A drawback of the sinuous weld configurations of the prior art heat exchangers is that the fluid flow distribution structures at the top of the elements are bulky, due to the double feed channel arrangements supplying the fluid flows to the inside and to the outside of each element, respectively. The thickness of the double feed channel structure then sets a minimum for the expansion of the elements, so as to bring the surfaces of the neighbouring elements into contact with each other. Therefore restricting the expansion in order to increase the number of heat exchange surfaces and thereby the heat exchanging capacity in a given volume is not possible.

According to a first aspect, there is provided a heat exchange element of flexible plastic film material bonded to form an expandable bag with inside and outside heat exchange surfaces, said element comprising an inlet opening for supplying a pressurized heat exchange fluid flow, an outlet opening for discharging the fluid flow after heat exchange, and an array of welds bonding the opposite plastic films to define routes for vertical fluid flow through subsequent heat exchange zones inside the bag, characterized in that there is an array of spot welds in an uppermost first zone of the element adjacent to the inlet opening, an array of parallel extended welds in a second zone of the element below said first zone, said extended welds defining fluid flow channels through the second zone, and an array of oblique welds in a lowermost third zone of the element below said second zone, said oblique welds defining channels for fluid flow towards the outlet opening.

Embodiments~~The goal~~ of the invention ~~is to~~ provide an improved heat exchange element, in which the above drawbacks have been avoided. In other words, embodiments of the invention aim~~s~~ at an easy flow of fluids between adjacent heat exchange elements while the elements have a high resistance to wear under high pressure conditions and an improved capacity due to restricted expansion and increased heat exchange surface area. The solution provided by embodiments of the invention is a heat exchange element, in which there is an array of spot welds in an uppermost first zone of the element adjacent to the inlet opening, an array of parallel extended welds in a second zone of the element below said first zone, said extended welds defining fluid flow channels through the second zone, and an array of oblique welds in a lowermost third zone of the element below said second zone, said oblique welds defining channels for fluid flow towards the outlet opening.

Spot welds in the uppermost first zone of the element permit a free lateral spread of fluid, usually pressurized vapor, which is thereby evenly distributed to the flow channels in the second zone below. The vapor inlet opening can thus be located on a vertical side of the element, separated from the inlet channels which feed a fluid to the outside of the elements. The thickness of the feed channel structure at the top end of the elements is only determined by the latter, resulting in a lesser expansion of individual elements required to bring the element surfaces into contact with each other. Furthermore, by increasing the number of spot welds the expansion in the first zone can be reduced and made to be less than in the second zone, which would improve the fluid flow between the uppermost parts of the adjacent elements.

According to a preferred embodiment of the invention the element comprises an array of parallel sinuous welds defining parallel sinuous fluid flow channels extending vertically through the second zone of the element. However, the

invention even covers linear welds in the second zone, useful particularly in a gas-to-gas heat exchanger.

The first and second zones of the heat exchange element may be generally rectangular, whereas the third zone is tapering towards the outlet opening. In the heat exchanger the heat exchange elements are usually standing in an upright position, and the outlet opening is lying at the lowermost end of the element, with the fluid flow channels in the third zone converging towards the outlet opening.

According to a second aspect, there is provided a~~The~~ heat exchanger ~~according to the invention~~ comprise~~s~~ing a pack of adjacent heat exchange elements of flexible plastic film material, each element having the form of an expandable bag with inside and outside heat exchange surfaces to enable heat exchange between a pressurized first fluid flowing inside the elements and a second fluid flowing between the adjacent elements, and each element comprising an inlet opening for supplying said first fluid, an outlet opening for discharging the first fluid after heat exchange, and an array of welds bonding the opposite plastic films to define routes for vertical fluid flow through subsequent heat exchange zones inside the bag. The heat exchanger of the invention is characterized in that in each heat exchange element there is an array of spot welds in an uppermost first zone of the element adjacent to the inlet opening, an array of parallel extended welds in a second zone of the element below said first zone, said extended welds defining fluid flow channels through the second zone, and an array of oblique welds in a lowermost third zone of the element below said second zone, said oblique welds defining channels for fluid flow towards the outlet opening.

According to a third aspect, there is provided an~~The~~ equipment for the manufacture of the above heat exchange elements, ~~according to the invention is~~ characterized in that it comprises a path of travel for a web of double plastic sheet material for provision of a plurality of bag-like elements, a succession of three heatable weld rolls along said path, said three rolls having protrusions for forming welds of three specific different configurations, respectively, and being provided with hydraulic or pneumatic means to selectively bringing the rolls into contact with the moving web and out of contact with it, and a backing roll on the opposite side of the web supporting the weld rolls brought into contact with the web.

The invention is now described in more detail by way of examples with reference to the attached drawings, in which

Claims

1. Heat exchange element (1) of flexible plastic film material bonded to form an expandable bag with inside and outside heat exchange surfaces, said element comprising an inlet opening (2) for supplying a pressurized heat exchange fluid flow, an outlet opening (3) for discharging the fluid flow after heat exchange, and an array of welds (4-6) bonding the opposite plastic films to define routes for vertical fluid flow through subsequent heat exchange zones inside the bag, characterized in that there is an array of spot welds (4) in an uppermost first zone (7) of the element adjacent to the inlet opening (2), an array of parallel extended welds (5) in a second zone (8) of the element below said first zone, said extended welds defining fluid flow channels (11) through the second zone, and an array of oblique welds (6) in a lowermost third zone (9) of the element below said second zone, said oblique welds defining channels (12) for fluid flow towards the outlet opening (3).

2. Heat exchange element according to claim 1, characterized in that the second zone (8) comprises an array of parallel sinuous welds (5) defining parallel sinuous fluid flow channels (11).

3. Heat exchange element according to claim 1 or 2, characterized in that the first and second zones (7, 8) of the heat exchange element (1) are generally rectangular, whereas the third zone (9) is tapering towards the outlet opening (3).

4. Heat exchange element according to claim 3, characterized in that the outlet opening (3) lies axially at the lowermost end of the element (1) set in an upright position, the fluid flow channels (12) in the third zone (9) converging towards the outlet opening.

5. Heat exchange element according to claim 4, characterized in that the upright element has a horizontal top end (13), two vertical sides (10) and a tapering bottom end (14) with the outlet opening (3), the inlet opening (2) lying on a vertical side beside said first zone (7).

6. Heat exchange element according to any one of claims 1 – 5, characterized in that the element (1) is worked for condensing pressurized vapor or humidity to liquid, which is discharged from the lowermost outlet opening (3) of the element.

7. Heat exchanger (15) comprising a pack of adjacent heat exchange elements (1) of flexible plastic film material, each element having the form of an expandable bag with inside and outside heat exchange surfaces to enable heat exchange between a pressurized first fluid flowing inside the elements and a second fluid flowing between the adjacent elements (1, 1'), and each element comprising an inlet opening (2) for supplying said first fluid, an outlet opening (3) for discharging the first fluid after heat exchange, and an array of welds (4, 5, 6) bonding the opposite plastic films to define routes for vertical fluid flow through_subsequent heat exchange zones inside the bag, characterized in that in each heat exchange element (1) there is an array of spot welds (4) in an uppermost first zone (7) of the element adjacent to the inlet opening (2), an array of parallel extended welds (5) in a second zone (8) of the element below said first zone, said extended welds defining fluid flow channels (11) through the second zone, and an array of oblique welds (6) in a lowermost third zone (9) of the element below said second zone, said oblique welds defining channels (12) for fluid flow towards the outlet opening (3).

8. Heat exchanger according to claim 7, characterized in that the first and second zones (7, 8) of each heat exchange element (1) are generally rectangular, whereas the third zone (9) is tapering towards the outlet opening (3).

9. Heat exchanger according to claim 8, characterized in that the heat exchange elements (1) are in an upright position and the outlet opening (3) is at the lowermost end of each element.

10. Heat exchanger according to claim 9, characterized in that each heat exchange element (1) has a horizontal top end (13), two vertical sides (10) and a tapering bottom end (14) with the outlet opening (3), the inlet opening (2) lying on a vertical side beside said first zone (7).

11. Heat exchanger according to claim 10, characterized in that there is a horizontal fluid distributor structure (19) adjacent to the top ends (13) of the heat exchange elements (1), said structure comprising feed channels (20) distributing fluid onto the heat exchange surfaces between the elements.

12. Heat exchanger according to claim 11, characterized in that the fluid distributor structure comprises horizontal bars (19) containing a set of fluid feed

channels (20), the bars being arranged in alternation with the top ends (13) of the flexible heat exchange elements (1).

13. Heat exchanger according to claim 12, characterized in that the inlet opening (2) of each heat exchange element (1) is provided with a vertical bar (17) comprising a set of vapor feed channels (18), said horizontal and vertical bars (19, 17) having their adjacent ends stapled and bound to each other in alternation.

14. Heat echanger according to any one of claims 9 – 13, characterized in that it is worked for condensing pressurized vapor or humidity to liquid, which is discharged from the lowermost outlet openings (3) of the heat exchange elements (1).

15. Heat exchanger according to claim 14, characterized in that it is a distiller evaporating liquid between the adjacent heat exchange elements (1, 1'), pressurizing the vapour generated from said liquid, and condensing the vapor back to liquid inside the heat exchange elements.

16. Equipment for the manufacture of heat exchange elements (1) according to any one of claims 1 – 6, characterized in that it comprises a path of travel for a web (22) of double plastic sheet material for provision of a plurality of bag-like elements, a succession of three heatable weld rolls (23-25) along said path, said three rolls having protrusions for forming welds of three different configurations, respectively, and being provided with hydraulic or pneumatic means to selectively bringing the rolls into contact with the moving web and out of contact with it, and a backing roll (26) on the opposite side of the web supporting the weld rolls brought into contact with the web.

17. Equipment according to claim 16, characterized in that the three rolls (23-25) have protrusions for forming welds (4-6) of spot, sinuous and converging configuration, respectively.