

GLASS FORMING DEVICE

The present invention relates to a glass forming device to be used for producing sheet glass by an overflow downdraw process.

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Sheet glass having a small thickness of, for example, 0.5 to 0.7 mm is used for glass substrates of a flat panel display (hereinafter referred to as "FPD") such as a liquid crystal display and a plasma display. Such sheet glass for FPD glass substrates has a large size of, for example, 300×400 mm in the first generation, and 2850×3050 mm in the tenth generation.

10 In order to produce the sheet glass for FPD glass substrates, an overflow downdraw process is most commonly used. In the overflow downdraw process, a belt-shaped glass ribbon is formed continuously by passing molten glass through a glass forming device. At that time, the glass ribbon is drawn downwardly, and the thickness thereof is adjusted by the drawing speed. Thereafter, the glass ribbon is cut into a predetermined length, so that sheet glass is produced.

15 For example, JP 2003-313034 A describes a glass forming device 10 as shown in FIG. 6. The glass forming device 10 includes a cross-sectionally wedge-shaped body 11 extending in a predetermined direction, and a pair of guides 12 that regulate the width of molten glass flowing down along both wall surfaces 11a of the body 11.

20 The glass ribbon 15 to be formed by the glass forming device 10, as shown in FIG. 7 A, preferably has a uniform thickness across ear portions 15a that are both edges in the width direction. However, according to the glass forming device 10 described in Patent Literature 1, when molten glass at the tip (lower edge portion) of the glass forming device 10 has a viscosity of, for example, about 50,000 Pa·s (1,100°C), as shown in FIG. 7 B, each ear portion 15a may spread in a two-pronged manner while waving in the longitudinal direction of the glass ribbon. Thus spread ear portions 15a may cause a defective shape of the glass ribbon 15 or a crack thereof that hinders the continuous operation.

25 In order to prevent this, it is effective to decrease the viscosity of the molten glass at the tip of the glass forming device 10 to, for example, about 4,000 Pa·s (1,200°C) and thereby to improve the fluidity of the molten glass. However, if the temperature of the molten glass is increased to decrease the viscosity of the molten glass as aforementioned, the life span of the glass forming device 10 that is mainly made of fire brick and thus expensive is shortened.

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In view of such circumstances, it is an object of the present invention to provide a glass forming device capable of forming a glass ribbon having ear portions in a stable shape even if molten glass has a relatively high viscosity.

5 The inventors of the present invention focused on the shape of the guides in order to achieve the object, and thought that it might be possible to prevent the ear portions from spreading, as above mentioned, by devising the shape of the guides. Specifically, in the glass forming device 10 described in Patent Literature 1, as shown in FIG. 6, guides 12 each have a rectangular contour and its lower edge is flat, so that the molten glass is separated from the body while being in contact with the guides. The inventors of the present invention then conceived the idea of improving this.

The present invention has been accomplished from such a viewpoint, and provides a glass forming device including: a body having an upper surface formed with a supply channel to be supplied with molten glass, and a pair of wall surfaces 15 that lead and fuse the molten glass flowing over both sides of the supply channel from the supply channel along the upper surface and flowing down from both edges of the upper surface; and a pair of guides facing each other that regulate the width of the molten glass flowing down along the pair of the wall surfaces. In the glass forming device, the pair of the guides each have a downwardly sharpened contour with a vertex being located on a ridge line that is formed by the intersection of each 20 lower edge of the pair of the wall surfaces, when viewed in the direction in which the pair of the guides face each other.

According to the aforementioned configuration, the guides each have a downwardly sharpened contour, and the vertex thereof is located on the ridge line 25 formed by the intersection of each lower edge of the pair of the wall surfaces. Therefore, the portion of the molten glass in contact with the guides flows toward the ridge line while reducing the contact area with the guides, and eventually is separated from the body in the state where the contact area is zero. Thus, it is possible to form a glass ribbon having ear portions in a stable shape even if the 30 molten glass has a relatively high viscosity.

FIG. 1 is a front view showing a glass forming device according to one embodiment of the present invention.

FIG. 2 is a perspective view showing the glass forming device of FIG. 1.

35 FIG. 3 is a side sectional view showing the glass forming device of FIG. 1.

FIG. 4 A is an enlarged view of the main portion of FIG. 3, FIG. 4 B is an enlarged sectional view of the main portion of a conventional glass forming device.

FIGs. 5 A to 5C each are a side sectional view showing a glass forming device of a modified embodiment.

FIG. 6 is a perspective view showing the conventional glass forming device.

FIG. 7 A is a sectional view showing a glass ribbon having a normal shape, and FIG. 7 B is a sectional view showing a glass ribbon having an ear portion in a defective shape.

Hereinafter, embodiments for carrying out the present invention is described with reference to the drawings. It should be noted that the following descriptions merely concern an example of the present invention and do not limit the present invention thereto.

As shown in FIG. 1 and FIG. 2, a glass forming device 1 according to one embodiment of the present invention includes a body 2 unidirectionally extending on a horizontal plane, and a pair of guides 3 fixed to the body 2. In this description, the direction in which the body 2 extends (the lateral direction in FIG. 1) is referred to as the front-rear direction, and the horizontal direction orthogonal to this is referred to as the lateral direction, for convenience of description. Particularly, the left side of FIG. 1 is referred to as the front, and the right side of FIG. 1 is referred to as the rear.

The body 2 has a downwardly sharpened and pentagonal wedge-shaped cross section (in a narrow home plate shape), an oblong upper surface 21 in parallel with the horizontal plane, and a pair of wall surfaces 23 extending downwardly from both edges in the lateral direction of the upper surface 21. The upper surface 21 is not necessarily in parallel with the horizontal plane, which may be, for example, a curved surface or an inclined surface descending toward the front.

The upper surface 21 is formed with a supply channel 22 extending in the front-rear direction. The length of the supply channel 22 is set so as to be about the same as or slightly shorter than that of the upper surface 21, and an opening 22a of the supply channel 22 has an oblong shape with a size smaller than the upper surface 21. Further, a bottom surface 22b of the supply channel 22 is an inclined surface ascending toward the front. The bottom surface 22b may be a curved surface bending and ascending toward the front.

In addition, the supply channel 22 is not necessarily cross-sectionally U-shaped having the bottom surface 22b, which may be, for example, cross-sectionally V-shaped.

Molten glass 5 is supplied to the supply channel 22 through a supply tube, which is not illustrated, from the rear side of the body 2. When the molten glass 5

is supplied from the not illustrated supply tube into the supply channel 22, the molten glass 5 flows inside the supply channel 22 toward the front and flows over the supply channel 22 to both lateral sides along the upper surface 21 so as to flow down from both lateral edges of the upper surface 21.

5 The pair of wall surfaces 23 function to lead and fuse the molten glass 5 flowing down from both lateral edges of the upper surface 21, and a ridge line 24 extending in the front-rear direction is formed by the intersection of each lower edge of the pair of the wall surfaces 23. Specifically, each of the pair of the wall surfaces 23 includes a perpendicular surface 23a hanging perpendicularly from the left edge
10 or right edge of the upper surface 21 and an inclined surface 23b inclining inwardly from the lower edge of the perpendicular surface 23a so as to approach each other. Then, the molten glass 5 flowing down from both lateral edges of the upper surface 21 flows down along each wall surface 23, and is fused with each other below the ridge line 24. Thus, a belt-shaped glass ribbon 50 is formed continuously.

15 The pair of guides 3 each have a flat plate shape in the front-rear direction, facing each other in the front-rear direction, and function to regulate the width of the molten glass 5 flowing down along both the wall surfaces 23. The pair of guides 3 each have an internal surface (the surface facing the other guide 3) 3a disposed at a position corresponding to the short side in the front-rear direction of
20 the opening 22a of the supply channel 22. Further, the pair of the guides 3 each have a downwardly sharpened contour with a vertex being located on the ridge line 24 formed by the intersection of each wall surface 23, when viewed in the front-rear direction as shown in Fig. 3. That is, a downwardly sharpened tip 33 of each guide 3 is located on the ridge line 24. In this embodiment, the contour of each guide 3
25 forms a bilaterally symmetrical heptagon with three upper sides perpendicularly intersecting each other and four lower sides being oblique.

 More specifically, each guide 3 has vertical guide portions 32 extending longitudinally along each of the pair of the wall surfaces 23 and a horizontal guide portion 31 located on the upper surface 21 of the body 2 and connected to the upper
30 ends of the vertical guide portions 32. Furthermore, the vertical guide portions 32 each include a perpendicular portion 32a extending along the perpendicular surface 23a and an inclined portion 32b extending along the inclined surface 23b. Then, a predetermined area of the lower part of the inclined portion 32b (from the tip 33 to about one-third of the inclined portion 32b) is sharpened toward the ridge line 24,
35 and the vertical guide portions 32b are tapered downwardly.

 Subsequently, the operation of the glass forming device 1 of this embodiment is described.

First, the operation of the conventional glass forming device 10 shown in FIG. 6 is described with reference to FIG. 4 B for comparison. In the conventional glass forming device 10, since a lower edge 12a of the guide 12 is flat, molten glass is separated from a body 11 while being in contact with the guide 12. From
5 another point of view, the portion of the molten glass in contact with the guide 12 flows down while traveling not only on the wall surface 11a but also on the guide 12, so that the downflow direction thereof is not a direction along the wall surface 11a but a slightly outward direction, as indicated by an arrow b in FIG. 4 B. This causes the trajectory L_2 of the portion of the molten glass in contact with the guide
10 12 to spread more than the trajectory L_1 in the center of the glass forming device 10.

In contrast, since the glass forming device 1 of this embodiment has the tip 33 of the downwardly sharpened guide 3 located on the ridge line 24, as shown in FIG. 4 A, the portion of the molten glass 5 in contact with the guide flows toward the ridge line 24 while reducing the contact area with the guide 3. That is, the
15 portion of the molten glass 5 in contact with the guide 3 flows down while traveling on the inclined portion 32b of the guide 3, thereby converging toward the ridge line 24, as indicated by an arrow a in FIG. 4 A. Then, the portion of the molten glass 5 in contact with the guide 3 is eventually separated from the body 2 in the state where the contact area with the guide 3 is zero. For this reason, it is possible to
20 form a glass ribbon 50 having ear portions 50a in a stable shape, as shown in FIG. 7A, even if the molten glass 5 has a relatively high viscosity of, for example, about 100,000 Pa·s (1,050°C).

It should be noted that, in the above-mentioned embodiment, although the contour of the guide 3 is heptagonal when viewed in the front-rear direction, the
25 contour of the guide 3 is not specifically limited, as long as it is sharpened downwardly with a vertex being located on the ridge line 24. For example, as shown in FIG. 5 A, the inclined portion 32b is entirely sharpened toward the ridge line 24, so that the contour of the guide 3 is pentagonal.

Further, the shape in which the lower part or the entire of the inclined
30 portion 32b is sharpened toward the ridge line 24 is not necessarily sharp triangular, and for example, the outward sides may be arcuate, as shown in FIG. 5 B.

Furthermore, the vertical guide portion 32 may be tapered downwardly, for example, as shown in FIG. 5 C, with a curved line continuously extending from the perpendicular portion 32a over the inclined portion 32b.

35 In addition, the guide portion 3 does not necessarily have a flat plate shape in the front-rear direction, as long as the portion of the internal surface 3a intersecting with the wall surface 23 is orthogonal to the wall surface 23. For

example, the guide portion 3 may have a shape in which the center of the horizontal guide portion 31 outwardly projects in the same manner as in the conventional glass forming device 10 shown in FIG. 6, or may have a three-dimensional shape in which the outward surface is convex outwardly.

5 The present invention is particularly suitably used for a glass forming device for producing sheet glass for FPD glass substrates.

 The invention may be embodied in other forms without departing from the spirit or essential characteristics thereof. The embodiments disclosed in this specification are to be considered in all respects as illustrative and not limiting.

10 The scope of the invention is indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.

CLAIMS

1. A glass forming device comprising:
 - a body having an upper surface formed with a supply channel to be supplied with molten glass, and a pair of wall surfaces that lead and fuse the molten glass flowing over both sides of the supply channel from the supply channel along the upper surface and flowing down from both edges of the upper surface; and
 - a pair of guides peripherally protruding from the body so as to face each other, the pair of guides regulating a width of the molten glass flowing down along the pair of the wall surfaces, wherein
 - the pair of the guides each have a contour downwardly sharpened at an angle greater than that of the body with a vertex being located on a ridge line that is formed by an intersection of each lower edge of the pair of the wall surfaces, when viewed in the direction in which the pair of the guides face each other.
2. The glass forming device according to claim 1, wherein
 - the pair of the guides each have vertical guide portions extending longitudinally along each of the pair of the wall surfaces and a horizontal guide portion located on the upper surface of the body and connected to upper ends of the vertical guide portions, and
 - the vertical guide portions are tapered downwardly.
3. The glass forming device according to claim 2, wherein
 - each of the pair of the wall surfaces includes a perpendicular surface hanging perpendicularly from an edge of the upper surface and an inclined surface inclining from a lower edge of the perpendicular surface,
 - the vertical guide portions each include a perpendicular portion extending along the perpendicular surface and an inclined portion extending along the inclined surface, and
 - a predetermined area of the lower part of the inclined portion is sharpened toward the ridge line.