced in connection with when forming the building panel. The first and second foil may be laminated together when laminating any other layer, for example a decorative
25 layer, a balancing layer, etc., to the core.

The wear resistant particles may be applied on the first foil.

The core, the first foil and the second foil may be adhered to each other by pressing the core, the first foil and the second foil together to form the building panel.

30 An advantage of at least embodiments of the present invention is that a wear resistant foil having improved wear resistance is provided. By including wear resistant particles in the wear resistant foil, the wear resistant particles provide additional wear resistance to the thermoplastic materials of the first and the second foil. The wear resistance of the foil is improved compared to a
35 conventional wear layer of LVT products.

Furthermore, conventional coatings, for example a UV curable polyurethane (PU) coating conventionally applied on the wear layer, may be

replaced by using the wear resistant foil according to the invention instead. A conventional coating step may be replaced by arranging a single foil.

Thereby, the production process is simplified and the number of steps in the production process is reduced by arranging a wear resistant foil having
5 improved wear resistant properties instead of several layers or coatings.

By using different thermoplastic material in the first and the second foil, it is possible to benefit from different thermoplastic material having different properties. The desired properties of the material of the first foil may differ from the desired properties of the second foil. For the second foil, properties
10 such as stain resistance and scratch resistance are important, and the material of the second foil can be chosen to match these criteria. Usually, suitable thermoplastic material for the second foil may be more expensive compared to thermoplastic material used as, for example, in printed film or as core material. By only using such thermoplastic material in the second foil, the
15 cost of the wear resistant foil can be controlled. Further, the second foil can have a layer thickness being less a layer thickness of the first foil. By choosing different thermoplastic materials for the first and second foil, the thermoplastic materials can be used in an efficient and cost effective manner. By adjusting the layer thickness of the first and second foil, the materials can
20 be used in an even more efficient manner.

The object of the wear resistant particles is to provide wear resistance of the foil when being worn, not to provide slip resistance.

The wear resistant foil is preferably transparent, or at least substantially transparent, for example, having a light transmittance index
25 exceeding 80%, preferably exceeding 90%. Thereby, any decorative layer or decorative print is visible through the wear resistant foil. Preferably, the wear resistant foil does not influence of the impression of any decorative layer or decorative print arranged beneath the wear resistant foil. The wear resistant foil is preferably non-pigmented.

The wear resistant particles may be enclosed, preferably completely enclosed, by the first and the second foil after being adhered to each other. The wear resistant particles may be encapsulated by the second foil. Preferably, the wear resistant particles do not protrude from a surface of the second foil being opposite the first foil. If the wear resistant particles protrude
35 beyond the surface of the second foil, the wear resistance foil will cause wear on items placed on the wear resistance foil. For example, when the wear resistant foil is used a top surface of a flooring, protruding wear resistant

particles will cause wear on socks, shoes, etc. Further, protruding wear resistant particles would cause a rough and/or harsh surface of the wear resistant foil, as provided by a slip resistant surface. The aim of the wear resistant particles enclosed by the foils is to provide wear resistance when the second foil is worn, not to provide slip resistance.

The first thermoplastic material may be or comprise polyvinyl chloride (PVC).

The second thermoplastic material may be or comprise polyurethane (PU). By arranging a second foil comprising polyurethane, no additional polyurethane containing coating has to be provided on top of the wear resistant foil. Thereby, the layered structure of a LVT product may be simplified. Furthermore, compared to for example a conventional wear layer substantially consisting of PVC, a wear resistant foil comprising an upper portion of polyurethane (PU) obtains improved chemical resistance. Its scuff resistance and micro scratch resistance are also improved. An upper layer of polyurethane (PU) also provides improved resistance against black heel marks. An additional advantage is that curable polyurethane, such as UV curable polyurethane, shrinks when curing. By pressing a thermoplastic polyurethane (PU) material, no, or at least reduced, such shrinking occurs.

The first foil may substantially consist of the thermoplastic material, preferably polyvinyl chloride, and optionally additives. Additives may be plasticizers, stabilizers, lubricants, degassing agents, coupling agents, compatibilizers, crosslinking agents, etc.

The first foil may be a decorative foil. The first foil may be printed, for example by digital printing, direct printing, rotogravure printing, etc.

The second foil may substantially consist of the thermoplastic material, preferably polyurethane, and optionally additives. Additives may be plasticizers, stabilizers, lubricants, degassing agents, coupling agents, compatibilizers, crosslinking agents, etc.

In one embodiment, the first thermoplastic material may be or comprise polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof.

In one embodiment, the second thermoplastic material may be or comprise polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene

terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof.

The wear resistant particles may preferably comprise aluminium oxide. The wear resistant particles may comprise aluminium oxide such as
5 corundum, carborundum, quartz, silica, glass, glass beads, glass spheres, silicon carbide, diamond particles, hard plastics, reinforced polymers and organics, or a combination thereof.

The wear resistant particles may have an average particle size of less than 45 μm .

10 The wear resistant particles may have a refractive index similar to the refractive index of the second foil. The wear resistant particles may have a refractive index of 1.4-1.7. In one embodiment, the wear resistant particle may have a refractive index of 1.4-1.9, preferably 1.5-1.8, for example, 1.7-1.8. The refractive index of the wear resistant particles may not differ from the
15 refractive index of the second foil more than $\pm 20\%$.

A thickness of the second foil may be less than 75 μm , for example, such as about 50 μm , after the wear resistant foil has been formed, such as after pressing.

The wear resistant particles may have an average particle size being
20 less than the thickness of the second foil. The wear resistant particles may have an average particle size being larger than the thickness of the second foil. However, during pressing, the wear resistant particles are pressed into the first foil such that the wear resistant particles do not protrude beyond an upper surface of the second foil after pressing, although the wear resistant
25 particles having an average particle size exceeding the thickness of the second foil.

The ratio between the size of the wear resistant particles and the thickness of the second foil may be less than 1.5:1.

30 The thickness of the second foil may be less than the thickness of the first foil.

The method may further comprise applying scratch resistant particles on the second foil and/or the first foil. The scratch resistant particles may be or comprise nano-sized silica particles, preferably fused silica particles. The scratch resistant particles may be or comprise aluminium oxide.

35 Pressing the core, the first foil and the second foil together may comprise calendering the core, first and the second foil together.

The second foil may be formed by an extrusion process, such as extrusion coating or extrusion lamination, preferably in connection with forming the building panel. The first foil may be formed by an extrusion process, such as extrusion coating or extrusion coating. The core may be
5 extruded or pressed, such as calendered.

The building panel may be formed in a continuous process.

The core may comprise a third thermoplastic material. The core may be a thermoplastic core, a WPC (Wood Plastic Composite), etc. The third thermoplastic material may be or comprise polyvinyl chloride (PVC),
10 polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polyvinyl butyral, or a combination thereof. The core may be provided with several layers. The core may be foamed.

The core may be a wood-based board or a mineral board. The core
15 may, in embodiments, be HDF, MDF, particleboard, OSB, or Wood Plastic Composite (WPC).

A decorative layer may be arranged on the core. The decorative layer may be a thermoplastic layer. The decorative layer may be a wood powder layer comprising a thermosetting binder and lignocellulosic or cellulosic
20 particles. The decorative layer may be a thermoplastic layer applied as a powder, preferably comprising a print printed into the thermoplastic material in powder form. The decorative layer may be a wood veneer layer, a cork layer or a decorative paper.

In one embodiment, the first foil is arranged directly on the core. The
25 core may be provided with a print, and the first foil is arranged on the print. Alternatively, or as a complement, the first foil may be a decorative foil. The first foil may be printed, for example by digital printing, direct printing, rotogravure printing, etc. Preferably, the print is provided on a surface of the first foil facing the core.

30 The method may further comprise applying a coating on the second foil. The coating may comprise acrylate or methacrylate monomer or acrylate or methacrylate oligomer. The coating may be radiation curing, such as UV curing or electron beam curing.

According to a fourth aspect, a method to produce a building panel is
35 provided. The method comprises providing a core, applying a second foil comprising a second thermoplastic material on the core, applying wear resistant particles on the core and/or the second foil prior to the second foil is

applied on the core, and adhering the core and the second foil together to form a building panel.

Embodiments of the fourth aspect incorporate the advantages of the previous aspects, which previously have been discussed, whereby the
5 previous discussion is applicable also for the building panel.

The wear resistant particles may be applied on the core.

The core and the second foil may be adhered by pressing the core and the second foil together to form the building panel.

The wear resistant particles may be enclosed, preferably completely
10 enclosed, by the second foil and the core. The wear resistant particles may be encapsulated by the second foil.

The second thermoplastic material may be or comprise polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate,
15 methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof.

The wear resistant particles may be aluminium oxide.

The wear resistant may have an average particle size of less than 45
µm.

The wear resistant particles may have a refractive index similar to the refractive index of the second foil. The wear resistant particles may have a refractive index of 1.4-1.7. In one embodiment, the wear resistant particle may have a refractive index of 1.4-1.9, preferably 1.5-1.8, for example, 1.7-1.8. The refractive index of the wear resistant particles may not differ from the
25 refractive index of the second foil more than $\pm 20\%$.

The core may be a thermoplastic core, a Wood Plastic Composite (WPC), a wood-based board or a mineral board. The core may polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate,
30 methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof. The core may be foamed.

The core may be provided with a decorative layer. The decorative layer may be a printed thermoplastic film, a wood veneer layer, a cork layer, a paper layer. Alternatively, a print may be printed on an upper surface of the
35 core.

A thickness of the second foil may be less than 75 µm, for example, such as about 50 µm, after the building panel has been formed.

The second foil may be formed by an extrusion process, such as extrusion coating or extrusion lamination on the core.

By the method according to the fourth aspect, a building panel comprising a core, a wear resistant foil comprising wear resistant particles
5 arranged on the core and a second foil comprising a thermoplastic material arranged on the wear resistant particles and attached to the core.

Embodiment of the third aspect is applicable also for the fourth aspect.

According to a fifth aspect, a building panel is provided. The building panel comprises a core, a wear resistant foil arranged on a surface of the
10 core, wherein the wear resistant foil comprises a first foil comprising a first thermoplastic material and a second foil comprising a second thermoplastic material, and wherein wear resistant particles are arranged between the first and the second foil.

Embodiments of the fifth aspect incorporate the advantages of the first
15 aspect, which previously has been discussed, whereby the previous discussion is applicable also for the building panel.

The first and the second foil may comprise different thermoplastic material, or may comprise thermoplastic material of the same type.

The wear resistant particles may be enclosed, preferably completely
20 enclosed, by the first foil and the second foil. The wear resistant particles may be encapsulated by the second foil.

The first thermoplastic material may be or comprise polyvinyl chloride (PVC).

The second thermoplastic material may be or comprise polyurethane
25 (PU).

The first thermoplastic material may be or comprise polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or
30 a combination thereof.

The second thermoplastic material may be or comprise polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate polyvinyl butyral, polybutylene terephthalate, or
35 a combination thereof.

The building panel may further comprise a decorative layer arranged on the core, wherein the wear resistant foil is arranged on the decorative layer.

The core may comprise a third thermoplastic material.

5 The core may be a thermoplastic core, a WPC (Wood Plastic Composite), a wood-based board, a mineral board, etc.

The third thermoplastic material may be or comprise polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polyvinyl butyral, or a combination thereof. The core may be provided with several layers. The core may be foamed.

10 The core may be a wood-based board or a mineral board. The core may in embodiments be HDF, MDF, particleboard, OSB, Wood Plastic Composite (WPC). Any intermediate layer or layers may be arranged between the core and the decorative layer, or the wear resistant foil.

15 The wear resistant particles may preferably comprise aluminium oxide. The wear resistant may comprise aluminium oxide such as corundum, carborundum, quartz, silica, glass, glass beads, glass spheres, silicon carbide, diamond particles, hard plastics, reinforced polymers and organics, or combinations thereof.

20 The wear resistant particles may have an average particle size of less than 45 μm .

The wear resistant particles may have a refractive index similar to the refractive index of the second foil. The wear resistant particles may have a refractive index of 1.4-1.7. In one embodiment, the wear resistant particle may have a refractive index of 1.4-1.9, preferably 1.5-1.8, for example, 1.7-1.8. The refractive index of the wear resistant particles may not differ from the refractive index of the second foil more than $\pm 20\%$.

25 A thickness of the second foil may be less than 75 μm , for example, such as about 50 μm , after the building panel has been formed.

Brief description of the drawings

The present invention will by way of example be described in more detail with reference to the appended schematic drawings, which show 35 embodiments of the present invention.

Fig. 1 shows a method to produce a wear resistant foil.

Fig. 2 shows a building panel.

Fig. 3 shows a method to produce a building panel.

Fig. 4A-C show embodiments of a building panel.

Fig. 5A shows a method to produce a wear resistant foil.

Fig. 5B shows a method to produce a building panel.

5

Detailed description

A method to produce a wear resistant foil 10 according to an embodiment will now be described with reference to fig. 1. Fig. 1 shows a production line for producing a wear resistant foil 10. A first foil 1 is provided, preferably as a continuous web. The first foil 1 may also be cut into sheets. The first foil 1 may also be formed by an extrusion process in connection with forming the wear resistant foil 10.

The first foil 1 comprises a first thermoplastic material. The first thermoplastic material may be polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof.

Preferably, the first foil 1 is formed of the thermoplastic material. The first foil 1 may substantially consist of the thermoplastic material, and optionally additives. Additives may be plasticizers, stabilizers, lubricants, degassing agents, coupling agents, compatibilizers, crosslinking agents, etc.

In one embodiment, the first foil 1 is a PVC foil.

The first foil 1 may have a thickness of 0.1-1 mm.

In one embodiment, the first foil 1 is a decorative foil. The first foil 1 may be printed, for example by digital printing, direct printing, rotogravure, etc. The print is preferably facing away from a second foil when applied on the first foil 1.

As shown in fig. 1, an applying device 3 applies, preferably scatters, wear resistant particles 4 on the first foil 1. The wear resistant particles 4 may be aluminium oxide particles such as corundum. Alternatively, or as a complement, the wear resistant particles 4 may be carborundum, quartz, silica, glass, glass beads, glass spheres, silicon carbide, diamond particles, hard plastics, reinforced polymers and organics, or a combination thereof.

The wear resistant particles 4 preferably have an average particle size within the range of 10-200 μm , preferably within the range of 50-120 μm , such as 50-100 μm . The wear resistant particles 4 may have an average particle size of less than 50 μm , preferably less than 45 μm . The wear resistant

35

particles 4 may have a spherical shape or an irregular shape. The wear resistant particles 4 may be surface treated. The wear resistant particles 4 may be silane-treated particles.

5 The wear resistant particles 4 may have a refractive index similar to the refractive index of the second foil 2. The wear resistant particles may have a refractive index of 1.4-1.7. In one embodiment, the wear resistant particle may have a refractive index of 1.4-1.9, preferably 1.5-1.8, for example, 1.7-1.8. The refractive index of the wear resistant particles may not differ from the refractive index of the second foil more than $\pm 20\%$.

10 The wear resistant particles may be applied in an amount of 20-100 g/m², preferably in an amount of 40-60 g/m².

After the wear resistant particles 4 have been applied on the first foil 1, a second foil 2 is provided and arranged on the first foil 1. The wear resistant particles 4 are thereby encapsulated by the first foil 1 and the second foil 2.

15 As an alternative or complement to apply the wear resistant particles 4 on the first foil 1, the wear resistant particles 4 may be applied on the second foil 2. In this embodiment, the second foil 2 with the wear resistant particles 4 is arranged on the first foil 1, or vice versa.

20 The second foil 2 comprises a second thermoplastic material. The second thermoplastic material may be the same as in the first foil 1, or being different from the thermoplastic material of the first foil 1. The second thermoplastic may be polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl
25 butyral, polybutylene terephthalate, or a combination thereof.

Preferably, the second foil 2 is formed of the thermoplastic material. The second foil 2 may substantially consist of the thermoplastic material, and optionally additives. Additives may be plasticizers, stabilizers, lubricants, degassing agents, coupling agents, compatibilizers, crosslinking agents, etc.

30 In one embodiment, the first foil 1 is a PVC foil and the second foil 2 is PU foil.

The second foil 2 may be provided as a foil produced in a separate production step. The second foil 2 may be provided as continuous web.

35 In other embodiments, the second foil 2 may be formed by an extrusion process such as extrusion coating or extrusion lamination the second foil 2 on the first foil 1, such as described with reference to fig. 5A.

The second foil 2 may have a thickness of 0.01 - 1 mm, preferably as measured in the final product, for example, after pressing or extruding. Preferably, the second foil 2 has a thickness less than 0.5 mm, more preferably less than 75 μm , for example, such as about 50 μm , preferably as measured in the final product, for example, after pressing or extruding.

The first foil 1 may have a thickness exceeding the thickness of the second foil 2. Especially if the first foil 1 comprises PVC and the second foil 2 comprises PU, the first foil 1 may have a thickness exceeding the thickness of the second foil 2.

The wear resistant particles 4 may have an average particle size being less than the thickness of the second foil 2. However, the wear resistant particles 4 may have an average particle size being larger than the thickness of the second foil 2. During pressing, the wear resistant particles 4 are pressed into the first foil 1 such that the wear resistant particles 4 do not protrude beyond an upper surface of the second foil 2 after pressing, although the wear resistant particles 4 have an average particle size exceeding the thickness of the second foil 2.

The ratio between the size of the wear resistant particles 4 and the thickness of the second foil 2 may be less than 1.5:1 .

Scratch resistant particles (not shown) may also be applied on the second foil 2. As an alternative or complement, scratch resistant particles may also be applied on the first foil 1. By scratch resistant particles are meant particles improving the scratch or scratch resistant properties of the first and/or second foil 1, 2. The scratch resistant particles may be applied together with the wear resistant particles 4, for example as a mix, or may be applied separately. The scratch resistant particles may be may be or comprise nano-sized silica particles, preferably fused silica particles. The scratch resistant particles may be or comprise aluminium oxide.

The scratch resistant particles may be disc shaped particles, preferably having a width/thickness ratio being equal or exceeding 3:1 , more preferably being equal or exceeding 5:1 . Such disc-shaped particles orientate along the surface of the foil, thereby improving the scratch resistance of the foil. The scratch resistant particles may have an average particle size of 1-50 μm , preferably 10-20 μm .

The first and the second foil 1, 2 are thereafter adhered to each other to form a wear resistant foil 10 comprising the first foil 1, the second foil 2,

and wherein at least a part of the wear resistant particles 4 are arranged between the first foil 1 and the second foil 2.

The wear resistant foil 10 is preferably transparent, or at least substantially transparent.

5 The first and the second foil 1, 2 may be adhered to each other by being pressed together, for example, in a calendaring process. As shown in fig. 1, the first and the second foil 1, 2 are pressed in a continuous press 5. The first and second foil may be adhered together by pressure alone, by heat and pressure, by pressure and adhesive, or by heat, pressure, and adhesive. 10 Preferably, both pressure and heat is applied in order to adhere the first and the second foil to each other. As alternative or complements to a calendaring process, a continuous or static press may also be used. The pressing operation may, for example, be a hot-hot process, a hot-cold process, etc. The pressing may be made with an embossed press matrix or press roller, 15 such that an embossed structure is formed in the wear resistant foil.

Depending on the thermoplastic materials and process used, the pressure applied may be 5-1 00 bar, applied for example during 5-500 seconds. The temperature may be 80-300°C, such as 100-250°C, such as 150-200°C, such as 100-1 30°C.

20 By the process described above with reference to fig. 1, a wear resistant foil 10 is formed. The wear resistant foil 10 may be formed as a continuous foil, or be cut into sheets.

As an alternative, the first and second foil 1, 2 may be adhered to each other by an adhesive such as, hot melt.

25 After adhering, for example, by pressing, the layers to each other, the wear resistant particles 4 are enclosed by the first and the second foil 1, 2. Preferably, the wear resistant particles 4 are completely enclosed by the first and the second foils 1, 2. Preferably, the wear resistant particles 4 do not protrude beyond the surface of the second foil 2 facing away from the first foil 30 1. Thereby, a wear resistant foil 10 having a smooth surface can be formed.

It is contemplated that the wear resistant foil 10 may be adhered to a decorative layer 22 as described below in the same step such that a decorative wear resistant foil is formed.

35 The wear resistant foil 10 may in a subsequent step be adhered to a core 21 to form a building panel 20, as shown in fig. 2. The building panel 20 may be a floor panel, a wall panel, a ceiling panel, a furniture component, etc.

The core 21 may comprise a third thermoplastic material. The third thermoplastic material may be the same as the first and/or second thermoplastic material, or be different from the first and/or the second material.

5 The third thermoplastic material may comprise polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof. The core 21 may be formed of several layers. The
10 core 21 may be foamed.

 In one embodiment, the core 21 comprises the third thermoplastic material and fillers. The fillers may comprise calcium carbonate, such as chalk and/or limestone.

 In one embodiment, the core 21 is a Wood Plastic Composite (WPC),
15 comprising the third thermoplastic material and wood particles as fillers.

 The core 21 may be provided with a decorative layer 22 arranged on an upper surface of the core 21 as shown in fig. 2. The wear resistant foil 10 is then arranged on the decorative layer 22. The decorative layer 22 may be a decorative foil comprising a thermoplastic material. The thermoplastic
20 material of the decorative layer may be or comprise polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof. The decorative foil is preferably printed, for example
25 by direct printing, rotogravure, or digital printing.

 The core 21 may also be provided with a balancing layer (not shown) arranged on a lower surface of the core 21, opposite the decorative layer 22. The core 21 may also be provided with intermediate layer or layers (not shown) arranged between an upper surface of the core and the decorative 22
30 layer or the wear resistant foil 11.

 The wear resistant foil 10 produced according to the method described above with reference to fig. 1, is arranged on the decorative layer 22. The core 21, the decorative layer 22, and the wear resistant foil 10 are pressed together to form a building panel. Heat may also be applied when applying
35 pressure. The core 21, the decorative layer 22 and the wear resistant foil 10 may be pressed together in continuous press, a static press, or in a calendering operation. The pressing may be made with an embossed press

matrix or press roller, such that an embossed structure is formed in the wear resistant foil 10.

As an alternative, the wear resistant foil 10 may be adhered to the core 21 by an adhesive such as, hot melt.

5 A coating (not shown) may be applied on the second foil 2. The coating may comprise acrylate or methacrylate monomer or acrylate or methacrylate oligomer. The coating may be radiation curing, such as UV curing or electron beam curing.

10 As an alternative to a separate decorative layer 22, a print may be printed directly on the top surface of core 21. The wear resistant foil 10 is thereby arranged directly on the core.

In one embodiment, the first foil 1 is a decorative layer. The first foil 1 may be printed, for example by digital printing, direct printing, rotogravure, etc. The wear resistant foil 10 is in this embodiment arranged directly on the core of the above described type. The wear resistant foil 10 thereby includes a decorative layer. Preferably, the print is facing the core 21.

15 An embodiment of the building panel 10 comprises a core 21 comprising PVC, a decorative foil 22 comprising PVC, a wear resistant foil 10 comprising PVC in the first foil 1 and PU in the second foil 2.

20 In other embodiments, the core 21 may be a wood-based board or a mineral board. The core 21 may, for example, be a HDF, MDF, particleboard, plywood, OSB, etc.

As an alternative to the decorative foil, the decorative layer 22 may be formed of a thermoplastic material applied as a powder on the core 21. A print may be printed in the powder thermoplastic material. The thermoplastic material in powder form may be polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof. The wear resistant foil 10 is arranged on the powder layer and pressed together. The core 21 may be of the above described type.

25 Another alternative to the decorative foil is to apply a thermosetting binder, preferably an amino resin and in powder form, and lignocellulosic or cellulosic particles for forming the decorative layer 22 on the core. A print is may be printed in the powder layer, or pigments may be included. The core 35 21 may be of the above described type. The wear resistant foil 10 is arranged

on the powder layer and pressed together under heat, such that the thermosetting binder of the decorative layer is cured.

Another alternatives for forming the decorative layer are providing a wood veneer layer, a cork layer or a paper layer for forming the decorative
5 layer.

The different layers, i.e., the core 21, the decorative layer 22, the wear resistant foil 10, may be provided as continuous layers or provided as sheets.

Fig. 3 shows a method to produce a building panel 10 including forming a wear resistant foil 10 integrated into the production of the building
10 panel 10. The building panel 10 may be a floor panel, a wall panel, a ceiling panel, a furniture component, etc.

A core 21 is provided. The core 21 may comprise a third thermoplastic material. The third thermoplastic material may be the same as the first and/or second material, or be different from the first and/or the second material.

The third thermoplastic material may comprise polyvinyl chloride
15 (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polycarbonate, polyacrylate, methacrylate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof. The core 21 may be formed of several layers. The core
20 21 may be foamed. The core 21 may be provided as a board or as a continuous material.

In one embodiment, the core 21 comprises the third thermoplastic material and fillers. The fillers may comprise calcium carbonate, such as chalk and/or limestone, or sand.

In one embodiment, the core 21 is a Wood Plastic Composite (WPC),
25 comprising the third thermoplastic material and wood particles as fillers.

The core 21 may be provided with a decorative layer 22 arranged on an upper surface of the core 21. The wear resistant foil 10 is then arranged on the decorative layer 22. The decorative layer 22 may be a decorative foil
30 comprising a thermoplastic material. The thermoplastic material of the decorative layer may be or comprise polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof. The
35 decorative foil is preferably printed, for example by direct printing, rotogravure, or digital printing. The decorative layer may be a wood veneer

layer, a cork layer, a paper layer. The decorative layer 22 may be provided as a continuous web or as sheets.

The core 21 may also be provided with a balancing layer (not shown) arranged on a lower surface of the core 21, opposite the decorative layer 22.

5 A first foil 1 is arranged on the core 21, or on the decorative layer 22. The first foil 1 comprises a first thermoplastic material. The first thermoplastic material may be polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl
10 butyral, polybutylene terephthalate, or a combination thereof.

Preferably, the first foil 1 is formed of the thermoplastic material. The first foil 1 may substantially consist of the thermoplastic material, and optionally additives. Additives may be plasticizers, stabilizers, lubricants, degassing agents, coupling agents, compatibilizers, crosslinking agents, etc.

15 In one embodiment, the first foil 1 is a PVC foil.

The first foil 1 may have a thickness of 0.1-1 mm preferably as measured in the final product, for example, after pressing or extruding.

The first foil 1 may be provided as a continuous web. The first foil 1 may also be cut into sheets. The first foil 1 may also be formed by an
20 extrusion process, preferably in connection with forming the building panel.

As shown in fig. 3, an applying device 3 applies, preferably scatters, wear resistant particles 4 on the first foil 1. The wear resistant particles 4 may be aluminium oxide particles, such as corundum. Alternatively, or as a complement, the wear resistant particles 4 may be carborundum, quartz,
25 silica, glass, glass beads, glass spheres, silicon carbide, diamond particles, hard plastics, reinforced polymers and organics, or a combination thereof. The wear resistant particles 4 may be surface treated. The wear resistant particles 4 may be silane-treated particles.

The wear resistant particles 4 preferably have an average particle size
30 within the range of 10-200 μm , preferably within the range of 50-120 μm , such as 50-100 μm . The wear resistant particles 4 may have an average particle size of less than 50 μm , preferably less than 45 μm .

The wear resistant particles 4 may have a spherical shape or an irregular shape. The wear resistant particles 4 may have a refractive index
35 similar to the refractive index of the second foil 2. The wear resistant particles may have a refractive index of 1.4-1.7. In one embodiment, the wear resistant particle may have a refractive index of 1.4-1.9, preferably 1.5-1.8, for

example, 1.7-1.8. The refractive index of the wear resistant particles may not differ from the refractive index of the second foil more than $\pm 20\%$.

The wear resistant particles may be applied in an amount of 20-100 g/m², preferably in an amount of 40-60 g/m².

5 The wear resistant particles 4 may have an average particle size being less than the thickness of the second foil 2. However, the wear resistant particles 4 may have an average particle size being larger than the thickness of the second foil 2. During pressing, the wear resistant particles 4 are pressed into the first foil such that the wear resistant particles do not protrude
10 beyond an upper surface of the second foil 2 after pressing, although the wear resistant particles 4 having an average particle size exceeding the thickness of the second foil.

The ratio between the size of the wear resistant particles 4 and the thickness of the second foil 2 may be less than 1.5:1.

15 After the wear resistant particles 4 have been applied on the first foil 1, a second foil 2 is provided and arranged on the first foil 1. The wear resistant particles 4 are thereby encapsulated between the first foil 1 and the second foil 2.

20 As an alternative or complement to apply the wear resistant particles 4 on the first foil 1, the wear resistant particles 4 may be applied on the second foil 2. In this embodiment, the second foil 2 with the wear resistant particles 4 is arranged on the first foil 1, or vice versa.

25 The second foil 2 comprises a second thermoplastic material. The second thermoplastic material may be the same as in the first foil 1, or being different from the thermoplastic material of the first foil 1. The second thermoplastic may be polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof.

30 The second foil 2 may be provided as a foil produced in a separate production step. The second foil 2 may be provided as continuous web as shown in fig. 3.

35 In other embodiments, the second foil 2 may be formed by an extrusion process such as extrusion coating or extrusion lamination the second foil 2 on the first foil 1 as described with reference to fig. 5B.

The second foil 2 may have a thickness of 0.01 - 1 mm, preferably as measured in the final product, for example, after pressing or extruding.

Preferably, the second foil 2 has a thickness less than 0.5 mm, more preferably less than 75 μm , for example, such as about 50 μm , preferably, as measured in the final product, for example, after pressing or extruding.

Preferably, the second foil 2 is formed of the thermoplastic material.

- 5 The second foil 2 may substantially consist of the thermoplastic material, and optionally additives. Additives may be plasticizers, stabilizers, lubricants, degassing agents, coupling agents, compatibilizers, crosslinking agents, etc.

In one embodiment, the first foil 1 is a PVC foil and the second foil 2 is PU foil.

- 10 Scratch resistant particles (not shown) may be applied on the second foil 2. As an alternative or complement, scratch particles may also be applied on the first foil 1 prior to applying the second foil 2. By scratch resistant particles are meant particles improving the scratch or scratch resistant properties of the first and/or second foil. The scratch resistant particles may
15 be applied together with the wear resistant particles 4, for example as a mix, or may be applied separately. The scratch resistant particles may be may be or comprise nano-sized silica particles, preferably fused silica particles. The scratch resistant particles may be or comprise aluminium oxide.

- The scratch resistant particles may be disc shaped particles, preferably
20 having a width/thickness ratio being equal or exceeding 3:1, more preferably being equal or exceeding 5:1. Such disc-shaped particles orientate along the surface of the foil, thereby improving the scratch resistance of the foil. The scratch resistant particles may have an average particle size of 1-50 μm , preferably 10-20 μm .

- 25 The different layers, i.e. the core 21, the decorative layer 22, the wear resistant foil 10, may be provided as continuous layers or being cut into sheets.

- The core 21, the first foil 1 and the second foil 2 are thereafter adhered to each other to form a building panel 20 comprising the core 21, the first foil
30 1, the second foil 2, and wherein a least a portion of the wear resistant particles 4 are arranged between the first foil 1 and the second foil 2. The first foil 1, the second foil 2 and the wear resistant particles 4 arranged therebetween form a wear resistant foil 10 of the building panel 20.

- The wear resistant foil 10 is preferably transparent, or at least
35 substantially transparent, for example, having a light transmittance index exceeding 80%, preferably exceeding 90%.

The core 21, the first and the second foil 1, 2 may be adhered to each other by being pressed together in a pressing station 5. The press may be a continuous or static press. The core 21, the first and the second foil 1, 2 may be calendered together. Preferably, both pressure and heat is applied in order to adhere the first and the second foil to each other. The pressing operation may for example be made as a hot-hot process, a hot-cold process, etc. The pressing may be made with an embossed press matrix or press roller, such that an embossed structure is formed in the wear resistant foil 10.

Depending on the thermoplastic materials and process used, the pressure applied may be 5-100 bar, applied for example during 5-500 seconds. The temperature may be 80-300°C, such as 100-250°C, such as 150-200°C.

As alternative, the layers may be adhered to each other by an adhesive, such as hot melt.

After adhering, for example, by pressing, the layers to each other, the wear resistant particles are enclosed by the first foil, or by the first and the second foil. Preferably, the wear resistant particles 4 are completely enclosed. Preferably, the wear resistant particles do not protrude beyond the surface of the second foil facing away from the first foil. Thereby, a wear resistant foil 10 having a smooth surface can be formed.

A coating (not shown) may be applied on the second foil 2. The coating may comprise acrylate or methacrylate monomer or acrylate or methacrylate oligomer. The coating may be radiation curing, such as UV curing or electron beam curing.

As an alternative to a separate decorative layer 22, a print may be printed directly on the upper surface of core 21. The wear resistant foil 10 is thereby arranged directly on the core.

As an alternative to a separate decorative layer 22, the first foil 1 of the wear resistant foil 10 may be a decorative foil. The first foil 1 may be printed, for example by digital printing, direct printing, rotogravure, etc. The wear resistant foil 10 is thereby arranged directly on the core 21. Preferably, the print faces the core 21.

As an alternative to the decorative foil described above, the decorative layer 22 may be formed of a thermoplastic material applied as a powder on the core. A print may be printed in the powder thermoplastic material. The thermoplastic material in powder form may be polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS),

polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or combination thereof. The first foil 1 of the wear resistant foil 10 is arranged on the powder layer and pressed together as described above. The core 21 may
5 be of the above described type.

Another alternative to the decorative foil described above is to apply a thermosetting binder, preferably an amino resin and in powder form, and lignocellulosic or cellulosic particles for forming the decorative layer 22 on the core 21. A print is may be printed in the powder layer, or pigments may be
10 included. The core 21 may be of the above described type. The first foil 1 of the wear resistant foil 10 is arranged on the powder layer and the powder layer and the first foil 1 are pressed together under heat as described above, such that the thermosetting binder of the decorative layer is cured.

Another alternatives for forming the decorative layer 22 are providing a
15 wood veneer layer, a cork layer or a paper layer for forming the decorative layer.

It is also contemplated that the first foil 1 may be excluded. The wear resistant particles 4 of the above described type may be applied directly on the core 21 of the above described type. The second foil 2 of the above
20 described type may be arranged on an upper surface of the core 21 and on the wear resistant particles 4. The upper surface of the core 21 may be provided with a print. Alternatively, a decorative layer 22 of the above type may be arranged on the core 21. The core 21, the wear resistant particles 4, and the second foil 2 are then pressed together to form a building panel 20 in
25 the above described way.

It is contemplated that the core 21 may be excluded in the embodiments described with reference to fig. 3. By pressing together the decorative layer 22 and the wear resistant foil 10, a decorative substrate having wear resistant properties is provided.

30 In addition to the building panel 20 described above with reference to fig. 2, building panels 20 having another structure may also be provided by the methods described above.

According to one embodiment, which is shown in fig. 4A, building panel 10 comprising a core 21 of the above described type and a wear resistant foil
35 10 manufactured according to the embodiment described with reference to fig. 1. Alternatively, the building panel 10 is manufactured according to the embodiment described with reference to fig. 3 wherein the decorative layer 22

is excluded. An upper surface of the core 21 may be provided with a print 23, for example printed by for example by digital printing, direct printing or rotogravure. The wear resistant foil 10 is arranged directly on the core 21.

5 According to one embodiment, which is shown in fig. 4B, a building panel 10 comprising a core 21 of the above described type and a wear resistant foil 10 manufactured according to the embodiment described with reference to fig. 1. Alternatively, the building panel 10 is manufactured according to the embodiment described with reference to fig. 3, wherein the decorative layer 22 is excluded. The first foil 1 of the wear resistant foil 10
10 may be a decorative foil. The first foil 1 may be provided with a print 23, for example printed by digital printing, direct printing or rotogravure. The wear resistant foil 10 is arranged directly on the core 21.

It is contemplated that in one embodiment, the first foil 1 may be excluded in the embodiment described above with reference to fig. 3.
15 According to this embodiment, which is shown in fig.4C, the wear resistant particles 4 are applied directly on a core 21 of the above described type. An upper surface of the core 21 may be provided with a print 23, for example printed by digital printing, direct printing or rotogravure. Alternatively, the core 21 may be provided with a decorative layer 22 of the above described type,
20 for example a printed thermoplastic foil, a wood veneer layer, a cork layer, a paper layer, etc. A second foil 2 of the above described type is applied directly on the wear resistant particles 4 of the above described type and the upper surface of the core 21. A building panel including a wear resistant foil 10' formed by the wear resistant particles 4 and the second foil 2 is thereby
25 formed.

In all embodiments, the second thermoplastic material of the above type may be applied in an extrusion process, which is shown in figs. 5A-B. In fig. 5A, a first foil 1 is provided. The first foil 1 is of the type described above with reference to figs. 1, 2, 3, 4A-B. In the embodiment shown fig. 5A, the
30 wear resistant particles 4 of the above described type are applied on the first foil 1 by the applying device 3. The second thermoplastic material 5 is preferably provided as granulates. The second thermoplastic material 5 in molten form is applied on the first foil 1 comprising the first thermoplastic material by an extruder 8. For example, the second thermoplastic material 5
35 is applied on the first foil 1 by an extrusion process such as extrusion lamination or extrusion coating. The second thermoplastic material 5 is

applied after the wear resistant particles 4 have been applied. Thereby, a wear resistant foil 10 has been produced.

The method to produce a wear resistant foil 10 by using an extrusion technique as described above with reference to fig. 5A is also applicable
5 when forming a building panel corresponding to the embodiment shown in fig. 4A-B, which is shown in fig. 5B.

In fig. 5B, a first foil 1 and a core 21 are provided. The first foil 1 and the core 21 are of the type described above with reference to figs. 3 and 4A-B. In the embodiment shown fig. 5B, the wear resistant particles 4 of the
10 above described type are applied on the first foil 1 by an applying device 3. The second thermoplastic material 5 is preferably provided as granulates. The second thermoplastic material 5 in molten form is applied on the first foil 1 comprising the first thermoplastic material by an extruder 8. For example,
15 the second thermoplastic material 5 is applied on the first foil 1 by an extrusion process such as extrusion lamination or extrusion coating. The second thermoplastic material 5 is applied after the wear resistant particles 4 have been applied.

The core 21, the first foil 1 provided with the wear resistant particles 4 and the second thermoplastic material 5 are adhered together for forming a
20 building panel 20, for example, by pressing, such as calendaring, for example, by calendaring rolls, as shown in fig. 5B. Alternatively, the layers may be adhered to each other by means of an adhesive such as hot melt.

It is also contemplated that the co-extruding may be used to form the wear resistant foil. The first foil comprising the first thermoplastic material and
25 a second foil comprising the second thermoplastic material may be formed by co-extruding the first and the second foil. The wear resistant particles may be mixed with the second thermoplastic material, or applied separately on the first and/or the second foil.

Any of the above described building panels 10 may be provided with a
30 mechanical locking system. The mechanical locking system may be of the type described in WO 2007/01 5669, WO 2008/004960, WO 2009/1 16926, or WO 201 0/087752, the entire contents of each is expressly incorporated by reference herein.

In the embodiments above, the wear resistant foil 10 is described as
35 including the first foil 1 and the second foil 2. However, after pressing, the boundaries between the first and the second foil 1, 2 may be less distinct, such that in some embodiments it may be difficult to distinguish the first foil 1

from the second foil 2. At least a part of the wear resistant particles are 4 located intermediate the first and the second foil 1, 2. A part of the wear resistant particles 4 may be located within the second foil 2.

5 It is contemplated that the first foil 1 may be formed of a powder layer, for example, comprising the first thermoplastic material of the above described type and optionally filler such as wood particles, calcium carbonate, sand, etc.

10 It is contemplated that there are numerous modifications of the embodiments described herein, which are still within the scope of the invention as defined by the appended claims. For example, it is contemplated that more than one wear resistant foil may be arranged on a core for forming a building panel.

15 EXAMPLES

Example 1: Comparative example

20 A PVC wear layer foil with a thickness of 0.3 mm was positioned on a decorative foil with a thickness of 0.1 mm. The two foils were laminated on to a PVC core material using a temperature of 160°C, a pressure of 20 bar and a pressing time of 40 seconds. The resulting product was a LVT product. The LVT product was found to have a wear resistance of 3200 revolutions as tested in a Taber abrader.

Example 2: PVC foil on PVC foil

25 A PVC wear layer foil with a thickness of 0.3 mm was positioned on a decorative foil with a thickness of 0.1 mm. On to the wear layer foil 10 g/m² Al₂O₃ was scattered using a scattering device. A second PVC wear layer foil with a thickness of 0.3 mm was positioned on the scattered Al₂O₃. The three foils were laminated on to a PVC core material using a temperature of 160°C, 30 a pressure of 20 bar and a pressing time of 40 seconds. The resulting product was a LVT product. The LVT product was found to have a wear resistance higher than 8000 revolutions as tested in a Taber abrader.

Example 3: PU foil on PVC foil

35 A PVC wear layer foil with a thickness of 0.3 mm was positioned on a decorative foil with a thickness of 0.1 mm. On to the wear layer foil 10 g/m² Al₂O₃ was scattered using a scattering device. A PU foil with a thickness of

0.05 mm was positioned on the scattered Al₂O₃. The three foils were laminated on to a PVC core material using a temperature of 140°C, a pressure of 20 bar and a pressing time of 40 seconds. The resulting product was a LVT product. The LVT product was found to have a wear resistance
5 higher than 8000 revolutions as tested in a Taber abrader.

Example 4: PU foil on PVC foil

A printed decorative PVC foil having a thickness of 0.08 mm was arranged on a core comprising three layers and having a thickness of 4 mm.
10 A PVC wear layer having a thickness of 0.25 mm was arranged on the decorative PVC foil. Wear resistant particles in form of aluminium oxide were applied in an amount of 40 g/m² on the PVC wear layer. A PU foil having a thickness of 0.05 mm was arranged on the wear resistant particles and the PVC wear layer. The different layers were pressed together in a cold-hot-cold
15 process. The pressure applied was 10 bar. The temperatures applied in the cold-hot-cold process were 50°C, 140°C, and 50°C. The product was pressed at 140°C during 4 minutes. The total pressing time was approximately 55 minutes. The resulting product was a LVT product. The LVT product was found to have a wear resistance higher than 8000 revolutions as tested in a
20 Taber abrader.

CLAIMS

- 5 1. A method to produce a wear resistant foil (10), comprising providing a first foil (1) comprising a first thermoplastic material, applying a second foil (2) comprising a second thermoplastic material on the first foil (1),
 applying wear resistant particles (4) on the first foil (1) and/or on the
10 second foil (2) prior to applying the second foil (2) on the first foil (1), and adhering the first foil (1) to the second foil (2) with the wear resistant particles (4) therebetween for forming a wear resistant foil (10).
2. The method according to claim 1, wherein the wear resistant
15 particles are enclosed by the first and the second foil (1, 2) after being adhered to each other.
3. The method according to claim 1 or 2, wherein the first
20 thermoplastic material comprises polyvinyl chloride (PVC).
4. The method according to any one of claims 1-3, wherein the
 second thermoplastic material comprises polyurethane (PU).
5. The method according to claim 1 or 2, wherein the first
25 thermoplastic material comprises polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof.
- 30 6. The method according to claim 1, 2 or 5, wherein the second thermoplastic material comprises polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate
35 polyvinyl butyral, polybutylene terephthalate, or a combination thereof.

7. The method according to any one of claims 1-6, wherein the wear resistant particles (4) comprise aluminium oxide.

5 8. The method according to any one of claims 1-7, wherein the wear resistant particles (4) have an average particle size of less than 45 μm .

9. The method according to any one of claims 1-8, wherein the first and the second foil (1, 2) are adhered to each other by pressing, preferably without an adhesive.
10

10. The method according to any one of claims 1-9, wherein the wear resistant particles (4) are applied on the first foil (1).

11. The method according to any one of claims 1-10, wherein the second foil (2) is formed by an extrusion process such as extrusion coating and/or extrusion lamination on the first foil (1).
15

12. The method according to any one of claims 1-11, wherein a thickness of the second foil (2) is less than 75 μm .
20

13. The method according to any one of claims 1-12, wherein the wear resistant foil (10) is substantially transparent.

14. A method to produce a building panel (20), comprising
25 providing a core (21),
applying a first foil (1) comprising a first thermoplastic material on the core (21),
applying a second foil (2) comprising a second thermoplastic material on the first foil (1),
30 applying wear resistant particles (4) on the first foil (1) and/or on the second foil (2) prior to applying the second foil (2) on the first foil (1), and
adhering the core (21), the first foil (1) and the second foil (2) to each other to form a building panel (20).

15. The method according to claim 14, wherein the wear resistant particles are enclosed by the first and the second foil (1, 2) after being

adhered to each other.

16. The method according to claim 14 or 15, wherein the first thermoplastic material comprises polyvinyl chloride (PVC).

5

17. The method according to any one of claims 14-16, wherein the second thermoplastic material comprises polyurethane (PU).

18. The method according to claim 14 or 15, wherein the first thermoplastic material comprises polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof.

19. The method according to claim 14, 15 or 18, wherein the second thermoplastic material comprises polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof.

20

20. The method according to any one of claims 14-19, wherein the wear resistant particles (4) comprise aluminium oxide.

21. The method according to any one of claims 14-20, wherein the wear resistant particles (4) have an average particle size of less than 45 μm .

25

22. The method according to claim 14-21, wherein the core (21), the first foil (1) and the second foil (2) are adhered to each other by pressing, preferably without an adhesive.

30

23. The method according to any one of claims 14-22, wherein the wear resistant particles (4) are applied on the first foil (1).

24. The method according to any one of claims 14-23, wherein the second foil (2) is formed by an extrusion process such as extrusion coating and/or extrusion lamination on the first foil (1).

35

25. The method according to any one of claims 14-24, wherein a thickness of the second foil (2) is less than 75 μm after pressing.

5 26. The method according to any one of claims 14-25, wherein the first foil (1), the second foil (2) and the wear resistant particles (4) form a wear resistant foil (10) being substantially transparent.

10 27. The method according to any one of claims 14-26, wherein the core (21) comprising a third thermoplastic material.

28. The method according to claim 27, wherein the third thermoplastic material comprises polyvinyl chloride (PVC), polyester, polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, 15 polyvinyl butyral, polybutylene terephthalate, or a combination thereof.

29. The method according to any one of claims 14-28, wherein the core (21) is a wood-based board, a Wood Plastic Composite (WPC), a thermoplastic board or a mineral board. 20

30. The method according to any one of claims 14-29, further comprising arranging a decorative layer (22) on the core (21).

25 31. A method to produce a building panel (20), comprising providing a core (21), applying a second foil (2) comprising a second thermoplastic material on the core (21), applying wear resistant particles (4) on the core (21) and/or on the second foil (2) prior to the second foil (2) is applied on the core (21), and 30 adhering the core (21) and the second foil (2) together to form a building panel (20).

32. The method according to claim 31, wherein the wear resistant particles are enclosed by the second foil (2) and the core (21).

35 33. The method according to claim 31 or 32, wherein the second thermoplastic material comprises polyvinyl chloride (PVC), polyester,

polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU), polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate, polyvinyl butyral, polybutylene terephthalate, or a combination thereof.

5 34. The method according to any one of claims 31-33, wherein the core (21) is a thermoplastic core, a Wood Plastic Composite (WPC), a wood-based board or a mineral board.

10 35. The method according to any one of claims 31-34, wherein the wear resistant particles (4) have an average particle size of less than 45 μm .

 36. The method according to any one of claims 31-35, wherein a thickness of the second foil (2) is less than 75 μm after pressing.

15 37. The method according to any one of claims 31-36, wherein the core (21) and the second foil (2) are adhered to each other by pressing.

 38. The method according to any one of claims 31-37, wherein the wear resistant particles (4) are applied on the core (21).

20

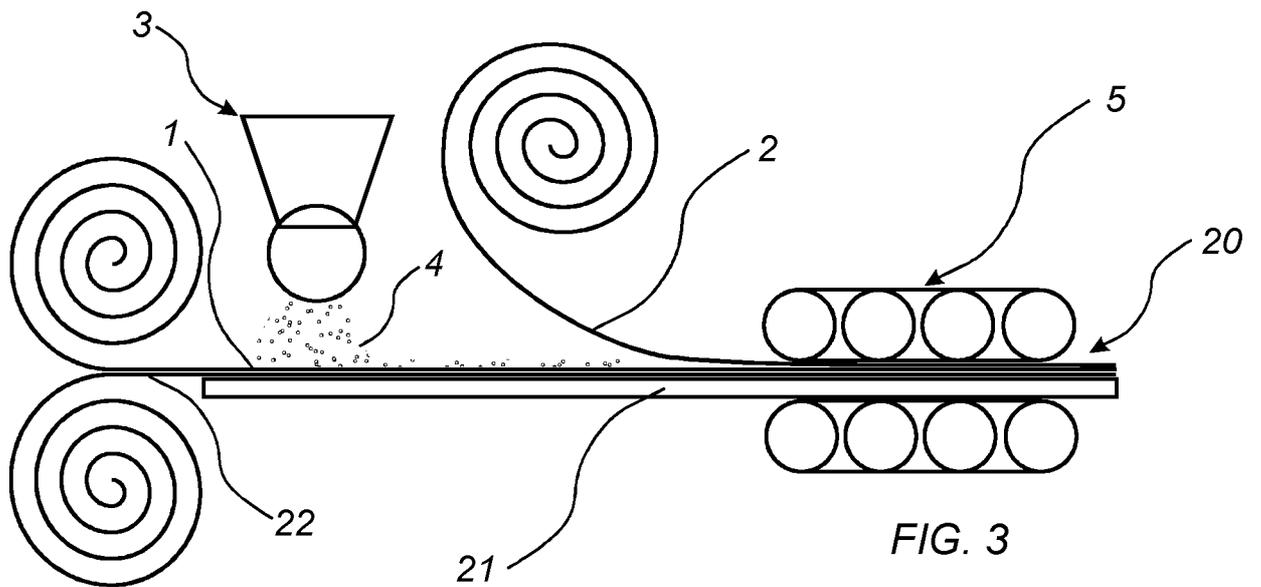
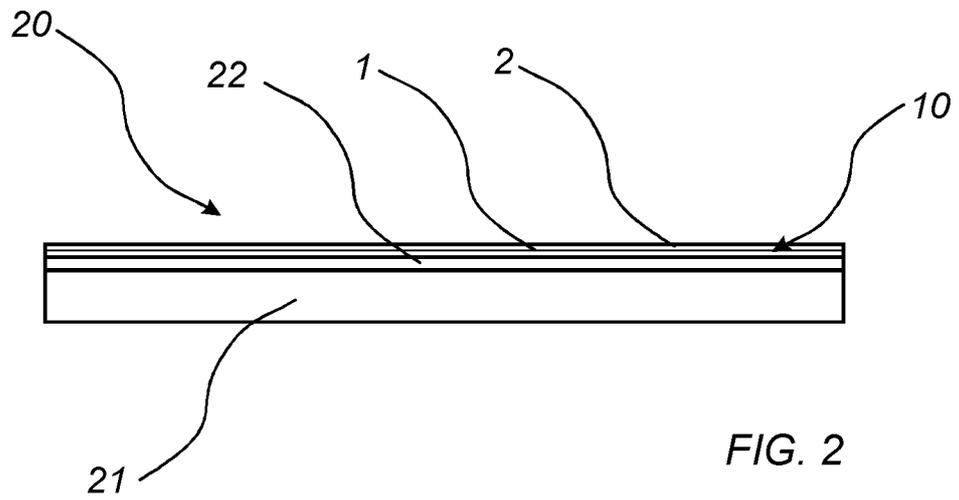
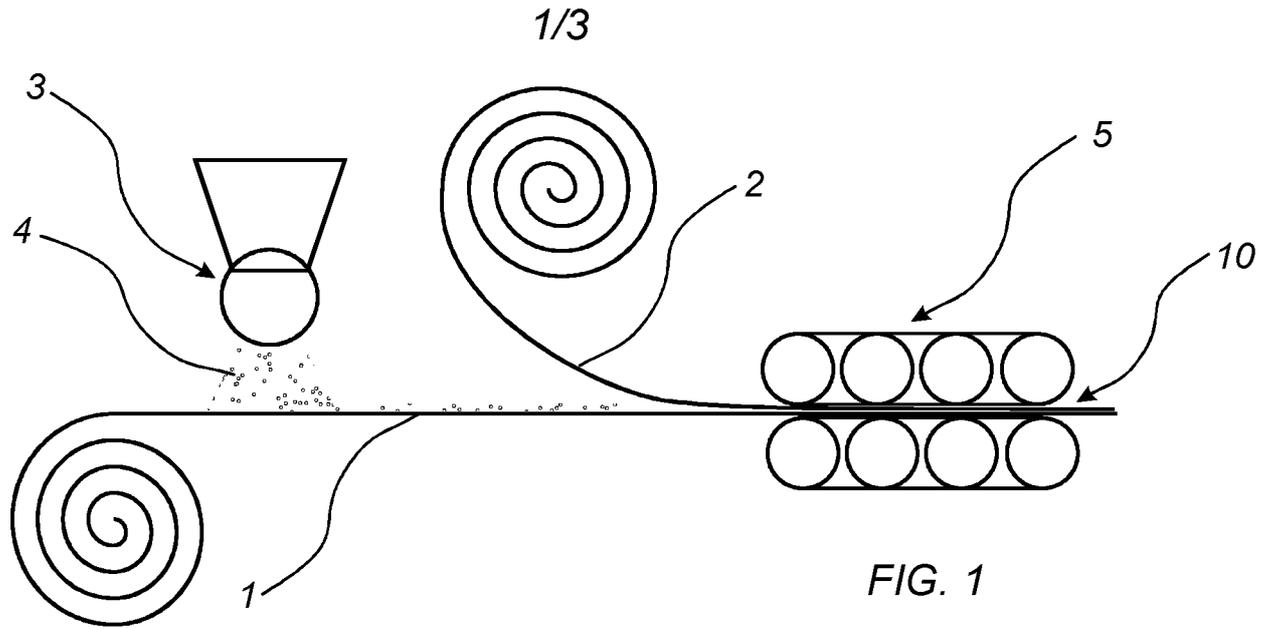
 39. The method according to any one of claims 31-38, wherein the second foil (2) is formed by an extrusion process such as extrusion coating or extrusion lamination on the core (21).

25 40. A building panel (20), comprising
 a core (21),
 a wear resistant foil (10) arranged on the core (21), wherein the wear resistant foil (10) comprises a first foil (1) comprising a first thermoplastic material and a second foil (2) comprising a second thermoplastic material,
30 and wherein wear resistant particles (4) are arranged between the first and the second foil (1, 2).

 41. The building panel according to claim 40, wherein the wear resistant particles are enclosed by the first and the second foil (1, 2).

35

42. The building panel according to claim 40 or 41, wherein the first thermoplastic material comprises polyvinyl chloride (PVC).
43. The building panel according to any one of claims 40-42,
5 wherein the second thermoplastic material comprises polyurethane (PU).
44. The building panel according to any one of claims 40-43,
wherein the wear resistant particles (4) comprise aluminium oxide.
- 10 45. The building panel according to any one of claims 40-44,
wherein the wear resistant particles (4) have an average particle size of less
than 45 μm .
46. The building panel according to any one of claims 40-45,
15 wherein the core comprises polyvinyl chloride (PVC), polyester,
polypropylene (PP), polyethylene (PE), polystyrene (PS), polyurethane (PU),
polyethylene terephthalate (PET), polyacrylate, methacrylate, polycarbonate,
polyvinyl butyral, polybutylene terephthalate, or a combination thereof.
- 20 47. The building panel according to any one of claims 40-46, further
comprising a decorative layer (22) arranged on the core (21), wherein the
wear resistant foil (10) is arranged on the decorative layer (22).
48. The building panel according to any one of claims 40-47,
25 wherein a thickness of the second foil (2) is less than 75 μm after pressing.



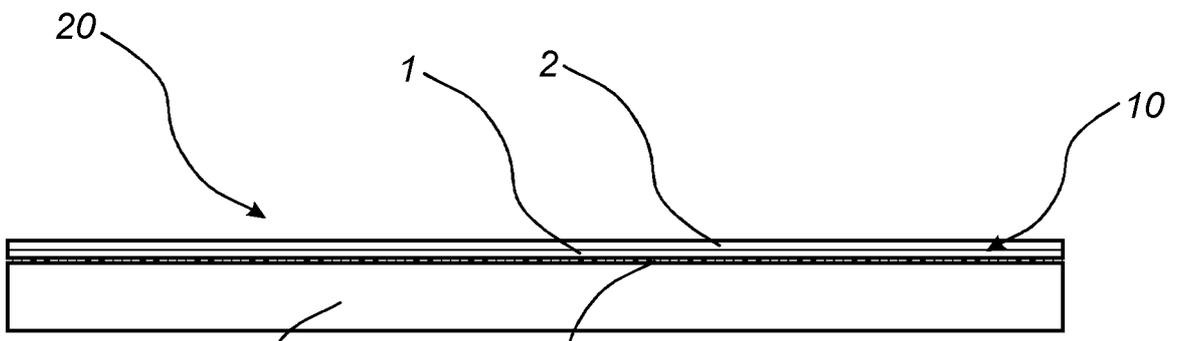


FIG. 4A

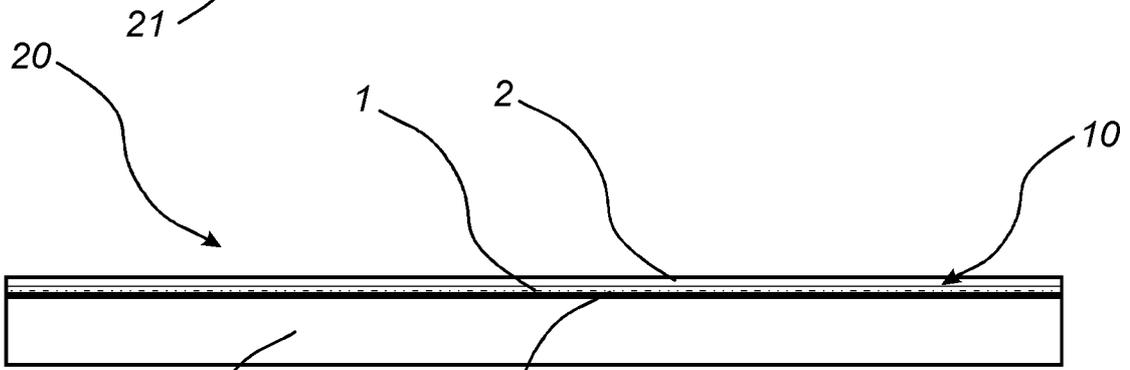


FIG. 4B

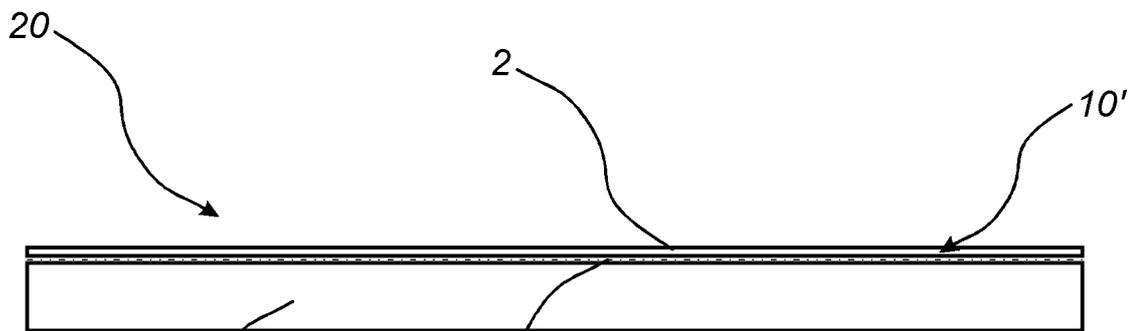


FIG. 4C

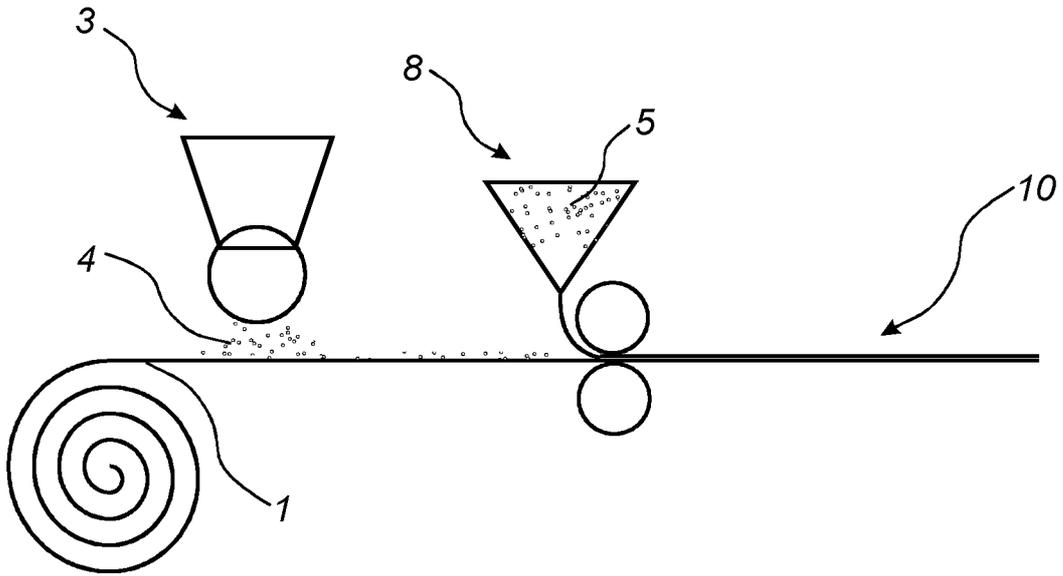


FIG. 5A

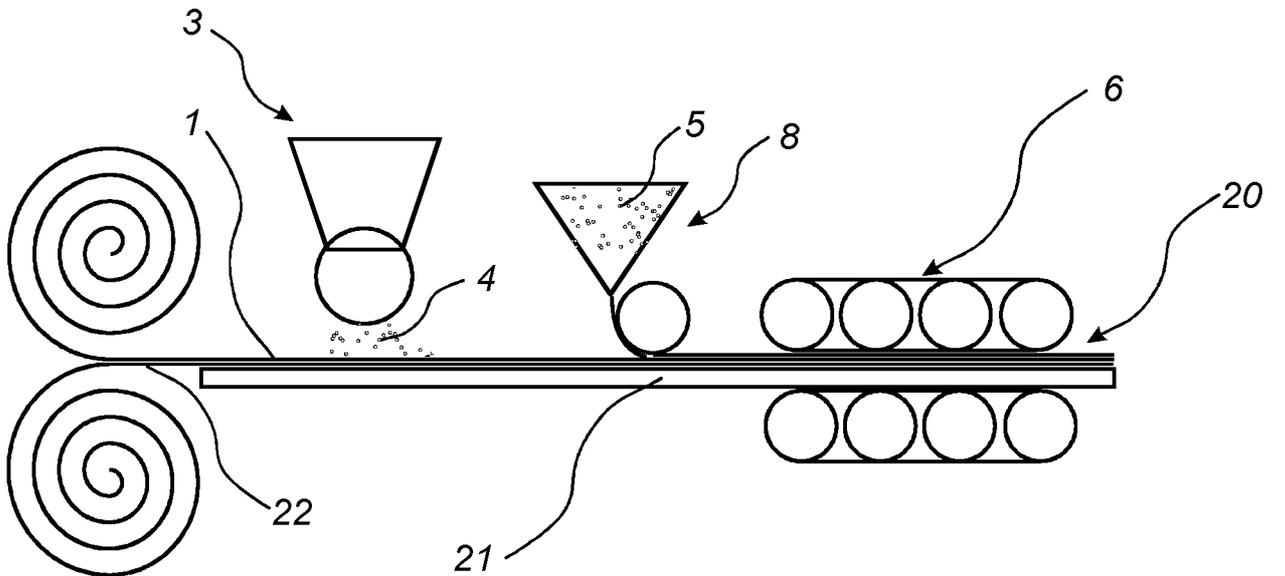


FIG. 5B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE201 5/050782

A. CLASSIFICATION OF SUBJECT MATTER		
IPC: see extra sheet		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC: B32B, B44C, E04F		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
SE, DK, FI, NO classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
EPO-Internal, PAJ, WPI data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 201 3079950 A 1 (JAMES HALSTEAD PLC), 6 June 201 3 (201 3-06-06); page 18, line 22 - page 19, line 10; page 6, line 5 - line 14; claims 1, 6, 8 --	1-48
A	WO 201 1129755 A2 (CERALOC INNOVATION BELGIUM ET AL), 20 October 201 1 (201 1-10-20); whole document --	1-48
A	US 5604025 A 1 (TESCH GUNTER), 18 February 1997 (1997-02-1 8); whole document --	1-48
A	WO 201 1082491 A 1 (CLAUSI ROBERT N ET AL), 14 July 201 1 (201 1-07-1 4); whole document --	1-48
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
20-1 0-201 5		20-1 0-201 5
Name and mailing address of the ISA/SE Patent- och registreringsverket Box 5055 S-1 02 42 STOCKHOLM Facsimile No. +46 8 666 02 86		Authorized officer Erika Stenroos Telephone No. +46 8 782 28 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE201 5/050782

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 201 10300393 A 1 (NO SHINJI ET AL), 8 December 201 1 (201 1-12-08); whole document --	1-48
A	EP 2263867 A 1 (HUELSTA WERKE HUELS KG), 22 December 201 0 (201 0-1 2-22); whole document -- -----	1-48

Continuation of: second sheet

International Patent Classification (IPC)

B44C 5/04 (2006.01)

B32B 27/08 (2006.01)

B32B 27/20 (2006.01)

E04F 15/10 (2006.01)

E04F 15/16 (2006.01)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SE201 5/050782

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				CN	1031 29069	A	05/06/201 3				
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				GB	2499289	B	25/06/201 4				
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				KR	201 30061 059	A	10/06/201 3				
				WO	201 1129755	A2	20/1 0/201 1	CA	2793863	A1	20/1 0/201 1
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EP	2558297	A2	20/02/201 3								
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UA	107489	C2	12/01/201 5								
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				WO	9324308	A1	09/1 2/1 993				
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				EP	2390998	A4	21/05/201 4				
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				KR	10 1344608	B1	26/1 2/201 3				
				WO	201 1033956	A1	24/03/201 1				

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SE201 5/050782

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				ES	238401 4	T3	28/06/201 2
				WO	201 0 145766	A 1	23/1 2/201 0
