

PATENT SPECIFICATION

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(19)



(54) IMPROVEMENTS IN OR RELATING TO THE MANUFACTURE OF FLAT GLASS

(71) We, PILKINGTON BROTHERS LIMITED, a Company incorporated under the laws of Great Britain, of 201-211 Martins Building, Water Street, Liverpool L2 5 3SR, England and GEORGE ALFRED DICKINSON of Bryn Mair, Prescot Road, St. Helens, Lancashire, England and FRANK NIXON of 17 Powell Drive, Billinge, Lancashire, England, both British Subjects, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

15 This invention relates to the manufacture of flat glass by the float process in which molten glass is delivered at a controlled rate on to a bath of molten metal and the glass is advanced in ribbon form along the bath and cooled as it is advanced until it is sufficiently stiffened to be taken un-
20 harmed from the bath.

The need for increasing the throughput of glass through a float glass manufacturing installation designed for high load operation, for example a throughput of glass of from 3,000 tonnes per week to 4,200 tonnes per week, has necessitated in-
25 crease in the speed of the ribbon of float glass discharged from the installation.

The resulting acceleration of the glass while it is still molten on the bath tends to cause undue reduction in ribbon width and thickness. Loss of ribbon width and thick-
35 nes can be countered by increasing the rate of cooling of the glass as the ribbon of glass is being formed. Too high a cooling rate at the hot end of the bath has been found to introduce undesirable dis-
40 tortion into the glass.

It has also been found that when producing thinner float glass, for example 5 mm or 4 mm thick, under high load conditions, the ribbon width can be main-
45 tained by increasing the rate of delivery of

molten glass to the bath, but as the speed of discharge of the ribbon is increased to accommodate the higher throughput there is a tendency for too great a reduction in ribbon thickness. This can be countered to
50 a certain extent by hot end cooling.

However under high load conditions it has now been discovered that for each required glass thickness, at higher speeds than a certain speed of ribbon discharge an
55 increase in the amount of hot end cooling is ineffective to retain the required thickness in the ribbon produced by the accelerating glass, and can be detrimental to the quality of the float glass product.

It is a main object of the present invention to provide an improved method of operating the float process under high load conditions, in which the use of coolers at the hot end of the bath is minimised.
60

The invention is based on the discovery that, under high load conditions, the molten glass can be accelerated as it is spreading on the molten metal bath, by forces which also serve to compensate for any
65 tendency to excessive attenuation and thereby maintain the desired glass thickness even though the glass is being accelerated for discharge at high speed from the bath.

Accordingly the invention provides a method of manufacturing flat glass in ribbon form on a bath of molten metal, comprising delivering molten glass to the bath at a rate which develops an advancing
75 layer of molten glass on the bath, permitting the layer of molten glass to spread laterally on the bath, applying forces each having inwardly and forwardly directed components to the margins of the spread
80 molten glass layer to regulate the extent of that maximum spread, to accelerate the glass, and simultaneously to impose a controlled reduction in width on the forwardly
85 flowing ribbon of glass which is effective to
90

[Price 25p]

SPECIFICATION AMENDED - SEE ATTACHED SLIP

retain the glass at a thickness which is thereafter reduced to a required thickness by the influence of applied preparatory to discharge from the bath.

5 The forces, in a preferred method of operating the invention, are operative to accelerate the spread molten glass to a speed which is less than the speed of discharge of the ultimate ribbon of glass from the bath, by an amount which ensures the required ribbon thickness is achieved.

10 Further change in thickness of the glass following the acceleration of the glass is thereby controlled and the dimensions of the ribbon can be stabilised at a location relatively near to the inlet end of the bath so that the effective length of the bath and its containing tank structure and roof structure can be shortened.

20 The invention particularly provides a method of manufacturing float glass of thickness in the range 5.7 mm to 6.2 mm at high load, comprising regulating said forces to accelerate the molten glass to a forward speed about twice the initial speed of the advancing layer of molten glass, regulating the effective inward angle of the applied forces to maintain the accelerated glass at a desired thickness, and cooling the accelerated glass to stabilise the glass at that thickness.

In one way of operating, the invention comprises applying said marginal forces to the glass at two locations spaced apart along the bath, and setting an inward angle of application of said forces at the first location different from that at the second location considered in the direction of advance of the glass.

40 Further the invention provides apparatus for use in the manufacture of float glass by the above-mentioned method comprising a tank structure containing a bath of molten metal, means at the inlet end of the bath for delivering molten glass to the bath and advancing the glass along the bath, traction means at the outlet end of the bath for discharging the ultimate float ribbon from the bath, inclined top rolls spaced from the inlet end of the bath by a distance just permitting spread of the molten glass on the bath, and positioned to engage the margins of the glass with axes converging towards the inlet end of the bath to apply marginal forces each having inwardly and forwardly directed components to the glass to influence said spread of molten glass.

60 Said inclined top rolls may comprise two pairs of top rolls, the rolls of one pair being set at a different angle with respect to the direction of advance of the glass to that of the rolls of the other pair.

65 The invention also comprehends flat glass produced by the method described

above.

In order that the invention may be more clearly understood an embodiment thereof will now be described by way of example with reference to the accompanying drawings, in which:—

Figure 1 is illustrated in plan view of a tank structure for operating the float process under high load conditions with the customary roof structure removed, and showing one pair of angled edge rolls bearings on the margins of the molten glass, and

Figure 2 is a view similar to Figure 1 illustrating the operation of the process with two pairs of edge rolls.

Referring to Figure 1 a bath of molten metal 1 is contained in a tank comprising side walls 2, an end wall 3 at the inlet end of the structure and an end wall 4 at the outlet end. The bath of molten metal may be a bath of molten tin or of a tin alloy in which tin predominates, as is well known in the operation of the float process.

A spout 5 extends over the inlet end wall 3 and has side jambs 6 which define a channel along which molten glass 7 flows from the forehearth of a glass melting furnace. The flow of molten glass 7 along the spout at a temperature of 1080°C is controlled by a wheel 8. The molten glass pours over the spout as indicated at 9 on to the surface of the bath 1 of molten metal at 1050°C where the molten glass spreads laterally as it flows forwardly to form a layer of molten glass 10 on the bath which spreads laterally in the manner indicated in the drawing.

The tank structure in this embodiment will firstly be described with reference to the production of 6 mm glass at a load of 3,000 tonnes per week.

The molten glass in the layer 10 is advancing forwardly at a speed in the region of 170 m/hr. to 210 m/hr. The ultimate ribbon of float glass which is 6 mm thick is indicated at 11 and this ribbon 11 is discharged through an outlet over the end wall 4 of the tank structure by conveyor rollers 12, in known manner. The conveyor rollers 12 are driven at a rate such that the ribbon 11 is being discharged from the bath at a speed of 450 m/hr. The conveyor rollers 12 apply traction to the ultimate ribbon 11 and this traction is transmitted upstream of the ribbon by the stiffened part of the ribbon.

Inclined top rolls 13 and 14 are mounted on shafts 15 and 16 which extend through bearings in the side walls of the tank structure. The shafts 15 and 16 are located with their axes converging towards the inlet end of the bath. The rolls 13 and 14 have knurled perimeters and engage the margins of the upper surface of the molten glass

just after the glass has achieved its spread. The shafts 15 and 16 are positioned at an angle of 12° to a line at right angles to the direction of advance of the ribbon of glass along the bath and are driven by driving means 15a, 16a, of conventional kind at an angular speed which gives an effective forward speed of 355 m/hr. at each roll perimeter where they engage the margins of the ribbon of glass. The knurled surfaces of the rollers bite into the glass surface and the rolls thereby apply forces having inwardly and forwardly directed components to the margins of the molten glass layer immediately after its spread is achieved. The glass is accelerated by the action of the top rolls 13 and 14 assisted by the effect of traction applied by the conveyor rollers 12, to a forward speed more than twice the initial speed of the advancing layer 10 of molten glass on the bath. In order to maintain the glass thickness at the target of about 6 mm as the glass is accelerated, the effective inward angle of the applied forces is set by slewing the angle of the shafts 15 and 16 to an angle preferably in the range 5° to 15° , to impose a controlled reduction in width on the forwardly flowing ribbon of glass which is effective to retain the glass at a desired thickness which is thereafter reduced to the desired 6 mm thickness by the influence of the applied traction acting on the ribbon as it is advancing downstream of the top rolls 13 and 14.

The top rolls further regulate the extent of the maximum spread so that under the conditions imposed on the layer of molten glass 10 as it is advanced there is a rapid acceleration of the molten glass to a speed approaching the eventual ribbon speed soon after the molten glass has arrived on the surface of the bath. Thereby a high throughput of glass is possible without the glass spreading to the side walls 2 of the tank structure so that the extent of the spread of the molten glass on the bath is determined by the effect of the top rolls in imposing a controlled reduction in width on the forwardly accelerating glass as its ribbon form is being developed.

The ribbon of glass advancing just downstream of the top rolls 14 and 15 is moving at a forward speed of about 355 m/hr. or just above and further acceleration takes place to the speed of 450 m/hr. at which the ultimate ribbon of glass 11, which is 2.7 m wide and 6 mm thick, is discharged from the bath. The glass is cooling throughout its advance along the bath and the glass which arrives on the bath surface at a temperature of about 1060°C has been cooled to about 920°C at the location of the top rolls 13 and 14 and thereafter may be rapidly cooled under

the influence of overhead coolers indicated at 17 to a temperature of about 850°C , below which there will be little further dimensional change in the ribbon under the influence of attenuating forces which are acting on the glass in the region of the coolers 17.

In the circumstance that the forward speed of the glass as it leaves the top rolls 13 and 14 is little different from the speed of discharge of the ultimate ribbon from the bath, the need for any special cooling as indicated at 17 may be obviated and the glass subjected to a usual gradual cooling regime until it is cooled to a temperature usually in the region of 600°C at which temperature the glass is discharged from the bath on to the conveyor rollers 12.

Control of the reduction of ribbon width and thickness can be even further improved by the use of a second pair of top rolls 18 and 19 which are located just downstream of the top rolls 13 and 14, as shown in Figure 2. Top roll 18 is mounted on a shaft 20, top roll 19 is mounted on a shaft 21, and the axes of the shafts 20 and 21 also converge towards the inlet end of the bath. The shafts 20 and 21 are driven by driving means 20a and 21a of conventional kind.

The shafts 15 and 16 of the top rolls 13 and 14 are set at an angle of 12° to a line at right angles to the direction of advance of the glass, and the shafts 20 and 21 are both set at an angle of 7° . In one setting the arrangement of Figure 2 produced a ribbon of float glass 2.7 m wide and 6 mm thick at a Lehr speed of 450 m/hr. and a load of 3040 tonnes per week. The speed of the top rolls 13 and 14 was 333 m/hr. and of the top rolls 18 and 19 was 331 m/hr.

The use of the two pairs of top rolls at different angles was found to lessen any distortion in the glass.

The invention thus provides a new way of operating the float process under high load conditions. The high load conditions may be 3,500 tonnes per week and as high as a load of 4,200 tonnes per week.

The method of the invention can be employed for the production of a range of thicknesses of float glass greater than or less than 6 mm thick. For example, when producing glass which is 5 mm thick at high load it has been found preferable to employ a speed of discharge of the ribbon from the bath greater than 450 m/hr. and the method of the invention can be employed to avoid too high a cooling rate. For the production of 4 mm glass even higher speeds of discharge are involved, and especially at discharge speeds greater than 600 m/hr. the invention is advanced

tageously employed.

For the production of glass of thickness greater than 6 mm, the inwardly and forwardly directed forces are applied to the margins of the layer of molten glass just before it has spread to a thickness approaching the desired thickness of the thicker glass. The applied marginal forces are thereafter adjusted in relation to the speed of discharge of the ultimate ribbon to retain the required greater thickness of the glass, e.g. 8 mm thick.

WHAT WE CLAIM IS:—

1. A method of manufacturing flat glass in ribbon form on a bath of molten metal, comprising delivering molten glass to the bath at a rate which develops an advancing layer of molten glass on the bath, permitting the layer of molten glass to spread laterally on the bath, applying forces each having inwardly and forwardly directed components to the margins of the spread molten glass layer to regulate the extent of that spread, to accelerate the glass, and simultaneously to impose a controlled reduction in width on the forwardly flowing ribbon of glass which is effective to retain the glass at a thickness which is thereafter reduced to a required thickness by the influence of applied traction advancing the ribbon as it is cooled preparatory to discharge from the bath.

2. A method according to Claim 1, wherein said forces are operative to accelerate the spread molten glass to a speed which is less than the speed of discharge of the ultimate ribbon of glass from the bath, by an amount which ensures that the required ribbon thickness is achieved.

3. A method according to Claim 2, of manufacturing float glass of thickness in the range 5.7 mm to 6 mm at high load, comprising regulating said forces to accelerate the molten glass to a forward speed about twice the initial speed of the

advancing layer of molten glass, regulating the effective inward angle of the applied forces to maintain the accelerated glass at a thickness of about 6 mm, and cooling the accelerated glass to stabilise the glass at that thickness.

4. A method according to Claim 3, comprising applying said marginal forces to the glass at two locations spaced apart along the bath, and setting an inward angle of application of said forces at the first location different from that at the second location, considered in the direction of advance of the glass.

5. Apparatus for use in the manufacture of float glass by a method according to Claim 1, comprising a tank structure containing a bath of molten metal, means at the inlet end of the bath for delivering molten glass to the bath and advancing the glass along the bath, traction means at the outlet end of the bath for discharging the ultimate float ribbon from the bath, inclined top rolls spaced from the inlet end of the bath by a distance just permitting spread of the molten glass on the bath, and positioned to engage the margins of the glass with axes converging towards the inlet end of the bath to apply marginal forces each having inwardly and forwardly directed components to the glass to influence said spread of molten glass.

6. Apparatus according to Claim 5, wherein said inclined top rolls comprise two pairs of top rolls, the rolls of one pair being set at a different angle with respect to the direction of advance of the glass to that of the rolls of the other pair.

7. Flat glass produced by a method according to any one of claims 1 to 4.

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