[0060] In one or more embodiments, the shell and tube heat exchanger 500 may comprise a shell expansion joint. The shell expansion joint may be any suitable expansion joint positioned in the shell 520 of the shell and tube heat exchanger 500. For example, the shell and tube heat exchanger may comprise a flute and flange shell expansion joint. Without being bound by theory, it is believed that the shell expansion joint may reduce thermal stress on the shell and tube heat exchanger 500 by allowing the shell of the heat exchanger 500 to expand and contract in an axial direction as a response to elongation or contracting of the tubes 510 that occurs due to thermal gradients between the tubes 510 and the shell 520 and differences in the coefficient of thermal expansion between the tubes 510 and the shell 520.

[0061] The shell and tube heat exchanger 500 may also comprise stress reduction features on a joint between the shell 520 and the inlet tube sheet 532 and/or the outlet tube sheet 534 . In one or more embodiments, the inlet tube sheet 532 and/or the outlet tube sheet 534 may comprise a notch or a groove. The notch may be a portion of the inlet tube sheet 532 and/or the outlet tube sheet 534 that has been carved out tangential to at least one of the tubes 510. Without being bound by theory, it is believed that the notch may reduce the thermal stress placed on the inlet tube sheet 532 and/or the outlet tube sheet 534 due to the different rates of thermal expansion of the tubes 510 and the shell 520 of the shell and tube heat exchanger 500. Specifically, tube sheets attached to the shell are generally prone to high stress at the corner joint between the tube sheet and the shell. By adding a notch having a compound radius to the corner joint, in which there is a tangential component to the radius, high thermal stress may be dissipated in a more efficient manner than could be achieved in systems without such a notch. In some embodiments, the notch may comprise a radius, a tangential machined cut, and a shallow section. This may allow for the removal of unnecessary material that could add stiffness to the joint between the inlet tube sheet 532 and/or the outlet tube sheet 534 and the shell 520.

[0062] In one or more embodiments, the inlet tube sheet 532, the outlet tube sheet 534, or both may be connected to the shell 520 by an expansion joint. In one or more embodiments, the outlet tube sheet 534 is connected to the shell 520 by an expansion joint and may be located inside the vessel shell. The expansion joint may be any suitable expansion joint. In one or more embodiments, the expansion joint may be a corrugated bellows expansion joint or an S shaped flexible joint or an omega or toroidal shaped flexible joint. In one or more embodiments, the expansion joint may comprise stainless steel, such as, but not limited to 321 or 316 stainless steel. Without intending to be bound by theory, it is believed that an expansion joint positioned between the tube sheet and the shell 520 may reduce thermal stress caused by different rates of thermal