A solar thermal collector comprising multiplicity of chords and webs is disclosed. The first, second and third horizontal chord of the solar thermal collector are connected to one another by webs positioned vertically to said horizontal chords. The first horizontal chord is transparent and the second horizontal chord, which is positioned between the first and third horizontal chords, absorbs thermal radiation and is perforated. The horizontal chords and said webs of the inventive solar thermal collector comprise thermoplastic materials. Producing the solar thermal collector including perforating the second horizontal chord by means of a laser beam is also disclosed.
Figure 1
SOLAR THERMAL COLLECTOR

FIELD OF THE INVENTION

[0001] The thermoplastically formed article of manufacture and in particular to a solar thermal collector.

BACKGROUND OF THE INVENTION

[0002] Air collectors, also called air heaters or solar thermal collectors, are radiation solar thermal collectors by means of which non-concentrated solar radiation energy is absorbed and transmitted in part to the heat carrier medium comprising air or another gas. This type of radiation or solar collectors is used for example in the low temperature range.

[0003] At the present time solar thermal collectors for solar radiation are mainly manufactured with absorbers of aluminum or other metals. The reason for this is the good thermal conductivity of metals, since on account of the low heat transmission from air to a flat surface the solar heat in solar thermal collectors has to be distributed over a large surface (e.g. over fins on the rear side of the absorber).

[0004] A fundamentally different concept is adopted in surface layer extraction-type solar thermal collectors and perforated absorbers. The structure of such a collector is described for example in DE 19 820 156 A, DE 2 943 159 A and EP 553 893 A.

[0005] Absorbers with perforations and surface layer extraction type collectors have two types of advantages compared to absorbers involving flow over the rear surface: on the one hand the perforations produce a significant improvement in the heat transmission from the absorber to the air; secondly, due to the suction effect convection in the collector is prevented, as a result of which the thermal losses from the absorber to the glazing fall dramatically and a well-cooled absorber (i.e. with a high heat transmission coefficient from the absorber to the air) is no longer absolutely necessary in order to achieve a high efficiency. In surface layer extraction-type absorbers the thermal conduction in the collector accordingly plays a minor role in regards to the efficiency of the collector. Extremely thin absorbers or absorbers with low thermal conductivity may therefore be used.

[0006] A disadvantage of the solar thermal collectors known from the prior art is the relatively large weight of the absorber, frame and covering, since they are manufactured from metal.

[0007] The object of the present invention is accordingly to provide a solar thermal collector of thermoplastics material that may be manufactured relatively easily, i.e. with a low technical expenditure, as well as a process for its production.

SUMMARY OF THE INVENTION

[0008] A solar thermal collector comprising multiplicity of webs and chords is disclosed. The first, second and third horizontal chords of the solar thermal collector are connected to one another by webs positioned vertically to said horizontal chords. The first horizontal chord is transparent and the second horizontal chord, which is positioned between the first and third horizontal chords, absorbs thermal radiation and is perforated. The horizontal chords and said webs of the solar thermal collector comprise thermoplastic materials. Producing the solar thermal collector including perforating the second horizontal chord by means of a laser beam is also disclosed.

DESCRIPTION OF THE DRAWING

[0009] FIG. 1 is a schematic representation of the inventive solar thermal collector.

[0010] FIG. 2 is a schematic representation of the solar thermal collector with a pumping circuit.

DETAILED DESCRIPTION OF THE INVENTION

[0011] The invention provides a solar thermal collector comprising a panel that contains a plurality of horizontally oriented chords of thermoplastics material optionally parallel to and separate from one another. The webs are connected to one another by a plurality of vertical webs. The panel includes at least one transparent outermost horizontal chord (referred to below as first horizontal chord), and an underlying perforated horizontal web with a multiplicity of holes (referred to below as second horizontal chord) that absorbs radiation.

[0012] In a preferred embodiment chords and webs are forming at least two superimposed rows of adjacent chambers, which are separated from each other and may be flowed through by a heat exchange gas in particular by air.

[0013] In another preferred embodiment the superimposed chambers are connected by a multiplicity of holes.

[0014] In a particular preferred embodiment the chambers are closed at their ends and the chambers located above the second (absorbing) horizontal chord have at least one inlet for a heat exchange gas and the chambers located below the second horizontal chord have at least one outlet for heated solar thermal collector gas.

[0015] In another preferred embodiment of the solar thermal collector the chambers are connected to a blower which optionally is part of a pumping circuit. Particularly preferred a solar thermal collector is located clown stream to the outlet of the chambers.

[0016] The cross section of the chambers preferably has a cross section area of 0.25 to 3600 mm².

[0017] The invention also provides a process for the production of the solar thermal collector according to the invention, in which in a first step a multiple web panel is formed by coextrusion of a transparent and a radiation absorbing thermoplastic material with a plurality of horizontally oriented chords, which are connected by a plurality of vertical webs and wherein the second horizontal chord comprises the radiation absorbing thermoplastic material and in a second step a laser beam is directed through the first horizontal web onto the second horizontal web and the second horizontal web is perforated and provided with a multiplicity of holes by means of the laser beam.

[0018] Panels containing a plurality of webs and chords are known. The multiple web panel used according to a preferred embodiment comprises at least three horizontal webs arranged preferably parallel to one another. The horizontal chords are connected to one another by vertical webs.
arranged preferably perpendicular thereto. The vertical webs are arranged preferably parallel to one another. In this way at least two superimposed layers of parallel-sided-shaped chambers lying adjacent to one another are formed, through which air or another gas flows during operation of the solar thermal collector. The horizontal chords and vertical webs may be of the same or different thicknesses and have a thickness of preferably 0.2 to 2 mm. The second horizontal chord in the perforation area (for example laser perforations) is designed having wall thicknesses of preferably 0.2 to 0.5 mm. The vertical webs are 3 to 50 mm high. The height of the vertical webs determines the height of the chambers, which may be formed having the same height or different heights. Preferably the vertical webs are shorter towards the middle of the multiple web panel than in the edge regions of the web panel in order to minimise the shadow area of laterally incident solar radiation.

[0019] In a further preferred embodiment of the solar thermal collector the diameter of the holes in the radiation absorbing chord is 0.1 to 0.5 mm, particular preferred 0.2 to 0.5 mm.

[0020] The first horizontal web is transparent for the radiation to be absorbed. The degree of transmission in the wavelength range from 400 to 1300 nm is preferably at least 60%. During operation of the solar thermal collector the transparent horizontal web is aligned facing the sun. The sunlight passes through the first horizontal web onto the second horizontal web, which forms the absorber surface.

[0021] The second horizontal web, which is positioned between the first and third horizontal chords, absorbs radiation, i.e. it has in particular an absorption capacity of at least 80% in the wavelength range from 400 to 2500 nm. The second horizontal chord with its comparatively high absorption capacity must be able-to-absorb as much sunlight as possible during operation of the solar thermal collector. For this purpose the second horizontal web is for example colored and/or coated with a black compound. A black coloration of the second horizontal web may be achieved for example by imprinting with a black colorant, coating with black chromium or black aluminium, or by direct coloration of the plastics composition with suitable colorants, preferably carbon black. The second horizontal web is hereinafter also termed absorber surface.

[0022] The partial transparency of the second horizontal chord of up to 20% in the visible wavelength range may be achieved by a compound with or without a high reflection capacity in the infrared wavelength range, or may be accomplished in combination with such a compound, for example in the form of an additional layer. The solar thermal collector is also suitable for use as a partially transparent glazing element, for example in a building enclosure.

[0023] In a preferred embodiment the second horizontal chord comprises a selective absorber layer on the side facing the sun during operation. In this connection the second horizontal web is coated with one or more compounds that have a reflection capacity of at least 70% in the infrared wavelength range. If the second horizontal chord is colored black and/or has in addition a coating of a black compound, the compound with a high reflection capacity in the infrared wavelength range may be largely permeable to visible light. Examples are indium/tin oxide (ITO), zinc oxide (ZnO) and tin oxide (SnO). The infrared wavelength range is understood to denote the wavelength range above 800 nm.

[0024] The second horizontal chord is perforated. The perforated surface amounts to at most 3%, preferably at most 1% and particularly preferably 0.1 to 0.4% relative to the total surface area of the second horizontal chord.

[0025] The third horizontal chord may be transparent or absorbent, for example colored and/or coated. This chord faces away from the sun during operation of the solar thermal collector.

[0026] In addition further layers of adjacent-lying chambers may be included in the structure of the inventive solar thermal collector. For this purpose further horizontal chords are provided that are in turn joined by vertical webs. For example, a fourth horizontal chord may be arranged underneath the third horizontal chord. In this way a third layer of adjacent-lying chambers is formed. This third layer is aligned facing away from the sun during operation of the solar thermal collector. The chambers of this third layer serve as insulating chambers.

[0027] In a preferred embodiment the multiple web panel is open on two sides lying opposite one another, i.e. the two surfaces perpendicular to the horizontal chords and vertical webs are not bordered. This enables gas flow through the chambers of the panel.

[0028] The two remaining sides lying opposite one another are terminated by vertical webs and are thus not open. The panel may be provided with a tongue-and-groove system on the two non-open sides, as described for example in DE10 304 536 A1 and in WO 2004/070297 incorporated herein by reference.

[0029] The chambers of the first layer between the first and second horizontal chords are aligned facing the sun. They are hereinafter also termed absorption chambers. The chambers of the second layer between the second and the third horizontal chord are aligned facing away from the sun. They are hereinafter also termed collecting chambers. During operation of the solar thermal collector the chambers of both layers are filled with gas or gas flows through them. Preferably the gas is air. In addition other gases or mixtures of various gases may also be used, for example those having a higher thermal capacity than air, such as for example argon. Cold gas (temperature in the range from –10°C to –30°C) is introduced into the absorption chambers exposed to sunlight. From there the gas flows through the perforations of the second horizontal web into the collecting chambers resting against the rear side of the chord. The gas heats up on passing through the perforations. The heated gas flows out of the collecting chambers.

[0030] The multiple web panel of the solar thermal collector according to the invention is made of thermoplastics material. Examples of suitable transparent thermoplastics materials, such as are used in particular for the first horizontal web, are polycarbonates, polymethyl methacrylate, polystyrene, polylethylene, polyethylene terephthalate, thermoplastic polyurethane and polyvinyl chloride. Alternatively, materials other than transparent plastics materials produced by multilayer extrusion processes may be used for the second horizontal web (absorber surface) and/or for the third horizontal web (i.e. the surface facing away from the sun), such as for example polybutylene terephthalate, polystyrene, acrylonitrile/butadiene/styrene (ABS), thermoplastic polyurethane or blends of polycarbonate and ABS.
The production of multiple web panels by extrusion is known.

According to the process of the invention a laser beam is directed through the first horizontal chord onto the second horizontal chord, and perforated. The wavelength of the laser beam is preferably in the range from 800 to 1200 nm. Diode lasers or Nd:Yag lasers for example are suitable as laser. The transparency of the first horizontal chord must therefore be sufficiently high that the laser beam passes through this substantially unhindered. The laser beam is absorbed first by the second horizontal chord. Due to the energy of the laser the material of the second horizontal chord is locally combusted, resulting in the formation of a hole. The laser energy is preferably 10 to 100 W.

By means of the laser a large number of holes may be produced in the second horizontal chord. The production of the holes may take place serially or sequentially.

During the perforation by means of the laser beam the upper layer of the chambers between the first and second horizontal webs is preferably subjected to compressed air from one of the two open sides of the multiple web panel. Due to the resultant gas flow through the chambers the combustion residues formed by the laser irradiation are expelled, so that these may not settle on the walls of the multiple web panel.

The process according to the invention is preferably carried out directly after the extrusion of the inventive panel, which means that the extrusion and the perforation of the panel take place in one work stage. To this end a row of laser beams may be arranged behind the extrusion nozzle in such a way that, when the panel leaves the extrusion nozzle, the laser beams are directed through the first horizontal web onto the second horizontal web.

The process according to the invention is described diagrammatically with reference to the figures.

Example

FIG. 1 shows panel 10 with a first, 11, second, 12, and third, 13 horizontal webs as well as vertical webs 15, positioned perpendicularly to the horizontal webs. The inventive solar thermal collector is open on the two sides lying opposite one another, i.e. on the two surfaces 18, 19 aligned perpendicularly to the horizontal and vertical webs. The first horizontal web 11 is transparent enabling directing laser beams (not shown) through the first horizontal web 11 onto the second horizontal web 12. The direction of the laser beams is indicated by the arrow 20. The laser beams pass through the first horizontal web 11 and are absorbed by the second horizontal web 12, which for example is colored with carbon black, holes (1) thereby being formed.

Such a multiple web panel was used as a solar-operated solar thermal collector, with a first horizontal chord 11 (i.e. a transparent horizontal web facing towards the sun) of polycarbonate (available as Makrolon DP 1-1853 polycarbonate from Bayer MaterialScience AG, Germany), which was covered with an outer UV protective layer of Makrolon DP 1-1816 polycarbonate (a product of Bayer MaterialScience AG, Germany), and a second horizontal chord 12 (i.e. an absorber surface) of non-transparent Makrolon 9415 polycarbonate (a product of Bayer MaterialScience AG, Germany). The absorber surface was colored with carbon black.

The absorber surface was perforated by means of an Nd:Yag laser with a wavelength of 1064 nm. The proportion of holes in the total surface was 0.1%, and the holes were of 0.3 to 1 mm. in diameters.

FIG. 2 demonstrates the use of the solar thermal collector according to FIG. 1 using air as heat exchange gas. Sunlight 2 passes through the transparent first horizontal chord 11 and is absorbed in the second horizontal chord 12 and heat energy is formed.

Air enters through inlet 3 into the collector by suction with blower 5, will pass through the holes 1 in the second chord 12 and leaves the chambers 8a via outlet 4.

 Chambers 8 and 8a are closed at their respective ends 9 and 9a. The collector is part of a pumping circuit 6 which can be an open or a closed loop. The heated air is guided through the solar thermal collector 7, to use the collected heat.

Although the invention has been described in detail in the foregoing for the purpose of illustration, it is to be understood that such detail is solely for that purpose and that variations can be made therein by those skilled in the art without departing from the spirit and scope of the invention except as it may be limited by the claims.

What is claimed is:

1. A solar thermal collector comprising a first, second and third horizontal chords that are connected to one another by webs vertical to said horizontal chords in which the first horizontal chord is transparent and the second horizontal chord, which is positioned between the first and third horizontal chords, absorbs radiation and is perforated with a multiplicity of holes, said horizontal chords and said webs comprising thermoplastic materials.

2. The solar thermal collector according to claim 1, characterised in that the proportion of the perforated surface in the whole surface of the second horizontal web is at most 3%.

3. The solar thermal collector of claim 2 wherein the proportion is at most 1%.

4. The solar thermal collector of claim 2 wherein the proportion is 0.1 to 0.4%.

5. The solar thermal collector according to claim 1 wherein the horizontal chords have a thickness of 0.2 to 2 mm.

6. Solar thermal collector according to claim 1 or 2 wherein chords and webs are forming at least two superimposed rows of adjacent chambers, which are separated from each other and may be flowed through by a heat exchange gas in particular by air.

7. Solar thermal collector according to claim 6 wherein the superimposed chambers are connected by a multiplicity of holes.

8. Solar thermal collector according to claim 6 or 7 wherein the chambers are closed at their ends and the chambers located above the second (absorbing) horizontal chord have at least one inlet for a heat exchange gas and the chambers located below the second horizontal chord have at least one outlet for heated solar thermal collector gas.

9. Solar thermal collector according to claim 6 or 7 wherein the chambers are connected to a blower which optionally is part of a pumping circuit.
10. Solar thermal collector according to claim 6 or 7 wherein the cross section of the chambers preferably has a cross section area of 0,25 to 3600 mm$^2$.

11. The solar thermal collector according to claim 1 wherein the vertical webs have a height of 3 to 50 mm.

12. The solar thermal collector according to claim 1 wherein the thermoplastics material is at least one member selected from the group consisting of polycarbonate, polymethyl methacrylate, polystyrene, polyethylene, polyethylene terephthalate, thermoplastic polyurethane and polyvinyl chloride.

13. The solar thermal collector according to claim 1 wherein the second horizontal chord and/or the third horizontal chord comprise at least one member selected from the group consisting of polybutylene terephthalate, polystyrene, thermoplastic polyurethane and acrylonitrile/butadiene/styrene/copolymer.

14. The solar thermal collector according to claim 1 wherein the second horizontal chord contains carbon black.

15. A method for the production of the solar thermal collector of claim 1 comprising in a first step forming a multiple web panel by coextrusion of a transparent and a radiation absorbing thermoplastic material with a plurality of horizontally oriented chords, which are connected by a plurality of vertical webs and wherein the second horizontal chord comprises the radiation absorbing thermoplastic material and in a second step directing a laser beam through the first horizontal chord onto the second horizontal web in a manner calculated to perforate said second horizontal chord and providing the chord with a multiplicity of holes.

16. The method according to claim 10 wherein the laser beam has a wavelength in the range of 800 to 1200 nm.