

SYSTEM AND METHOD OF MAKING COMPOSITE BOARDS

FIELD OF THE INVENTION

The invention relates to a system and method of making composite boards. The invention is particularly suited for composite boards requiring a high strength to weight ratio such as, but not limited to a shuttering board.

BACKGROUND TO THE INVENTION

The following discussion of the background to the invention is intended to facilitate an understanding of the present invention. However, it should be appreciated that the discussion is not an acknowledgment or admission that any of the material referred to was published, known or part of the common general knowledge in any jurisdiction as at the priority date of the application.

Composite boards in the form of shuttering boards are commonly used at construction sites to maintain poured concrete in a desired shape. It is particularly used in maintaining poured concrete so that, when set, it forms a vertical pylon or the like. This process of maintaining the poured concrete in predefined shapes is also known as formwork.

There are essentially three types of shuttering boards that can be used:

Plywood shuttering boards. Such shuttering boards are cheap. However, they are subjected to degradation with each use. As a result, plywood shuttering boards are often re-used somewhere between 8 to 10 times before they need to be changed. Changing such shuttering boards consumes additional labour and material costs. Furthermore, the used plywood shuttering boards must be disposed of in some manner, often by incineration, which creates further environmental problems.

Steel shuttering boards. Being made of a more durable material, steel shuttering boards may be re-used up to 100 times before needing to be changed. However, this durability is also a disadvantage as such shuttering boards are difficult to handle and shape at the construction site.

Plastic shuttering boards. Plastic shuttering boards have been introduced to the market with limited success. The main reason for this lack of success has been their low strength to weight ratio. While some attempts to improve the strength to weight ratio of plastic shuttering boards have been technically successful, it has been done at such a high production cost that the commercial viability of such boards has been significantly compromised.

Typical methods of producing the aforementioned composite shuttering boards include the hot and cold press methods. In the two methods, a plurality of layers making the composite boards have to be pre-cut to fit into a relevant press. In addition, the dimensions of the composite boards produced are often limited by the press. If there is a need to produce a composite board which falls out of range of dimensions allowable by the press, there is a need to acquire suitable press(es). This will incur further costs for the producer.

In addition, it generally takes about 10 minutes on average to press a composite board using the cold press method, wherein the adhesive between each of the plurality of layers of the composite board is activated by pressure. While the hot press method may reduce the press time to about 8 minutes by using adhesive which is both heat and pressure activated, the hot press method is not particularly suited for plastic based shuttering boards because melting of the plastic layer(s) is likely to take place when the adhesive is being heated. Such melted plastic layer(s) are likely to be cooled unevenly, and thus compromising the overall quality of the composite board.

Further, the hot press method requires 'cooling' periods to prevent overheating. This reduces productivity.

Another method of producing plastic shuttering boards is through extrusion of the plastic layers. While extrusion typically overcomes the problem of speed of the cold and hot press methods, the dimension of the composite boards is limited by the extrusion capacity. In addition, extrusion methods typically incur high wastage of materials during start up stage.

It is therefore an object of the present invention to provide a method of producing the composite boards which alleviates at least one of the aforementioned problems.

SUMMARY OF THE INVENTION

Throughout this document, unless otherwise indicated to the contrary, the terms "comprising", "consisting of", and the like, are to be construed as non-exhaustive, or in other words, as meaning "including, but not limited to".

In accordance with a first aspect of the invention there is a method of bonding a plurality of layers for producing a laminated composite board comprising the steps of: applying heat activated adhesive on a bonding surface of each or alternate layer from the plurality of layers which is to be bonded, and directing a localized heat source to the bonding surface and the applied heat activated adhesive as the composite board is being laminated.

Preferably, the process of directing the localized heat source and the lamination of the composite board is facilitated by a conveyer assembly.

Preferably the conveyer assembly moves at a speed of up to 4 metres per minute. Ideally the conveyer assembly moves at a production speed of 0.7 metres per minute to 4 metres per minute.

Preferably the temperature of the localized heat source is between 60 and 500 degree Celsius.

Preferably the temperature of the localized heat source is approximately 10 to 50 degree Celsius higher than the softening temperature of the heat activated adhesive.

Preferably the localized heat source is directed to a focused heating zone at a distance of approximately 100mm from the bonding surface.

Preferably, the focused heating zone is applied to the heat activated adhesive continuously until the composite board is fed into pressure rollers for bonding and lamination.

Preferably, the focused heating zone is created using pressurized hot air of between 5 to 50 bars.

Preferably, the focused heating zone is created using infra-red heating tubes or laser.

Preferably the heat activated adhesive is a film type adhesive.

Preferably, the heat activated adhesive comprises a single layer or multiple layers of adhesive films, each layer formed of a different composition, depending on type of materials to be bonded.

Preferably, the heat activated adhesive is about 0.02mm to 0.5mm thick.

In accordance with a second aspect of the invention there is a system of bonding a plurality of layers for producing a laminated composite board comprising: at least one conveyer assembly; and at least one localized heat source; wherein the plurality of layers (each layer or alternate layer of the plurality of layers is applied with heat activated adhesive on a bonding surface) is loaded on the conveyer assembly, and the localized heat source is directed to the bonding surface and the applied heat activated adhesive as the composite board is being laminated.

Preferably the conveyer assembly moves at a speed of up to 4 metres per minute. Ideally the conveyer assembly moves at a production speed of 0.7 metres per minute to 4 metres per minute.

Preferably the temperature of the localized heat source is between 60 and 500 degree Celsius.

Preferably the temperature of the localized heat source is approximately 10 to 50 degree Celsius higher than the softening temperature of the heat activated adhesive.

Preferably the localized heat source is directed to a focused heating zone at a distance of approximately 100mm from the bonding surface.

Preferably, the focused heating zone is applied to the heat activated adhesive continuously until the composite board is fed into pressure rollers for bonding and lamination.

Preferably, the focused heating zone is created using pressurized hot air of between 5 to 50 bars.

Preferably, the focused heating zone is created using infra-red heating tubes or laser.

Preferably the heat activated adhesive is a film type adhesive.

Preferably, the heat activated adhesive comprises a single layer or multiple layers of adhesive films, each layer formed of a different composition, depending on type of materials to be bonded.

Preferably, the heat activated adhesive is about 0.02mm to 0.5mm thick.

In accordance with a third aspect of the invention there is a laminated composite board comprising: a plurality of layers, each layer from the plurality of layers thermally bonded to its adjacent layer ; wherein the thermal bond comprises the application of heat activated adhesive to the surface of each layer to be bonded (bonding surface) followed by directing a localized heat source to the bonding surface and the applied heat activated adhesive as the composite board is being laminated.

Preferably, the temperature of the localized heat source is 10 to 50 degree Celsius higher than the softening temperature of the heat activated adhesive.

IPUS 27SEP13 PM 5:10

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is an exploded view of a composite board according to a first and second embodiment of the present invention.

Figure 2A is a schematic illustration of making the composite boards as according to the first and second embodiments of the present invention.

Figure 2B is a schematic illustration of making the composite board as according to the third embodiment of the present invention.

PREFERRED EMBODIMENTS OF THE INVENTION

It should be noted that dimensions provided in the description should be construed as approximate (and not exact).

In accordance with a first embodiment of the invention as shown in **Fig. 1**, there is a composite board **10**. The composite board **10** comprises five layers of various material compositions. The first layer **12** and the fifth layer **20** are made of virgin polyethylene. The second layer **14** and fourth layer **18** are made of aluminium sheeting. The third, middle, layer **16** is made of recycled polyethylene. In this embodiment, the polyethylene of the third layer **16** is solid state polyethylene.

The composite board **10** will next be described in the context of a system and method of making the same.

A system of making composite board **10** is illustrated in Figure 2A. The system comprises a conveyer assembly **24**, pressure rollers **26**, and an adhesive sub-system (not shown). The adhesive sub-system includes heat activated adhesive **32**. The heat activated adhesive **32** can be either in the liquid or solid form.

A predetermined length of the five layers **12, 14, 16, 18, 20** is applied with heat activated adhesive **32**. The heat activated adhesive **32** may be applied

- (i) between the middle layer **16** and the second and fourth layer **14, 18**;
- (ii) between the first and second layers **12, 14**; and
- (iii) between the fourth and fifth layer **18, 20**.

IPUS 27SEP13 PM 5:10

The heat activated adhesive **32** may be applied on the surface of any of the layers **12, 14, 16, 18, 20** as long as it fulfils the preceding requirements (i), (ii) and (iii). The surface on which the heat activated adhesive **32** is applied on is defined as the bonding surface in the context of describing the embodiment.

The heat activated adhesive **32** may be solid (in the form of an adhesive film) or liquid. For the adhesive film type, the heat activated adhesive **32** may further comprise a single layer or multiple layers of adhesive films, each layer being formed of a different composition, depending on the type of materials to be bonded. Care must be taken to ensure that the heat activated adhesive **32** is

applied evenly on the respective surfaces. It is to be appreciated that the five layers **12, 14, 16, 18, 20** do not need to be pre-cut to any specified width.

The five layers **12, 14, 16, 18, 20** (applied with heat activated adhesive **32** on the relevant bonding surface) are next loaded onto the conveyer assembly **24**.

The conveyer assembly **24** is switched on. A focused heating zone of between 60 degree Celsius to 500 degree Celsius (localized heating temperature) is directed to the heat activated adhesive **32** and bonding surface(s). Preferably, the localized heating temperature applied at the bonding surface is higher than the softening temperature of the plastic layer **12, 16, 20**, and preferably 10 to 50 °C higher than the softening temperature of the plastic layers **12, 16, 20**. For purpose of illustration, the following focused heating zone will be further described with the assumption that the heat activated adhesive is the solid film type.

Each heat activated adhesive **32** is recommended to be about 0.02mm to 0.5mm thick. The focused heating zone may be created using pressurized hot air of between 5 to 50 bars (about 500 to 5000 kilopascals), infra-red heating tubes, laser, or other heat generating method as known to a person skilled in the art. The focused heating zone is applied at a distance of 100mm from each of the bonding surface(s).

At the same time the focused heating is carried out, the pressure rollers **26** moves at a speed of 0.7 metres per minute to 4 metres per minute (i.e. 0.012 metres per second to 0.067 metres per second). The focused heating is applied to heat activated adhesive **32** continuously until the composite board **10** is fed into the pressure rollers for bonding and lamination. After passing through the rollers, the laminated composite board **10** is left to cool and cure.

It is to be appreciated that the finished laminated composite board **10** may be cut to any width as desired. Further, the process may be repeated without the need to switch off the conveyer assembly **24**. This minimizes the down time required to produce the composite board **10**. Further, the source(s) for creating the localized heating zone may be replaceable or alternated with minimal disruption to the down time.

In accordance with a second embodiment of the invention (not shown), there is provided a composite board **10**. The composite board **10** comprises five layers of various material compositions: a middle core layer **16** sandwiched between intermediate second layer **14** and fourth layer **18**, and outer first layer **12** and last layer **20** cladding the intermediate second layer **14** and fourth layer **18**. The first layer **12** and the last layer **20** are made of polyethylene. The intermediate second layer **14** and fourth layer **18** are made of aluminium sheeting. The middle core layer **16** is made of plywood.

The same conveyer assembly **24** for producing the composite board **10** in the first embodiment may be applied to the second embodiment as described above. The heat activated adhesive **32** is suited for the material composition of each of the layers **12, 14, 16, 18, 20** as known to a person skilled in the art.

In accordance with a third embodiment of the invention (not shown), there is provided a composite board **10**. The composite board **10** comprises three layers of various material compositions: a middle core layer **16** sandwiched between outer first layer **12** and last layer **20**. The middle core layer **16** is made of plywood.

The composite board **10** will next be described in the context of a system and method of making the same.

A system of making composite board **10** is illustrated in Figure 2B. The system comprises a conveyer assembly **24**, pressure rollers **26**, and an adhesive sub-system **30**. The adhesive sub-system **30** is a heat activated system.

A predetermined length of the three layers **12, 16, and 20** is applied with heat activated adhesive **32**. The heat activated adhesive **32** is applied between the middle core layer **16** and the first and last layer **12, 20**.

The heat activated adhesive **32** may be applied on the surface of any of the layers **12, 16 and 20**. The surface on which the heat activated adhesive **32** is applied on is defined as the bonding surface.

The heat activated adhesive **32** may be solid (in the form of an adhesive film) or liquid. For the adhesive film type, the heat activated adhesive **32** may further comprise a single layer or multiple layers of adhesive films, each layer being

formed of a different composition, depending on the type of materials to be bonded. Care must be taken to ensure that the heat activated adhesive **32** is applied evenly on the respective surfaces. It is to be appreciated that the three layers **12, 16, 20** do not need to be pre-cut to any specified width.

The three layers **12, 16, 20** (applied with heat activated adhesive **32** on the relevant bonding surface) are next loaded onto the conveyer assembly **24**.

The conveyer assembly **24** is switched on. A focused heating zone of between 60 degree Celsius to 500 degree Celsius (localized heating temperature) is directed to the heat activated adhesive **32** and bonding surface(s). Preferably, the localized heating temperature applied at the bonding surface is higher than the softening temperature of the plastic layer **12, 20** and preferably 10 to 50°C higher than the softening temperature of the plastic layers **12, 20**. For purpose of illustration, the following focused heating zone will be further described with the assumption that the heat activated adhesive is the film type.

Each heat activated adhesive **32** is recommended to be about 0.02mm to 0.5mm thick. The focused heating zone may be created using pressurized hot air of between 5 to 50 bars (about 500 to 5000 kilopascals), infra-red heating tubes, laser, or other heat generating method as known to a person skilled in the art. The focused heating zone is applied at a distance of 100mm from each of the bonding surfaces.

At the same time the focused heating is carried out, the pressure rollers **26** moves at a production speed of 0.7 metres per minute to 4 metres per minute (i.e. 0.012 metres per second to 0.067 metres per second). The focused heating is applied to heat activate the adhesive **32** continuously until the composite board **10** is fed into the pressure rollers for bonding and lamination. After passing through the rollers, the laminated composite board **10** is left to cool and cure.

It is to be appreciated that the finished laminated composite board **10** may be cut to any width as desired. Further, the process may be repeated without the need to switch off the conveyer assembly **24**. This minimizes the down time required to produce the composite board **10**. Further, the source(s) for creating the localized

heating zone may be replaceable or alternated with minimal disruption to the down time.

The Applicant has discovered that the defined focused heating zone at a distance of 100mm from the bonding surfaces and speed range of 0.7 metres per minute to 4 metres per minute to provide the optimum distance and speed depending on

- (a) the thickness of the composite boards to be produced;
- (b) the material composition of the composite boards; and
- (c) the type of heat activated adhesive used.

It is apparent that as the distance from the bonding surfaces increase, more of the bonding surface is exposed to the localized heat source and vice versa. The present method may be adapted for other composite boards by tuning the distance from the bonding surface and speed of the conveyer assembly.

The applicant has further found that the re-use cycle of composite boards made in accordance with the invention, and used as shuttering boards, ranges from 200 to 500 uses. Furthermore, such composite shuttering boards are completely recyclable.

The inherent strength of the composite boards also makes them suitable for other uses such as non-load bearing walls, scaffolding boards, floor decking, roofing shelters and truck cabins. The inherent high strength is attributable to the heat activated system employed. In particular, the heat activated system is useful for low surface energy plastics (typically having surface energy of less than 35 on a dyne scale) such as polyethylene whereby conventional adhesive glue or epoxy glue do not provide good bonding strength between the laminated wood and plastic layers, or between metal and plastic layers. By providing a focused heating zone between the bonding layers as the bonding layers are being fed continuously between rollers, heat is provided consistently, uniformly and directly to the bonding joint between the bonding layers. The heat activated system affords ease of production, good bonding strength, and the ability of the adhesive bond to withstand functional use of the product with the bond being waterproof, the ability

to withstand high impact stress and the ability to maintain the bond integrity during temperature change.

It should be appreciated by the person skilled in the art that the above invention is not limited to the embodiment described. In particular, the following modifications and improvements may be made without departing from the scope of the present invention:

- The polyethylene material used in the first and last layers may be replaced with other hard plastic materials such as polyvinyl chloride or polypropylene.
- The method of making the composite boards may be extended to any number of layers, and is not necessarily limited to the 3 and 5 layer configuration as described in the embodiments. However, the choice of the composition of the adhesive film or layers depends on the types of materials to be bonded.
- The material used in the middle core layer in each embodiment may be of virgin or recycled origin. In this manner, new composite boards may be made by recycling the material used in older composite boards.
- The thickness of the composite boards described in all three embodiments may vary from the 6-50mm. While the preferred thickness range identified by the applicant is from 9mm to 30mm thickness, boards of other sizes may just as easily be created via the described method.
- The thickness of the first and last layers should be limited to a maximum of 2mm for any composite board less than or equal to 50mm in thickness (total).
- The thickness of the core layer, as a proportion of the total thickness of the composite board, should be roughly 80%.
- The composite board may have a groove cut along each edge adapted to receive an edge bander made of a plastic material. By edge-banding the board in this manner, the edges of the board are protected during

handling and usage – thereby also further prolonging the lifespan of the board. The plastic material that may be used for the edge bander includes polyvinyl chloride, polyethylene, polypropylene and rubber.

- The whole composite board may be applied under heavy loads for a certain duration until the adhesives are set.
- The heat activated adhesive film may be applied on the plastic layer alone, or the core wood layer alone, or both layers.
- The second and fourth layers **14, 16, 18** may be made of metal other than aluminium. In other variations of the invention, the second and fourth layers **16, 18** may be stainless steel or copper.
- The material used in the third layer **20** of the composite board **10** as described in the first embodiment may take the form of a foam of such material.
- A filler material may be used in the third layer 16 of the composite board 10 as described in the first embodiment. Examples of the type of filler material that may be used include: talc fillers; wood fillers, fibreglass or any other reinforcing filling agent.
- The thickness of the middle core layer of wood as described in the third embodiment may be varied between 5 to 30mm.
- The thickness of the first and last layer of plastic as described in the third embodiment may be varied between 0.5 to 5mm.
- The thickness of the core middle layer of plastic as described in the first embodiment may be varied between 5 to 30mm.
- The thickness of the second and fourth layer of metal as described in the first embodiment may be varied between 0.1 to 2mm.
- The thickness of the first and last layer of plastic as described in the third embodiment may be varied between 0.5 to 5mm.

It should be further appreciated by the person skilled in the art that the features described above, where not mutually exclusive, can be combined to form yet further embodiments of the invention.

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We Claim:

1. A method of bonding a plurality of layers for producing a laminated composite board comprising the steps of:
 - a. applying heat activated adhesive on a defined bonding surface between each layer from the plurality of layers which is to be bonded, and
 - b. directing a localized heat source to the bonding surface and the applied heat activated adhesive as the composite board is being laminated.
2. A method according to claim 1, wherein the process of directing the localized heat source and the lamination of the composite board is facilitated by a conveyer assembly.
3. A method according to claim 2, wherein the conveyer assembly moves at a speed of up to 4 metres per minute.
4. A method according to claim 3, wherein the conveyer assembly moves at a speed of 0.7 metres per minute to 4 metres per minute.
5. A method according to any of claim 1 to 4, wherein the temperature of the localized heat source is between 60 and 500 degree Celsius.
6. A method according to any of claim 1 to 5, wherein the temperature of the localized heat source is approximately 10 to 50 degree Celsius higher than the softening temperature of the heat activated adhesive.
7. A method according to any of the preceding claims, wherein the localized heat source is directed to a focused heating zone at a distance of approximately 100mm from the bonding surface.
8. A method according to claim 7 wherein the focused heating zone is applied to the heat activated adhesive continuously until the composite board is fed into pressure rollers for bonding and lamination.
9. A method according to claim 7 or 8 wherein the focused heating zone is created using pressurized hot air of between 5 to 50 bars.

- 10.A method according to any of claims 7 to 9 wherein the focused heating zone is created using infra-red heating tubes or laser.
- 11.A method according to any of the preceding claims, wherein the heat activated adhesive is a film type adhesive.
- 12.A method according to claim 11 wherein the heat activated adhesive comprises a single layer or multiple layers of adhesive films, each layer formed of a different composition, depending on the type of materials to be bonded.
- 13.A method according to claim 11 or 12 wherein the heat activated adhesive is about 0.02mm to 0.5mm thick.
- 14.A system of bonding a plurality of layers for producing a laminated composite board comprising:
- At least one conveyer assembly; and
 - At least one localized heat source;
- wherein the plurality of layers (between each layer of the plurality of layers is applied with heat activated adhesive on a defined bonding surface) is loaded on the conveyer assembly, and the localized heat source is directed to the bonding surface and the applied heat activated adhesive as the composite board is being laminated.
- 15.A system according to claim 14, wherein the conveyer assembly moves at a speed of up to 4 metres per minute.
- 16.A system according to claim 15, wherein the conveyer assembly moves at a 0.7 metres per minute to 4 metres per minute.
- 17.A system according to any of claim 14 to 16, wherein the temperature of the localized heat source is between 60 and 500 degree Celsius.
- 18.A system according to any of claim 14 to 17, wherein the temperature of the localized heat source is approximately 10 to 50 degree Celsius higher than the softening temperature of the heat activated adhesive.

IPDS 27SEP13 PM 5:09

19. A system according to any of claims 14 to 18, wherein the localized heat source is directed to a focused heating zone at a distance of approximately 100mm from the bonding surface.
20. A system according to claim 19 wherein the focused heating zone is applied to the heat activated adhesive continuously until the composite board is fed into pressure rollers for bonding and lamination.
21. A system according to claim 19 or 20 wherein the focused heating zone is created using pressurized hot air of between 5 to 50 bars.
22. A system according to any of claims 19 to 21 wherein the focused heating zone is created using infra-red heating tubes or laser.
23. A system according to any of claims 14 to 22, wherein the heat activated adhesive is a film type adhesive.
24. A system according to claim 23 wherein the heat activated adhesive comprises a single layer or multiple layers of adhesive films, each layer formed of a different composition, depending on type of materials to be bonded.
25. A system according to claims 23 or 24 wherein the heat activated adhesive is between 0.02mm to 0.5mm thick.
26. A laminated composite board comprising:
- a plurality of layers, each layer from the plurality of layers thermally bonded to its adjacent layer ;
- wherein the thermal bond comprises the application of heat activated adhesive to the surface of each layer to be bonded (bonding surface) followed by directing a localized heat source to the bonding surface and the applied heat activated adhesive as the composite board is being laminated.
27. A laminated composite board according to claim 26, wherein the temperature of the localized heat source is 10 to 50 degree Celsius higher than the softening temperature of the heat activated adhesive.