Thermoforming apparatus wherein the opposite longitudinal edge portions of a sheet of thermoplastic material are gripped by an indexing conveyor which conveys the sheet through a heating oven wherein it is heated to forming temperature and through a thermoformer wherein the heated sheet is deformed into a mold cavity by pressure and/or vacuum, said apparatus being characterized in that at least the portion of the length of the heating oven adjacent the thermoformer has therein one or more perforated tubes which extend longitudinally between the gripped edges of the sheet with air being discharged upwardly through said tubes against the bottom surface of the sheet to form an air bearing support to inhibit sagging of the heated sheet between its gripped longitudinal edges. The apparatus herein is further characterized in that there is a heat interchange between the air and the sheet supporting tubes so that the latter are cooled to avoid possible overheating of the sheet thereabove while the air flowing through the tubes is heated so as not to have undue chilling effect on the regions of the sheet upon which the air jets impinge.

6 Claims, 5 Drawing Figures
3,867,085

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THERMOFORMING APPARATUS WITH WEB SUPPORT MEANS

BACKGROUND OF THE INVENTION

In one known form of thermoforming apparatus as disclosed in the Herbener U.S. Pat. No. 3,632,272, it is known to provide sag bands which are driven by the sheet conveyor and extend through the heating oven and the thermoformer to prevent sagging of the heated plastic sheet as it is progressively heated during its transport through the oven and because the bands extend through the thermoformer the mold cavities must be arranged to straddle said bands. Moreover, as said sag bands move through the oven toward the thermoformer they may reach oven temperature whereby the portions of the heated plastic sheet resting thereupon may be overheated with more pronounced scalloped formation and thinning of the sheet where it rests upon the overheated sag bands.

In lieu of sag bands traveling with the sheet through the oven and thermoformer it has been proposed to cause the sheet gripping chains to travel in a diverging path to compensate for the width-wise elongation of the sheet due to heating thereof. Yet another proposal hereof has been to include transverse sheet support strips in the oven over which the sheet is conveyed to inhibit sagging of the heated sheet in the oven under its own weight.

SUMMARY OF THE INVENTION

In contradistinction to known thermoforming apparatus for inhibiting sagging of the heated sheet as it is conveyed to the thermoformer, it is herein proposed to provide stationary longitudinally extending perforated tubes in the oven through which a gaseous medium such as air is discharged upwardly to impinge on the under surface of the sheet thus to form a gas bearing for low friction transport of the sheet through the oven and to inhibit sagging of the heated sheet.

It is a principal object of this invention to provide thermoforming apparatus of the character indicated in which the sag inhibiting sheet support means is in heat exchange relation with the gas bearing medium such that the sheet support tubes will be at less than oven temperature and such that the gaseous medium is heated so that the heated sheet supported by the gas bearing is not unduly chilled.

Other objects and advantages will appear from the ensuing description.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevation view of a thermoforming apparatus embodying the present invention;

FIG. 2 is a partial top view of the heating oven at the outlet zone thereof adjacent to the thermoformer illustrating the sag inhibiting tubes which provide an air bearing for indexing movement of the sheet as it is heated in the oven and advanced into the thermoformer;

FIG. 3 is a cross-section view on enlarged scale taken substantially along the line 3—3, FIG. 2 illustrating the sheet gripping means which grips a longitudinal edge portion of the sheet and illustrating one of the sag inhibiting tubes which extend longitudinally of the sheet and parallel to the side edges thereof to provide a gas bearing to support the sheet for transport through the oven to the thermoformer with low friction;

FIG. 4 is an elevation view as viewed along the line 4—4, FIG. 2; and

FIG. 5 is a much enlarged top plan view as viewed along the line 5—5, FIG. 4 illustrating the series perforations through the top of the sag inhibiting tube through which a gaseous medium such as air flows upwardly to impinge on the bottom surface of the heated sheet as it is transported through the oven thus to form a gas bearing of low friction characteristics.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

As shown in the drawing and especially FIG. 1 thereof, the thermoforming apparatus comprises a base structure 1 on which is supported a thermoformer 2 with a heating oven 3 on one side thereof and having on the other side thereof a drive means 4 for moving the top run of a pair of sheet gripping and conveying chains 5 length-wise through the heating oven 3 and the thermoformer 2 in stepwise manner.

Each chain 5 is of the pin chain type having a series of pins 6 thereon which at the right hand end 7 of the apparatus as viewed in FIG. 1 are operative to puncture the opposite edges of the sheet 8 to be heated and thermoformed and to convey the sheet 8 thus gripped by the pin chains 5 longitudinally through the heating oven 3 and thermoformer 2. The punctured edge portions of the sheet 8 are supported by longitudinally extending cooled guide rails 9 which are mounted on channel members 9 on opposite sides of the oven 3.

The oven 3 has a series of electric heating elements 10 or the like disposed in spaced relation above and below the sheet 8 which is transported through the oven 3 by said pin chains 5. For a detailed description of the pin chain conveyor 5, the heating oven 3, the thermoformer 2, and the drive means 4 for the pin chain conveyor 5 reference may be had to the aforesaid Herbener U.S. Pat. No. 3,632,272. Opposite sides of the oven 3 have angular heat shields 11 and 12 secured thereto which are spaced apart as shown to accommodate the edge portions of the gripped sheet and to shield such edge portions from the intense heat in the oven 3. Extending lengthwise in the oven 3 especially at the end thereof adjacent the thermoformer 2 whereat the sheet 8 reaches forming temperature, are sag inhibiting means which comprise one or more longitudinally extending tubes 14 having perforations 15 through the top through which air under pressure is introduced through a filter and pressure regulator 16 and air manifold 17 with flexible hose 18 connected to the ends of the tubes 14 which extend laterally from the oven 3. The tubes 14 are supported at spaced intervals by adjustable brackets 19 bolted to the lower heat shields 12 and at the ends of the tubes 14 remote from the thermoformer end of the oven 3 are sloped downwardly so as not to be engaged by the sheet 8 and at that portion of the oven 3 the sheet 8 is not yet heated to extent such as to require support against sagging. Such sloping portions of the sheet supporting tubes 14 have a useful function in that they are yet disposed in the oven 3 and hence serve to preheat the air prior to its being discharged from the series of orifices 15 to impinge on the bottom surface of the sheet 8 disposed thereon.

By way of illustrative example, the sag inhibiting tubes 14 may be ¼ inch diameter stainless steel tubes with holes of 0.013 to 0.015 inch diameter spaced apart
¾ inch and with an air pressure of, say, 15 psi in the manifold 17 the air jets directed upwardly from the tubes 14 impinges on the bottom surface of the sheet S thereof to form an air bearing for ease of transport of the sheet S through the oven 3 and, moreover, although the tubes 14 otherwise would reach oven temperature, the air flow therethrough is in heat exchange relation with the tubes 14 so that the tubes are cooled to less than oven temperature and by the same token the interchange of heat heats the air so that its impingement on the bottom surface of the sheet S does not result in undue chilling of portions of the sheet directly above the tubes 14.

The brackets 19 aforesaid include screw means 20 and slots 21 which enable desired spacing of the sag inhibiting tubes 14 with respect to the gripped edge portions of the sheet S and it will be apparent that depending upon the width of the sheet S and its gage one, two, or more sag inhibiting tubes 14 may be employed. It is to be understood that the sag inhibiting tubes 14 may extend throughout the length of the oven 3 or a major portion thereof but it has been found that in an oven of say 10 foot length, the straight horizontal portion of the sag inhibiting tubes 14 may be of say 4 foot length with perforations 15 extending for somewhat less than 5 feet, partly extending into the sloping portion which is out of contact with the sheet S. Accordingly, as the line of travel of the sheet S approaches the horizontally extending portion of each sag inhibiting tube 14, the upwardly directed jets of air progressively offer increasing support to the sheet S which is of progressively increasing temperature so that by the time that the sheet S reaches the juncture of the sloping portion and the horizontal portion of each tube 14 the sheet S will be supported by an air film between its bottom surface and the upper surface of each sag inhibiting tube 14 to provide for low friction transport of the sheet S. By reason of the heat interchange between the tube 14 and the air, the tubes 14 are cooled to a temperature less than oven temperature and by the same token the air is heated so as not to impose an undue chilling effect on the lines of the sheet S which are disposed directly above the sag inhibiting tubes 14. Moreover, the sloping and lateral portions of each tube being disposed in the oven serve to preheat the air.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Thermoforming apparatus comprising an elongated heating oven into one end of which a thermoplastic web is introduced for transport therethrough for heating said web to forming temperature; a thermoformer adjacent the other end of said oven into which the heated web is transported for forming therein; a conveyor operative to grip the opposite longitudinal edge portions of said web to convey said web through said oven and thermoformer for respectively heating said web to forming temperature and forming the web; sag inhibiting web support means in said oven extending longitudinally from such other end of said oven toward such one end and disposed underneath said web to support the latter between its longitudinal edge portions, said means comprising at least one elongated tube laterally spaced between said edge portions and having a series of openings through the wall thereof juxtaposed to the bottom surface of the web; and a fluid pressure source to supply gaseous medium into said tube for flow upwardly through said openings to impinge on the web thereof thus to define a gas bearing to facilitate transport of the web through said oven while inhibiting sagging thereof.

2. The apparatus of claim 1 wherein said gaseous medium is introduced into said tube at a temperature substantially less than oven temperature and which gaseous medium is in heat exchange relation with said tube to cool the tube to less than oven temperature and to heat the air discharged through said openings so as not to have an undue chilling effect on the portions of the web upon which said air jets impinge.

3. The apparatus of claim 1 wherein said oven has heat shields on opposite sides thereof forming longitudinally extending gaps therebetween through which the edge portions of the web pass to protect the gripped edge portions from the high temperature in the oven; and wherein there are longitudinally spaced apart tube supporting brackets on the lower one of said shields to support said tube beneath the traveling web.

4. The apparatus of claim 3 wherein said brackets are laterally adjustable to predeterminately space said tube from the lateral edges of said web.

5. The apparatus of claim 1 wherein said tube has a laterally extending portion extending through one side of said oven in spaced relation beneath the traveling web and a longitudinally extending portion which slopes upwardly toward the web supporting portion thereof thus to provide an additional length of tube within said oven for preheating of said gaseous medium before reaching said series of openings.

6. The apparatus of claim 5 wherein said openings begin in the sloping portion of the tube to provide an progressively increasing impingement effect as the sloping portion approaches the web supporting portion.

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