steel **316** material. Feature creation in the ortho direction allows a full radius at the end of a slot to reduce stress concentration as compared to a square or filleted corner. The full radius features also minimize possibility of re-circulation zones in the water flow, which could increase surface deposits which cause fouling.

[0117] Water flows from the inlet header **202** through the channels to the outlet header **204**. For water, there are 17 layers **216** of 6 identical channels. For air, there are 18 layers **218**. Each air flow layer **218** has 5 identical channels with 2 half-width channels at each side. Between layers **216** and **218** there is a web layer **220**. In this configuration, the height of each layer **216**, **218** is the same as the height of each support **214** within each layer. The height of each channel is 0.6 mm and the web layer **220** extends over a distance of 0.76 mm between channels.

[0118] Two distribution plates are used divide the water flow into the vaporizer to achieve even flow distribution in the 102 water channels. The first plate **230** distributes the flow from the center inlet **215** through holes **227** biased toward the outside edges. Circles **225** indicate holes for thermocouples used in this test design, while circles **229** indicate inlet dimensions but do not represent features on plates **226** or **230**. After flowing through the first set of holes, a second plate **226** distributes the flow in a pattern matching the channel layout. Balanced flow through the second plate is aligned with the solid webs between the channels, requiring the water to flow in relatively equal length, circuitous paths from the inlet to the channels.

[0119] The two-phase water/steam flow is collected in header space **241** in the footer **240** and exits through a central port **242**. Orientation of the device is with this outlet at the top. A sloping (pent) roof shape **244** in the space from the channel exits to the outlet port eliminates pockets where vapor could collect and could cause pulsating flow of separated volumes of vapor and liquid.

[0120] In the vaporizer, air flows in a Z configuration—into a wedge shaped inlet manifold **203**, through the 5 identical channels and 2 half-width channels, and through a wedge shaped outlet manifold **205**. The wedge shape is in the interior of each inlet and outlet. The header and footer widths are chosen so that sum of the pressure drop at the inlet and outlet provides the same the flow rate through the full channels and the same in the two half channels. The headers and footers are designed such that air flow is equal through all the air flow channels (even when air enters in a direction that is not parallel to air flow through the body of the vaporizer). The air inlet/outlet header/footer design is shown in **FIGS. 10***e***-10***i*. Air entering the shims from the right-hand side of the figures flows into air slots **1060** which are interleaved with liquid flow channels **1062**. The header shims are stacked on the vaporizer body and arranged with the area of the air slots increasing in the direction toward the vaporizer body with greatest air inlet slot area nearest the air inlet. Because the shim pattern is reversed in the footer (with greatest air outlet slot area nearest the air outlet), air flow rate is equal in all channels through the vaporizer device. Air exits the opposite face from which it enters.

[0121] The body of the vaporizer was manufactured by photo-chemical machining flat metal shims with the desired channel shapes at each cross section then diffusion bonding an assembly into a solid volume. The shims were plated with a nickel phosphate interlayer, stacked in the correct order, and bonded under heat and pressure. After bonding, the body was machined to provide access to the air manifolds, then the air and water headers and footers were attached by welding. As shown in **FIG. 12**, each shim contains four identical sets of features. Four vaporizer bodies are made from each stack **250**, which were then cut apart after bonding. There are 174 identical center shims, header shims (e.g., **252**), and 33 shims (not shown) of 6 configurations form each air manifold section. All air manifold shims were initially fabricated identically, then the unique feature for each configuration was electric-discharge-machined. End plates isolated the water channels from the air channels and provided a thicker solid section for welding headers and footers to the body.

[0122] Non-symmetric alignment holes keep identical shims in the same orientation to reduce misalignment. Alignment holes are electric-discharge-machined for improved precision.

[0123] The air manifold shims do not open to the outside of the device. A short end section must be machined away to allow the air to enter and exit. The air manifold shims have a narrow outer boundary to maintain shape during fabrication. After bonding, a pocket is machined to open up the layers for access. A heat relief groove is machined parallel to the sides where the air header and footer side plates are welded.

[0124] The water header and footer are welded to the body at the end plates. Full width side plates for air header and footer attachment are welded to the end plates and the body. These side plates eliminate welding along the shim bond seam. The air header and footer are then welded to the side plates.

[0125] Air flow testing was performed to measure velocity in each channel in a single layer to assess flow distribution and minimal deviation was observed. Performance testing has proceeded for over 5000 hours of operation.

[0126] The high-pressure vaporizer continued to operate without signs of degradation at about 5000 hours (211 days), shown in **FIG. 11**. It operated at 44-46% steam quality and was fed with about 1.5 ppm total dissolved solids (TDS) water. The primary inorganic solid constituents in the water are Mg, Ca, and Si. These three solids are present in roughly 7%, 15%, and 2% respective concentration of the 1.5 total ppm solids. Data are shown in **FIG. 11**. Although the pressure drop slightly increased, there does not seem to be appreciable degradation due to the consistency of the outlet air temperature. The variability seen from ~3240 hrs to 3780 hrs was due to a problematic needle valve which made the pressure difficult to control. This system had experienced more than 10 process upsets without significant change in performance.

[0127] Air can be used to partially boil water to generate steam for chemical processing. Air was fed at 247 SLPM (standard liters per minute) and entered at 279° C. The average outlet air temperature was 212° C. The water flowrate is 20 mL/min. At these conditions 282 Watts of heat was transferred, or an average heat flux of 0.49 W/cm^2. On a volumetric basis, this heat is transferred within a core volume of 1.74 inches flow length by 1.985 inch high by 1.553 inch wide. Thus the volumetric heat flux is over 3.4