onto the underlying catalyst bed, and other deficiencies.

[0006] One of the key considerations in flow distributor design is the discharge pattern of liquid and gas from the device. A conventional chimney distributor provides a limited number of points of contact of the liquid feed with the catalyst bed. As a result, a larger distance from the chimney to the bed is required to wet the catalyst surface.

[0007] U.S. Patent No. 7,473,405 to Kemoun et al. discloses a nozzle device for coupling with a fluid distribution conduit.

[0008] There is a continuing need for hydroprocessing reactor apparatus providing improved hydrogen/oil mixing at the mixing tray, more uniform and consistent liquid distribution on the catalyst bed, a decreased mixing tray height, and decreased amounts of fabrication material, as well as easier maintenance, assembly and disassembly. There is also a need for systems and apparatus that provide improved tolerance for distributor tray out-of-levelness conditions. There is still a further need for fluid distribution apparatus that can provide more uniform distribution of liquid on a catalyst bed under liquid-only conditions.

SUMMARY OF THE INVENTION

[0009] In one aspect, there is provided a fluid distribution nozzle, comprising: (a) a substantially cylindrical nozzle body having a plurality of outer slots disposed circumferentially around the nozzle body; (b) a cap affixed to a proximal portion of the nozzle body, the cap having an axial proximal opening therein; (c) a base affixed to a distal portion of the nozzle body, the base having an axial distal opening therein; and (d) a substantially cylindrical inner conduit disposed axially within the proximal portion of the nozzle body, the inner conduit disposed within the proximal opening of the cap, and the inner conduit extending proximally from the cap to define a proximal end of the inner conduit, the inner conduit having a plurality of inner slots disposed circumferentially around the proximal end of the inner conduit, and a distal end of the inner conduit terminating distally at a location proximal to a distal end of each of the outer slots.

[0009a] Disclosed herein is ~~According to one aspect of the present invention there is provided~~ a reactor system comprising a reactor shell, a primary feed distribution unit disposed within the reactor shell, and at least one secondary feed distribution unit disposed beneath the primary feed distribution unit within the reactor shell. The primary feed distribution unit comprises a primary deflector plate and a first nozzle tray disposed beneath the deflector plate. The at least one secondary feed distribution unit comprises a collection tray and a second nozzle tray disposed beneath the collection tray. Each of the first nozzle tray and the second nozzle tray comprises a plurality of nozzles, the nozzles each comprise a nozzle body including a distal body portion having at least one liquid inlet configured for the passage of liquid therethrough. The distal body portion defines a substantially

cylindrical distal void. Each liquid inlet is disposed tangentially to an inner surface of the distal body portion.

[0010] Disclosed herein is~~In an embodiment, the present invention also provides~~ a reactor system comprising a reactor shell having an inner wall, a primary feed distribution unit disposed within the reactor shell, and at least one secondary feed distribution unit disposed beneath the primary feed distribution unit within the reactor shell. Each secondary feed distribution unit comprises a collection tray, a nozzle tray disposed beneath the collection tray, at least one support ring affixed to the reactor shell inner wall, and a plurality of trusses. Each truss spans the at least one support ring. Each truss has an upper flange and a lower flange, the upper flange supports the collection tray and the lower flange supports the nozzle tray.

[0011] Disclosed herein is~~In another embodiment of the present invention, there is provided~~ a feed distribution unit for a catalytic reactor, the feed distribution unit comprising a deflector plate and a nozzle tray disposed beneath the deflector plate. The nozzle tray includes a plurality of nozzles. Each nozzle comprises a nozzle body including a distal body portion having at least one liquid inlet configured for the passage of liquid therethrough. The distal body portion defines a substantially cylindrical distal void. Each liquid inlet is disposed tangentially to an inner surface of the distal body portion.

[0012] Disclosed herein is~~In an embodiment, the present invention further provides~~ a nozzle for the even distribution of a multi-phase fluid mixture, the nozzle comprising a nozzle body having a proximal body portion, an intermediate body portion, and a distal body portion. The proximal body portion defines a substantially cylindrical proximal void, and the proximal body portion has at least one gas inlet configured for the passage of gas therethrough into the proximal body portion. The intermediate body portion defines a substantially cylindrical intermediate void in fluid communication with the proximal void. The distal body portion has a body wall and at least one liquid inlet configured for the passage of liquid therethrough into the distal body portion. The distal body portion defines a

substantially cylindrical distal void, and the at least one liquid inlet is disposed tangentially to an inner surface of the distal body portion.

[0013] Disclosed herein is~~In another embodiment of the present invention, there is provided~~ a fluid distribution apparatus for a reactor, the apparatus comprising a nozzle tray; a plurality of chimneys affixed to, and extending through, the nozzle tray; and a fluid distribution nozzle disposed within each chimney. Each chimney has a chimney wall defining a substantially cylindrical void extending substantially vertically from a lower surface of the nozzle tray to a location above an upper surface of the nozzle tray. The chimney has an open proximal end and an open distal end, and the chimney wall has at least one lateral opening therein. The nozzle comprises a nozzle body comprising a proximal body portion, an intermediate body portion, and a distal body portion having a distal body wall. The proximal body portion defines a substantially cylindrical proximal void, and the open proximal end is configured for the passage of gas therethrough. The intermediate body portion defines a substantially cylindrical intermediate void in fluid communication with the proximal void. The distal body portion has a liquid inlet configured for the passage of liquid therethrough into the distal body portion. The distal body portion defines a substantially cylindrical distal void. The liquid inlet comprises a curved channel within the distal body wall, and the curved channel has an inner terminus disposed tangentially to an inner surface of the distal body portion.

[0014] Disclosed herein is~~In another embodiment, the present invention still further provides~~ a fluid distribution device comprising a substantially cylindrical hollow nozzle body having a plurality of outer slots disposed circumferentially around the nozzle body; a cap affixed to a proximal portion of the nozzle body, the cap having an axial proximal opening therein; a base affixed to a distal portion of the nozzle body, the base having an axial distal opening therein; and a substantially cylindrical inner conduit disposed axially within a proximal portion of the nozzle body. The inner conduit is disposed within the proximal opening of the cap, and the inner conduit extends proximally from the cap to define a proximal end of the inner conduit. The inner conduit has a plurality of inner slots disposed circumferentially around the proximal end of the inner conduit. A distal