IMPROVED LAMINATION PROCESS

FIELD OF THE INVENTION

The present invention is for an improved process to laminate two clear panels using liquid adhesive to produce clear display panels used in mobile phones, PDAs and other screen panels used in electronic gadgets and devices.

BACKGROUND OF THE INVENTION

Optically clear panels made of light plastic material or thin glass are used as display screens for electronic gadgets and devices. However, such panels are very thin. Laminating two layers of optically clear panels provide a way of strengthening these panels for use as display screens.

Conventional laminated panels are made when a sheet of optically clear material such as plastic or thin glass is bonded to another layer of plastic or thin glass. Sometimes it could be a combination of clear plastic and thin glass. Various lamination processes are well known wherein an adhesive film is applied to bond the two optically clear panels together. However there are known problems arising from the lamination process such as introduction of air bubbles in the adhesive when it is applied to the panels. In addition, when the two panels are brought together, tiny air pockets are also formed between the surface of the panel and the film of adhesive. This is because the film of adhesive is usually applied onto the surface of a first panel and then a second panel is then brought into close contact with the first panel. When this is being carried out, air pockets are inevitably created. Existence of air bubbles and air pockets will cause improper adhesion which if not addressed, could cause bulges or cracks in the display screen made from the lamination of two optically clear panels.

Air bubbles are therefore considered a visible and objectionable defect which is not acceptable to most electronic goods manufacturers.

Various methods have therefore been proposed to remove the air bubbles formed in the adhesive during the bonding of the two panels. These methods are often used in combination as not one single method can effectively

remove all the air bubbles and air pockets formed between the adhesive and a panel, or formed in the adhesive or formed between the two panels. The steps in the lamination process after the adhesion of the first panel to the second panel will also include steps directed at removing remaining air bubbles so that the final end product is effectively free of air bubbles.

Removing air bubbles in the adhesive and removing air pockets formed between the adhesive and the panel is not an easy task. There are only two mechanisms by which the air can escape: diffusion and dissolving in the film. One is the use of heat and the second is applying high pressure. Both processes are very slow, whichever method is employed. Usually a combination of methods have to be employed to effectively remove the air bubbles. The bigger the sheet of panel, the longer the time required. As a result, the productivity of such processes is low and they require considerable capital expenditure to set up the necessary costly apparatus such as autoclaves.

What is required is an improved process wherein most of the air bubbles are removed before the joining of the two panels.

The inventor has studied the process for laminating two optically clear panels using liquid adhesive. The inventor had found the initial step of bringing together the first and second clear panel is very important to ensure the process starts with as little air bubbles in the adhesive film spread on the first clear panel and as little air pockets are formed when the two clear panels are brought together.

It is recognised that removal of air bubbles and air pockets trapped in the process of bonding the first and second clear panels in the lamination of optically clear panels will result in lower costs of wastage due to lower number of rejects, and consequently higher yields.

The inventor has proposed an improved process wherein two clear panels are brought close together in a specified process including the angle of approach between a first clear panel which is horizontally laid and a second clear panel so as to minimize the trapping of air upon initial contact between the inner surfaces of the two clear panels after liquid adhesive has been applied to the inner surface of the first clear panel.

SUMMARY OF THE INVENTION

A first object of the invention is an improved process to laminate two clear panels in the manufacture of clear display panels used in electronic gadgets and electronic devices, the process consisting of :-

a. applying a liquid adhesive to a first clear panel laid horizontally;
b. removing any air bubbles in the liquid adhesive;
c. bringing a first end of a second clear panel at an angle of approach of 2º to a first end of the first clear panel but without the first end of both clear panels touching each other;
d. lowering the other end of the second clear panel until it is placed horizontally over the first clear panel

so that there is a gap between both clear panels.

Preferably, the improved process to laminate two clear panels further includes these steps:

e. applying centrifugal force to the first and second clear panels; and
f. applying pressure to the first and second clear panels

in order to spread the liquid adhesive throughout the inner surfaces of both clear panels in order to laminate the two clear panels.

More advantageously, the improved process further include a final step of curing the laminated clear panel by UV treatment so that the liquid adhesive binding the laminated clear panel is cured.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, its advantages, and the objects attained by its use, reference should now be made to the accompanying drawings. The accompanying drawings illustrate one or more embodiments of the invention and together with the description herein, serve to explain the workings and principles of the invention.

FIG. 1 is a cross section view of the first clear panel.

FIG. 2 is a cross section view of the second clear panel being brought into a position with the first clear panel, for the lamination process, in a manner proposed in this invention.

FIG. 3 is a cross section view of the angle of approach when the first end of the second clear panel is brought in close contact with the first end of the first clear panel, (but the first ends of both clear panels never touching) for the lamination process, in a manner proposed in this invention,

FIG. 4 shows a 2nd panel being lowered into a horizontal position onto the first clear panel from the angled approach.

FIG. 5 shows a spread of liquid adhesive after the second clear panel had been placed close to the first clear panel, there being a gap between the two clear panels.

FIG. 6 is a flow diagram of the main steps in the inventive process.

FIG 7 is an embodiment of a system for carrying out the inventive process.

DETAILED DESCRIPTION OF THE INVENTION

It is the main object of the invention to manufacture laminates of clear panels of synthetic thermoplastic or glass or a combination of both thermoplastic and glass for, but not limited to, display screens and panels in electrical and electronic gadgets. Such optically clear panels which are formed by laminating two optically clear panels cannot contain air bubbles, so as to be as clear and as transparent for its use for display purposes.

The present inventive process will now be described in greater detail based on a non-limiting exemplary embodiment as illustrated by Fig. 1 to 7. The dimensions of the clear panels as shown in the illustrations have been exaggerated to show the workings of this inventive process.

FIG. 1 is a cross section of the first clear panel (10).

The clear panels (10,12) to be laminated are optically clear panels of glass or plastic or polymer of other clear composite material or a combination of one type of material with another type of material. To laminate the clear panels (10,12), a liquid adhesive (20) with viscosity range of 1000 to 6000 cps is used.

Referring to Fig. 1, a first clear panel (10) is first cleaned and placed onto an inverted T-shaped jig (30). The first clear panel (10) may be heated to a predetermined temperature of 50º, to change the viscosity of the liquid adhesive (20). A predetermined volume of liquid adhesive (20) is placed around the centre of the inner surface of a first clear panel (10). In applying the liquid adhesive (20), it is preferable to ensure that the liquid adhesive (20) is applied evenly from the centre and with no bubbles or gaps. The predetermined volume of liquid adhesive (20) is based on the shape of the clear panel, its dimension and the type of clear panel material. The dispensing pattern is also based on the shape and dimension of the clear panel. The predetermined volume of liquid adhesive (20) is then spread over approximately 60 percent of the inner surface of the first clear panel (10). The thickness of the clear panels (10,12), dimensions and the drop of liquid adhesive (20) have been exaggerated for the purpose of explaining the invention. Should there be bubbles formed during the dispensing stage, the bubbles are removed by means of agitation with the use of a stylus.

FIG. 2 is a cross section view of the second clear panel (12) being brought into a position to be laminated with the first clear panel (10). As the liquid adhesive (20) spreads outwards from the centre, the first end of the second clear panel (16) is brought at an angle to come close to the first end of the first clear panel (14). However, the first end of the second clear panel (16) and the first end of the first clear panel (14) are not in contact, there being a gap of 0.2 mm between the both first ends of the clear panels (14,16). The gap may vary from the type and size of clear panels (10,12) used.

FIG. 3 is a cross section view of the angle of approach when the first end of the second clear panel (16) being lowered having been brought in at an angle to the first clear panel (10), with a gap between both first ends for the clear panels (14,16). The second clear panel (12) is also cleaned before being brought to the first clear panel (10). In the lowering of the second clear panel (12), the second end of the second clear panel (18) is lowered until both clear panels

(10,12) have a gap of 0.2 mm between the inner surface of the second clear panel (12) and inner surface of the first clear panel (10). The first inventive feature is that the first end of second clear panel (16) must be brought close to the first end of the first panel (14), but not touching, the first end of the second panel (16) at an approach angle of preferably 5º to the first end of the first clear panel (14). Once this is done, the second clear panel (12) is then slowly brought to a horizontal position so that the second clear panel (12) is close to the first clear panel (10), there being a gap of 0.2 mm between the inner surface of the second clear panel (12) and the inner surface of the first clear panel (10). The gap may vary from the type and size of clear panels (10,12) used.

The bringing together of the first clear panel (10) and second clear panel (12) is controlled in the manner described herein so that the inner surfaces of both clear panels (10,12) have a gap of 0.2 mm. The controlled bring together of the second clear panel (12) to the first clear panel (10) is to avoid air in between the inner surfaces of both clear panels (10,12) being trapped and forming air pockets between the liquid adhesive (20) and the inner surfaces of both clear panels (10,12). The angle of approach wherein the first end of second clear panel (16) must be brought to the first end of the first clear panel (14) could range from 2º to 10º.

FIG. 4 shows a second clear panel (12) being lowered into a horizontal position onto the first clear panel (10) from the angled approach.

FIG. 5 shows a spread of liquid adhesive (20) after the second clear panel (12) had been placed close to the first clear panel (10), there being a gap between the two clear panels (10,12).

The first clear panel (10) and second clear panel (12) could be of different type of materials. The first clear panel (10) could be optically clear panels of glass or plastic or polymer of other clear composite material. The second clear panel (12) could be optically clear panels of glass or plastic or polymer of other clear composite material.

Although the manner of placing the first end of the first clear panel (14) to the first end of the second panel (16) is one of the inventive feature of this

process, and has been described in detail by reference to Fig.1 to Fig 5, the rest of the process which also has inventive features therein, will be described by reference to Fig 6.

FIG. 6 is a flow diagram of the main steps in the inventive process.

After the placing of the second clear panel (12) onto the first clear panel (10) in the manner described with reference to Fig 1 to Fig 5, the adhering clear panels (10,12) are then placed in a centrifugal station (34).

Once the two clear panels (10,12) are brought together, the clear panels (10,12) are placed in an inverted T-shaped jigs (30) within a centrifugal station (34). The horizontal surface of the inverted T-shaped jigs (30) are smaller in surface area than the surface area of the combined clear panels (10,12). In the centrifugal station (34), the clear panels (10,12) are spun so that the liquid adhesive (20) will begin to spread from the centre towards all sides, until the liquid adhesive (20) covers approximately over 90 percent of the inner surfaces of first and second clear panels (10,12).

Spread of the liquid adhesive (20) when the two clear panels (10,12) are joined together is determined by height/distance or the gap between the two clear panels (10,12) plus the thickness of the two clear panels (10,12). The height is self adjusted as the spread of liquid adhesive (20) continues to spread throughout the inner surfaces of both clear panels (10,12) due to the centrifugal action. The clear panels (10,12) are then spun for a predetermined period of time. The rate of spin and time of spinning in the centrifugal station (34) is set to ensure a further spread of the liquid adhesive (20) now spread out between the two inner surfaces of both clear panels (10,12). The centrifugal station (34) may also have a heater which applies heat to the spinning clear panels (10,12), depending on the viscosity of the liquid adhesive (20), type of clear panels (10,12) laminated. The heating is to change the viscosity of the liquid adhesive (20), to control the spread of the liquid adhesive (20) throughout the inner surfaces of the two clear panels (10,12).

As the surface area of the combined clear panels (10,12) are larger than the surface area of the horizontal surface of the inverted T-shaped jig (30), the liquid adhesive (20) will continue to spread out wards due to the centrifugal force.

However, the liquid adhesive (20) will only come out at the ends of the clear panels (10,12) but the liquid adhesive (20) will not ooze onto the horizontal surface of the inverted T-shaped jigs (30). In the manner, the horizontal surfaces of these inverted T-shaped jigs (30) are not covered with liquid adhesive (20) and thus kept clean.

After going through the centrifugal station (34), the laminated clear panels (10,12) are transferred to an alignment station (36). Referring to FIG. 6 , the laminated clear panels (10,12) are then aligned to square the two clear panels (10,12) said step being carried out in an alignment station (36). Two methods can be used. The first method uses a side guide that pushes two of the edges together. The other method uses vision to align the target points of the two clear panels (10,12) together. After the alignment stage, a spot cure of the liquid adhesive (20) using UV is carried out along the edges at the corners of the clear panels (10,12).

After the alignment station (36), the clear panels (10,12) are then passed to an autoclave (38). Again the clear panels (10,12) are placed on inverted T-shaped jigs (30) where the surface area of the clear panels (10,12) are greater than the surface area of these inverted T-shaped jigs (30). Referring to Fig 6, compression is applied to the laminated clear panels (10,12) to further spread the liquid adhesive (20). As the surface area of the combined clear panels (10,12) are larger than the surface area of the horizontal surface of the inverted T-shaped jig (30), the liquid adhesive (20) will continue to spread outwards due to the pressure applied. However, the liquid adhesive (20) will only come out at the ends of the clear panels (10,12) but the liquid adhesive (20) will not ooze onto the horizontal surface of the inverted T-shaped jigs (30). In the manner, the horizontal surfaces of these inverted T-shaped jigs (30) are not covered with liquid adhesive (20) and thus kept clean. The amount of compression range from 2 to 7 bar and is based on the viscosity of the liquid adhesive (20) used. Heat treatment may also be used in the autoclave (38), to further change viscosity of the liquid adhesive (20) to control the spread of the liquid adhesive (20) throughout the inner surfaces of the two clear panels (10,12) and to shorten the process. After the autoclave stage, a pre-cure of the liquid adhesive (20) using UV is also carried out to prevent air bubbles from re-forming when the clear panels (10,12) are taken out from the autoclave (38) and subjected to contraction due to lowering of the temperature of the clear panels (10,12).

Referring to Fig 6, the UV cure stage is the last stage of the inventive process. After inspection, the laminated clear panels (10,12) are then placed in the UV chamber (not shown) for a final cure. After completion of the curing of the laminated clear panels (10,12) in the UV chamber (not shown), the lamination process is completed.

Detailed description of Inventive process

The inventive process has to be carried out with a system for the manufacture of laminate clear panels (10,12) using customised machinery. The specification of the customised machinery depends on the size of the clear panels (10,12) to be laminated and the type of laminated clear panel (10,12) to be manufactured.

Without going into details of manufacture of each type of laminated clear panel, a general description of the inventive process using a system for carrying out the inventive process is described below. An embodiment of such a system for carrying out the inventive process is shown in FIG 7.

Preparation of clear panels

The clear panels (10,12) selected for the lamination are prepared and cleaned in accordance to the art.

Dispensing station

The first clear panel (10) is cleaned and then loaded placed horizontally in an inverted T shaped jigs (30) in this station. The surface area of the horizontal surface of the inverted T shaped jig (30) is smaller than the surface area of the clear panels (10,12). The surface of the inverted T-shaped jig (30) may be heated to a predetermined temperature. An predetermined volume of liquid adhesive (20) from a liquid adhesive dispenser (22) is placed around the centre of the inner surface of a first clear panel (10). In applying the liquid adhesive (20), it is preferable to ensure that the liquid adhesive (20) is applied evenly from the centre and with no bubbles or gaps. The predetermined volume of liquid adhesive (20) is based on the shape of the clear panel, its dimension and the type of clear panel material. The dispensing pattern is also based on the

shape and dimension of the clear panel. The predetermined volume is then spread over approximately 60 percent of the inner surface of the first clear panel (10). Any bubble in the liquid adhesive (20) as it is dispensed onto the inner surface of the first clear panel (10) will expand due to the heat and disappear.

Lamination Station (32)

The first clear panel (10) is then transferred to the lamination station (32). A second clear panel (12) is in the meanwhile clean and loaded onto the lamination station (32). The second clear panel (12) is held by a robotic arm using vacuum. The first end of the second clear panel (16) is then tilted so that an angle of approach of 5º is formed between the first end of the second clear panel (16) and the first end of the first clear panel (14), which is laid horizontally. When the angle of approach formed between the first end of the second clear panel (16) and the first end of the first panel (14) is at 5º, the second clear panel (12) which is tilted at this angle, as measured from the first clear panel (10), which is laid horizontally, is then gently lowered with its first end (16) to come close to the first end of the first clear panel (14). However, both first ends (14,16) do not meet. When this is done, the inner surface of the second clear panel (12) is increasingly lowered and brought very close to the inner surface of the first clear panel (10). This second clear panel (12) is lowered until it is laid horizontal and there is a gap of 0.2 mm between its inner surface and the inner surface of the first clear panel (10). The bringing together of the first clear panel (10) and second clear panel (12) so that the inner surfaces of both clear panels (10,12) are close to each other having a gap is to avoid trapping air to form air pockets between the liquid adhesive (20) and the inner surfaces of both clear panels (10,12). The angle of approach formed wherein the first end of second clear panel (16) must be brought close to the first end of the first clear panel (14) could vary depending on the type of clear panel material and its dimensions. As such the angle of approach could vary from 2º to 10º.

Centrifugal Station (34)

After both panels (10,12) have been brought together, the clear panels (10,12) are transferred to a centrifugal station (34). The clear panels (10,12) are held firmly onto inverted T-shaped jigs (30) by means of vacuum. In the centrifugal station

(34), the spread of the liquid adhesive (20) continues, now from the initial 60 to 80% percent of the surface area of the inner surfaces of the two clear panels (10,12). Spread of the liquid adhesive (20) when the two clear panels (10,12) are joined together is determined by height/distance or the gap between the two clear panels (10,12) plus the thickness of the two clear panels (10,12). The height is adjusted so that the spread is approximately 60 to 80 percent after the lamination. The clear panels (10,12) are then spun for a predetermined period of time. The rate of spin and time of spinning in the centrifugal station (34) is set to ensure a further spread of the liquid adhesive (20) now spread out between the two inner surfaces of both clear panels (10,12). The centrifugal station (34) will also have a heater which applies heat to the spinning clear panels, depending on the type of clear panels laminated. The heating is to change the viscosity of the liquid adhesive (20) to control the spread of the liquid adhesive (20) throughout the inner surfaces of the two clear panels (10,12). As the surface area of the combined clear panels (10,12) are larger than the surface area of the horizontal surface of the inverted T-shaped jig (30), the liquid adhesive (20) will continue to spread out wards due to the centrifugal force. Once again, the liquid adhesive (20) will only come out at the ends of the clear panels (10,12) but the liquid adhesive (20) will not ooze onto the horizontal surface of the inverted T-shaped jigs (30). In this manner, the horizontal surfaces of these inverted T-shaped jigs (30) in the centrifugal station (34) are not covered with liquid adhesive (20) and thus kept clean.

The centrifugal force will thus spread the liquid adhesive (20) from the centre towards all sides, until the liquid adhesive (20) covers approximately 90% percent of the inner surfaces of first and second clear panels (10,12). The joined clear panels (10,12) then have to undergo processes in other stations in the system for lamination of clear panels (10,12) to further spread and to further cure the liquid adhesive (20) in the laminated clear panels (10,12).

The average time spent in the centrifugal station (34) for the clear panels (10,12) is 4 minutes. For different size of clear panels (10,12), the average time spent in the centrifugal station (34) ranges from 1 to 4 minutes.

Alignment Station (36)

After going through the centrifugal station (34), the laminated clear panels (10,12) are transferred to an alignment station (36). The laminated clear panels (10,12) are then aligned to square the two clear panels (10,12). Two methods can be used. The first method uses a side guide that pushes two of the edges together. The other method uses vision to align the target points of the two clear panels (10,12) together. A line cure is also carried out during the alignment station (36).

After the alignment stage, a spot cure of the liquid adhesive (20) using UV is carried out along the edges at the corners of the clear panels (10,12).

Autoclave (38)

After the alignment station (36), the clear panels (10,12) are transferred to an autoclave (38). Pressure is applied to the laminated clear panels (10,12) to further spread the liquid adhesive (20) between the inner surfaces of both laminated clear panels (10,12). The amount of pressure range from 2 to 7 bar and is based on the viscosity of the liquid adhesive (20) used. Heat treatment may be is also used in the centrifugal station (34), to further change viscosity of the liquid adhesive (20) to control the spread of the liquid adhesive (20) throughout the inner surfaces of the two clear panels (10,12) and to shorten the process. At the end of the autoclave (38) stage, a pre cure of the liquid adhesive (20) using UV is also carried out to prevent air bubbles from re-forming when the laminated clear panels (10,12) leave the autoclave (38).

The average time spent in the autoclave (38) for the clear panels (10,12) is 4 minutes. For different size of clear panels (10,12), the average time spent in the autoclave (38) ranges from 1 to 4 minutes.

UV Chamber (Not shown)

After the treatment in the centrifugal station (34), the laminated clear panels (10,12) are then transferred to an UV chamber (not shown) to cure the liquid adhesive (20) in the laminated clear panels (10,12). This UV Chamber (not shown) is the last station in the system using the inventive process. By now, the laminated clear panels (10,12) are almost free of air bubbles. After inspection, the

laminated clear panels (10,12) are then placed in the UV chamber (not shown) for a final cure. After completion of the curing of the laminated clear panels (10,12) in the UV chamber (not shown), the lamination process is completed.

The laminated clear panels (10,12) manufactured by the inventive process has almost no air bubbles formed inside the laminated clear panels (10,12) and consequently results in high yields.

While an embodiment of the improved lamination process has been described, it should be apparent, however, that various modifications, rearrangements, substitutions alterations and adaptations to those embodiments may occur to persons skilled in the art with the attainment of some or all of the advantages of the present invention. Accordingly, it should be clearly understood and appreciated by the skilled person that the present inventive process is not intended to be limited by the particular features and structures hereinbefore described and depicted in the accompanying drawings. It is therefore intended to cover all such modifications, alterations and adaptations without departing from the scope and spirit of the present invention as defined by the appended claims.

ADVANTAGEOUS EFFECTS OF THE INVENTION

The invention offers high yields of good laminated panels through

1) No trapped air bubbles
2) No spillage in the process
3) Complete coverage of adhesive through out the clear panel.
4) Very even spread of liquid adhesive

As a consequence, wastage is reduced resulting in cost savings.

CLAIMS

1. An improved process to laminate two clear panels (10,12) in the manufacture of clear display panels used in electronic gadgets and electronic devices, the process consisting of :-

a. applying a liquid adhesive (20) to a first clear panel (10) laid horizontally;
b. removing any air bubbles in the liquid adhesive (20);
c. bringing a first end of a second clear panel (16) at an angle of approach of 2º to a first end of the first clear panel (14) but without the first end of both panels (14,16) touching each other;
d. lowering the other end of the second clear panel (18) until it is placed horizontally over the first clear panel (10)

so that there is a gap between both clear panels (10,12).

2. An improved process to laminate two clear panels (10,12) as claimed in Claim 1, further including the steps of:

e. applying centrifugal force to the first and second clear panels (10,12); and
f. applying pressure to the first and second clear panels (10,12)

in order to spread the liquid adhesive (20) throughout the inner surfaces of both clear panels (10,12) in order to laminate the two clear panels (10,12).

3. An improved process to laminate two clear panels (10,12) as claimed in Claim 1, further including the step of :

g. curing the laminated clear panels (10,12) by UV treatment

so that the liquid adhesive (20) binding the laminated clear panels (10,12) is cured.