

VACUUM MULTI-LAYER GLASS AND ITS MANUFACTURING METHOD

TECHNICAL FIELD

5 The present invention relates to vacuum multilayer glass and its manufacturing method.

BACKGROUND ART

10 A conventional method of manufacturing vacuum multilayer glass will be described below with reference to Figs. 6(a) and 6(b).

 In Fig. 6(a), the peripheries of two glass plates 100 and 101 are sealed with a sealing member 102 therebetween. Then, a glass tube 104 having a low melting point is inserted into an insertion hole 103 of the glass plate 100 and soldered to the glass plate 100 with soldering glass
15 105.

 The other end of the glass tube 104 is connected to a vacuum pump 106 which evacuates the space between the glass plates 100 and 101 and keeps it in a vacuum. Under this condition, the portion of the glass tube 104 which corresponds to the height h_1 is heated and melted by a heating
20 device (a burner, electric heater, or the like).

 In Fig. 6(b), the glass tube 104 is sealed at the height h_1 so as to form a protruding end 104a. This completes the manufacture of vacuum multilayer glass.

25 On the other hand, Japanese Patent Application No. 5-501896 "THERMAL INSULATING GLASS PANEL AND ITS CONSTRUCTION METHOD" discloses another conventional method of manufacturing vacuum multilayer glass. This manufacturing method will be described below.

30 Figs. 7(a) and 7(b) show the manufacturing method of vacuum multilayer glass.

In Fig.7 (a), the peripheries of two glass plates 110 and 111 are sealed with a sealing material 112 therebetween. Then, a short glass tube 114 is soldered to a spot facing surface 113 provided on the top glass plate 110 by a soldering glass 115.

5 The glass short tube 114 is covered with a vacuum-drawing chamber 116, and an exhaust pipe 117 is attached to the vacuum-drawing chamber 116. A vacuum is drawn on the vacuum-drawing chamber 116 with a vacuum pump through the exhaust pipe 117, so as to exhaust the air in the space between the two glass plates 110 and 111 through the
10 glass short tube 114.

The top of the glass short tube 114 is heated and melted by a localized heating device (a localized heater, infrared lamp, or the like) which is provided inside the vacuum-drawing chamber 116.

In Fig. 7(b), the opening of the protruding end 114a of the glass
15 short tube 114 is sealed. Thus, the opening of the glass short tube 114 is sealed and the manufacture of the vacuum multilayer glass is completed.

In Fig. 7(a), the spot facing surface 113 has a depth a_1 from the thickness center of the glass plate 100.

In Figs. 6(a)-6(b), when the glass tube 104 is melted by the heating
20 device, if the melting position of the glass tube 104 is close to the glass plate 100, the soldering glass 105 is heated and melted, causing a vacuum leak. To avoid this, the height h_1 must be large enough. Consequently, the glass tube 104 has a high protrusion. The high protrusion of the glass tube 104 causes a problem that when the vacuum multilayer glass
25 is used as a house windowpane, the glass tube 104 touches the sash frame when the window is opened or closed.

In Figs. 7(a)-7(b), the glass short tube 114 is heated and melted by the localized heating device provided above the glass short tube 114, so as to seal the opening of the glass short tube 114. Therefore, it is necessary
30 to control the heat capacity of the localized heating device so that the

soldering glass 115 and the part of the glass plate 110 around the soldering glass 115 are not heated and melted while the localized heating device is being used. Consequently, it is inevitable to use the glass short tube 114 having a small outer diameter. However, the use of the glass short tube 114 having a small outer diameter causes a problem that the glass short tube 114 may be broken while it is being handled.

In addition, when the glass short tube 114 has a small inner diameter, the exhaust resistance inside the glass short tube 114 becomes larger, so that it takes time to reach a predetermined degree of vacuum.

Furthermore, when the space between the two glass plates 110 and 111 is in a vacuum, the glass plates 110 and 111 are warped by the atmospheric pressure so that their centers become concave. As a result, a tensile stress acts on the portion below half the thickness of the glass plate 110, whereas a compressive stress acts on the portion above half the thickness of the glass plate 110. Since the space facing surface 113 of the glass plate 110 is formed at the level lower than half the glass thickness by a_1 , a tensile stress acts on the stage portion of the spot facing surface.

Generally, glass plates are resistant to compression and vulnerable to tensility, so that it is not preferable in view of the durability of glass plates to provide a spot facing surface at the level on which a tensile stress acts as in Fig. 7(a).

In Fig. 7(a), a spot facing process is needed in addition to a drilling process, which results in a decrease in the production efficiency.

Therefore, the first object of the present invention is to provide vacuum multilayer glass with excellent durability by making the protruding end of the glass short tube be short enough to prevent the glass short tube from being damaged while it is handled, and further to provide the manufacturing method of the vacuum multilayer glass.

The second object of the present invention is to provide vacuum multilayer glass having further excellent durability by setting the base of

the glass tube on the level on which a compressive stress is applied, and further to provide the manufacturing method of the vacuum multilayer glass.

5 DISCLOSURE OF THE INVENTION

In order to solve the above-mentioned problems, in the vacuum multilayer glass of the present invention where the peripheries of two glass plates are sealed with a spacer therebetween and a vacuum is drawn on the space between the two glass plates, there are features that
10 a glass tube is provided on the main surface of one of the glass plates so as to evacuate the space, the opening of the glass tube is sealed by a melting method after the space is evacuated, and the distance between the main surface of the glass plate and the protruding end of the glass tube is made not longer than 3mm.

15 According to this construction, when the vacuum multilayer glass is used as a house windowpane, the glass tube does not touch the sash frame when the window is opened or closed. As a result, there is no fear of the glass short tube being damaged while it is handled. Thus, it becomes possible to provide vacuum multilayer glass with excellent
20 durability.

When the base of the glass tube is attached to the main surface of one of the glass plate, the depth of insertion can be smaller than half the thickness of the glass plate.

Consequently, when the hole into which the glass tube is inserted
25 has a stage, the stage is on the level not exceeding half the thickness of the glass plate. By evacuating the space between the two glass plates, the two glass plates are warped by the atmospheric pressure and their centers become concave, so that a compressive stress acts on the stage of the stage-provided hole. Since glass plates are generally resistant to
30 compression, they do not conveniently suffer from a decrease in

durability.

In the method of manufacturing vacuum multilayer glass of the present invention where the peripheries of two glass plates are sealed with a spacer therebetween, then the space between the two glass plates is evacuated through a glass tube attached to the main surface of one of the glass plates, there is a feature that a thermal insulation member is attached in the middle of the glass tube before the melting of the opening, so as to prevent the heat generated while the opening is being melted from reaching the glass plate.

10 The thermal insulation member attached in the middle of the glass tube before the melting of the opening enables the radiant heat generated during the melting of the opening to be prevented from reaching the soldering glass or the part of the glass plate around the soldering glass. As a result, the melting position of the glass tube can be closer to the glass plate.

15 Therefore, when the opening of the glass tube is sealed by melting, the distance from the main surface of the glass tube to the protruding end of the glass tube can be shorter than 3mm. As a result, when the vacuum multilayer glass is used as a house windowpane, the glass tube does not touch the sash frame when the window is opened or closed.

20 Furthermore, the outer diameter of the glass tube can be made larger because the soldering glass and the part of the glass plate around the soldering glass are not melted even if the heat capacity during the melting is increased. As a result, the glass tube can be prevented from being damaged while it is handled, which results in an increase in the productivity.

The thermal insulation member is preferably made from a metal or a fire-resistant material.

30 The thermal insulation member can improve its oxidation resistance and extend the life by being made from a metal (a noble metal such as

platinum or rhodium, stainless, molybdenum, tantalum, or niobium) or a fire-resistant material (such as a mica lamination plate or aluminum oxide).

It is preferable that the melting of the opening of the glass tube is
5 conducted in a vacuum.

By conducting the melting of the opening of the glass tube in a vacuum, the thermal insulation member is less oxidized and corroded than it is in the air when heated to a high temperature, thereby lengthening its life to a large extent.

10 In addition, in a vacuum, the heat of the heat insulation member is not directly conducted to the soldering glass, which is made not to be in contact with the heat insulation member, so that the soldering glass is prevented from being easily melted.

15 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of the vacuum multilayer glass of the present invention.

Fig. 2 is a cross section taken along the line 2-2 of Fig. 1.

Figs. 3(a)-3(c) show the first manufacturing process of the vacuum
20 multilayer glass of the present invention.

Figs. 4(a)-4(c) show the second manufacturing process of the vacuum multilayer glass of the present invention.

Figs. 5(a)-5(b) show the elastic deformation of the vacuum multilayer glass of the present invention.

25 Figs. 6(a)-6(b) show the manufacturing method of a conventional vacuum multilayer glass.

Figs. 7(a)-7(b) show the manufacturing method of another conventional vacuum multilayer glass.

30 BEST MODE FOR CARRYING OUT THE INVENTION

The embodiment of the vacuum multilayer glass of the present invention will be detailed with reference to the drawings. These drawings are supposed to be seen in the direction indicated by the reference numbers.

5 Fig. 1 is a perspective view of the vacuum multilayer glass of the present invention.

 The vacuum multilayer glass 1 comprises a first glass plate 2 and a second glass plate 3 which are disposed with a fixed space therebetween, a sealing member 4 for sealing the peripheries of the first and second
10 plates 2 and 3, and an exhaust unit 5 attached to the main surface of the first plate 2 for evacuating the space between the first and second plates 2 and 3.

 Fig. 2 is a cross section taken along the line 2-2 of Fig. 1.

 The exhaust unit 5 comprises a stage-provided hole 6 which has a
15 stage 6a on the level higher than half the thickness t of the first glass plate 2 (in other words, higher than the center line c), a glass short tube 7 which is inserted into the stage-provided hole 6 and whose protruding end 7a is sealed by melting, and soldering glass 8 for soldering the glass short
20 tube 7 to the first glass plate 2. The protruding end 7a of the glass short tube 7 has a height h which is not larger than 3mm.

 The stage-provided hole 6 consists of a larger diameter portion 6b and a smaller diameter portion 6c. The specific sizes of these diameters will be described later. The hole diameter of the larger diameter portion 6b is made slightly larger than the outer diameter of the glass short tube
25 7. The hole diameter of the smaller diameter portion 6c is made smaller than the outer diameter of the glass short tube 7 so as to prevent the glass short tube 7 from coming off from the smaller diameter portion 6c, and also made to have an appropriate size so that it does not take too much time to draw the vacuum.

30 The soldering glass 8 is formed either by pressing and burning

power and forming it into a ring or by kneading powder into a paste.

The manufacturing method of the vacuum multilayer glass of the present invention will be described as follows.

5 Figs. 3(a)-3(c) show the first manufacturing process of the vacuum multilayer glass of the present invention. In Fig. 3(a), the stage-provided hole 6 is formed in the first glass plate 2. Since the larger diameter portion 6b and the smaller diameter portion 6c of the stage-provided hole 6 can be processed at the same time in a single drilling process with a stage-provided drill, the process of the conventional spot facing (refer to Fig. 7(a)) becomes unnecessary, and the production efficiency is improved.

10 Then, the first glass plate 2 and the second glass plate 3 are disposed with a fixed space therebetween, and the peripheries of these glass plates 2 and 3 are sealed with the sealing material 4 (refer to Fig 1) therebetween.

In Fig. 3(b), the glass short tube 7 is inserted into the stage-provided hole 6 of the first glass plate 2, and the ring-shaped soldering glass 8 is provided around the glass tube. The soldering glass 8 may be applied in the state of a paste.

20 In Fig. 3(c), the soldering glass 8 is burned in a kiln and used to solder the glass short tube 7 to the first glass plate 2.

Figs. 4(a)-4(c) show the second manufacturing process of the vacuum multilayer glass of the present invention. In Fig. 4(a), a thermal insulation board (thermal insulation member) 10 with a hole is inserted
25 into the glass short tube 7.

The thermal insulation board 10 can be round, rectangular, or polygonal as long as it is a plate having a hole in the center. However, the outer diameter of the hole of the thermal insulation board 10 must be larger than the spot diameter d of the infrared radiant heater 11 shown in
30 Fig. 4(b).

The hole diameter of the thermal insulation board 10 is made to be large enough to prevent the glass short tube 7 from adhering to the thermal insulation board 10 when it is melted, and also made to have an appropriate size so as to prevent the infrared rays from going through the hole of the thermal insulation board 10 and melting the soldering glass 8 below the thermal insulation board 10. The thermal insulation board 10 is preferably made from either a metallic material (a noble metal such as platinum or rhodium, iron, molybdenum, tantalum, niobium, or an alloy such as stainless) or a fire-resistant material (such as a mica lamination plate or aluminum oxide). This is because stainless, platinum, and a mica lamination plate have excellent high-temperature and oxidation resistance. When the thermal insulation board 10 made from a metal is used, it is necessary to prevent the thermal insulation board 10 from being in contact with the soldering glass 8. This is because their contact might cause the heat of the thermal insulation board 10 to be directly conducted to the soldering glass 8 and to melt it.

In Fig. 4(b), a vacuum-drawing chamber 13 is fixed on the first glass plate 2 with an O-ring 12 therebetween in the vicinity of the exhaust unit 5. The exhaust unit 5 is covered with the vacuum-drawing chamber 13. The vacuum-drawing chamber 13 is provided with an infrared-permeable glass 14 (quartz glass or the like) on its upper window.

The vacuum-drawing chamber 13 is evacuated through the exhaust pipe 15, so as to exhaust the air in the space between the first and second glass plates 2 and 3 in the direction indicated by the arrow. As the result, the space between the first and second glass plates 2 and 3 is under vacuum.

Then, infrared rays 11a are emitted from the infrared radiant heater 11 which is placed above the infrared-permeable glass 14.

In Fig. 4(c), the protruding end 7a of the glass short tube 7 is melted by the infrared rays 11a so as to seal the top end of the glass short tube 7.

In this case, the thermal insulation board 10 reflects the infrared rays 11a which go straight around the glass short tube 7 so as to prevent these infrared rays 11a from reaching the soldering glass 8.

5 The vacuum-drawing chamber 13 shown in Fig. 4(b) is then removed from the first glass plate 2, and the thermal insulation board 10 is removed from the glass short tube 7, thereby completing the manufacture of the vacuum multilayer glass 1.

Figs. 5(a)-5(b) show the elastic deformation of the vacuum multilayer glass of the present invention.

10 In Fig. 5(a), since the glass short tube 7 is inserted as deep as the level not exceeding half the thickness of the first glass plate 2, the stage 6a of the stage-provided hole 6 is positioned higher than the center line c of the first glass plate 2 by the distance a.

In Fig. 5(b), when the space between the first and second glass
15 plates 2 and 3 is evacuated, the first and second glass plates 2 and 3 are warped by the atmospheric pressure and their centers become concave. As a result, the tensile stress $\sigma 1$ is generated below the center line c of the first glass plate 2 whereas the compressive stress $\sigma 2$ is generated above the center line c. On the stage unit 6a of the first glass plate 2, the
20 compressive stress $\sigma 2$ is applied.

Since glass plates are generally resistant to compression, the first glass plate 2 does not suffer from a decrease in durability.

In the above embodiment, the protruding end 7a of the glass short tube 7 is melted by using the infrared radiant heater 11; however, the
25 heater 11 can be replaced by a hot blast generator, an infrared laser, or the like.

EXAMPLE

An example of the present invention will be described with reference
30 to Table 1 below.

TABLE 1

	first glass (thickness)	3.0mm
	second glass (thickness)	3.0mm
	stage-provided hole	
5	larger diameter portion (hole diameter)	2.2mm depth:1.5mm
	smaller diameter portion (hole diameter)	1.5mm
	glass short tube outer diameter	2.0mm
	inner diameter	1.5mm
	length	4.0mm
10	thermal insulation board (hole diameter)	2.5mm
	protruding end of glass short tube (height)	2.8mm

- The first and second glass plates 2 and 3 which compose the vacuum multilayer glass 1 both have a thickness of 3.0mm. The stage-provided
- 15 hole 6 formed in the first glass plate 2 has a larger diameter portion 6b whose hole diameter and depth are 2.2mm and 1.5mm, respectively, and a smaller diameter portion 6c whose hole diameter is 1.5mm. The glass short tube 7 to be inserted in the stage-provided hole 6 has an outer diameter of 2.0mm, an inner diameter of 1.5mm. and a length of 4.0mm.
- 20 The thermal insulation board 10 to be attached to the glass short tube 7 has a hole diameter of 2.5mm.

When the top end of the glass short tube 7 was melted under these conditions, the protruding end 7a of the glass short tube 7 had a height of 2.8mm. This value is much smaller than the target value: 3mm.

What is claimed is:

1. Vacuum multilayer glass comprising:

two glass plates (2, 3) whose peripheries are sealed with a spacer
5 therebetween, said two glass plates having a space therebetween on
which a vacuum is drawn; and

a glass tube (7) which is provided on a main surface of said glass
plate (2) in order to evacuate said space and which includes an opening
sealed by a melting method after said space is evacuated, a distance
10 between the main surface of said glass plate (2) and a protruding end of
said glass tube (7) being not longer than 3mm.

2. The vacuum multilayer glass of claim 1, wherein

when a base of said glass tube (7) is attached to the main surface of
15 said glass plate (2), a depth of insertion is smaller than half a thickness of
said glass plate (2).

3. The vacuum multilayer glass of claim 2, wherein

said glass plate (2) comprises a stage-provided hole (6) having a
20 stage (6a) on a level higher than half a thickness (t) of said glass plate (2),
and

said stage-provided hole (6) comprises a larger diameter portion (6b)
which is slightly larger than an outer diameter of said glass tube (7) and a
smaller diameter portion (6c) which is smaller than the outer diameter of
25 said glass tube (7) and which has an appropriate size so that it does not
take too much time in drawing a vacuum.

4. The vacuum multilayer glass of claim 3, wherein

a soldering glass (8) for soldering said glass tube (7) inserted into
30 said stage-provided hole (6) to said glass plate (2) is formed on said glass



plate (2) so as to seal a point where said glass tube (7) is in contact with said glass plate (2).

5. A method of manufacturing vacuum multilayer glass comprising the steps of:

sealing peripheries of two glass plates with a spacer therebetween;
attaching a glass tube on a main surface of one of said glass plates, a space between said two glass plates being evacuated through said glass tube;

10 melting and sealing an opening of said glass tube; and
attaching a thermal insulation member in a middle of said glass tube prior to the step of melting and sealing the opening of said glass tube so as to prevent heat generated while the opening of said glass tube is melted from reaching said glass plate.

15 6. The method of manufacturing vacuum multilayer glass of claim 5, wherein

the step of melting and sealing the opening of said glass tube is carried out so as to make a distance between the main surface of said glass plate and a protruding end of said glass tube not longer than 3mm, and when a base of said glass tube is inserted into the main surface of one of said two glass plates, a depth of insertion is made smaller than half a thickness of said one of said two glass plates; and

20 the step of attaching said glass tube on the main surface of said one of said two glass plates includes providing soldering glass around said glass tube and burning said soldering glass.

7. The method of manufacturing vacuum multilayer glass of claim 6, wherein

30 a hole diameter of said thermal insulation member is large enough



to prevent said glass tube from adhering to said thermal insulation member in the step of melting and sealing the opening of said glass tube and has an appropriate size to prevent heat for melting said glass tube from going through a hole of said thermal insulation member and melting
5 said soldering glass below said thermal insulation member.

8. The method of manufacturing vacuum multilayer glass of claim 5, wherein
said thermal insulation member is made from a metal and more
10 preferably made from a noble metal or a fire-resistant material.

9. The method of manufacturing vacuum multilayer glass of claim 5, wherein
the step of melting and sealing the opening of said glass tube is
15 carried out in a vacuum.

10. The method of manufacturing vacuum multilayer glass of claim 9, wherein
the step of melting and sealing the opening of said glass tube in a
20 vacuum is carried out by using a vacuum-drawing chamber provided with an infrared-permeable glass on a top surface thereof and an infrared rays heater.

