

A heat exchanger mixing system

Present invention relates to a heat exchanger mixing system, use of a heat exchanger mixing system, and a process for mixing fluids.

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Background of invention

Mixers are often used for different applications wherein it is important that the contact between reactants, fluids, etc. is as great as possible. The contact is improved by turbulence and turbulence is effectuated by the use of different types of mixing elements. Due to the need of heat transfer in many of these operations the mixers are usually combined with heat exchangers.

A great number of combinations of mixers and heat exchangers are known from literature for example WO 97/21061 discloses a plurality of cooperating assemblies each comprising a central tube, provided with one or more static mixing elements, an annular space surrounding the tube and a shell tube. The annular spaces form continuous compartments, which enables transfer of heat to and from the process. A mixing element attached to an opening of a heat exchanger is disclosed by WO 2002/46679.

A device for processing fluids by controlling the residence time and/or the reaction time by the use of a single block or a set of several blocks or subblocks placed one next to the other are disclosed by US patent application published under number US 2004/0109798.

One problem with the combined mixer heat exchangers of the prior art is the length of transportation between mixer and reaction chamber. This results in inferior heat transfer, temperature control, and spacious equipments. Thus, one object of the present invention is to design equipment with a more effective heat balance, and another object is to design a more compact mixer heat exchange system.

The invention

Accordingly, the present invention provides a compact system, which enables a more sufficient heat balance. Thus, the present invention relates to a heat exchanger mixing system comprising at least one heat exchanger zone, at least one connection plate having one or more mixing units, at least four fluid transfer corners per connection plate, wherein each fluid transfer corner, herein after called corner or corners, being either a blind passage corner, a through passage corner, a single passage corner, or a double passage corner. The one or more mixing units are provided with mixing elements. The blind corner acts as a stopper and no fluid passes through it. A through passage corner may pass fluids through a connection plate without mixing the fluids with any other fluids, or a through passage corner may be a passage into a connection plate from the outside of the plate. A single corner is directing a flow of fluids in any pre-designed angle compared to the inlet angle, and the corner may be used for directing a flow of fluids into a connection plate or out of a connection plate, or may direct the flow to by-pass a connection plate. A double corner is transferring two flow of fluids in different directions without mixing the two flows. Double corners may be used for adding flows of fluids to the system. Examples of corners, which may be used according to the invention, are disclosed in US 4373579 and WO 99/51926. The invention comprises any type suitable corners. The corners are connected to for example a connection plate, a mixing unit, a reactor zone, a heat exchanger zone, or combinations thereof. Fluids may be transferred by the corners into a connection plate or out a connection plate, or if the corner is a double corner it may transfer both process fluids and heat exchanger fluids for instance into or out of a connection plate, but a double corner may also transfer two process fluids to two mixing units, to two reactor zones, to two heat exchanger zones, or combinations thereof.

The heat exchanger zone or zones may be heat exchanger plates arranged on one or both sides of the at least one connection plate, or be placed between two or more connection plates. According to another alternative may the heat exchanger zone be a space inside a connection plate outside an internal mixing

unit or may the heat exchanger zone surround an externally connected mixing zone. Thus, the at least one heat exchanger zone may be placed inside, outside, or both of the at least one connection plate. Yet another alternative may the at least one heat exchanger zone be placed as a combination of heat
5 exchanger plates arranged on one or both sides of the at least one connection plate and of heat exchanger zones placed inside, outside, or both of the at least one connection plate.

According to one alternative may two, three or more connection plates be
10 directly connected to each other between for instance two or more packages of heat exchanger plates, but as an alternative may it be not necessary that the heat exchange mixing system has heat exchanger plates, instead may the system have heat exchanging zones either externally, internally or both.

15 The connection plate may have a shape, which may be essentially square or rectangular, but any shape is possible as long as the performance of the heat exchanger mixing system produces the aimed results. The connection plate may have a section, which may harbour mixing units, heat exchanger fluids, process fluids or combinations thereof. The at least one connection plate may
20 have one or more mixing units connected externally, arranged internally or both of the at least one connection plate. Inlets and outlets of the connection plate may be connected to heat exchanger fluids or process fluids through the corners and the at least one connection plate may have at least one inlet and at least one outlet for fluids. The one or more mixing units may be connected
25 externally of the connection plate. One process fluid may be transferred in a mixing unit inside the connection plate and another process fluid may be transferred in an externally placed mixing unit. The mixed process fluids may be combined and mixed together in yet another mixing unit all depending what type of reaction or physical step the fluids are passing. The connection plate may
30 harbour one or more mixing units internally, one may be inside a tube or other type of closed channel and another may be a mixing unit surrounding the tube or the other type of closed channel. Another alternative may the connection

plate harbour one or more mixing units arranged internally and at least one inlet and at least one outlet for heat exchanger fluids. The connection plate may be hermetically sealed. The corners may be integrated in the at least one of the connection plates.

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The mixing units may be provided with mixing elements. The mixing elements may have wings, fins, or other mixing promoting arrangements, the mixing elements could be nets, metallic foams, mesh, fins etc. The mixing elements may be selected from the group consisting of static mixers, helical mixers, combination of right- and left-turned mixer blades, vortex mixers, dynamic
10 mixing elements, lanced offset turbulators, flow controlling inserts, metallic foams, mesh, etc. The mixing unit may be mixing elements such as flow controlling inserts disclosed by WO 2004/045761. The mixing unit and the mixing elements may be manufactured of any suitable alloy, stainless steel,
15 Hastelloy®, Inconel®, fluoropolymer, polyester, plastics, polyvinyl chloride (PVC), nylon, glassfibers, ceramics, (polypropylene, polystyrene, polycarbonate, polyethylene, poly(methyl) (met)acrylate, poly ether etherketone (PEEK), or combinations thereof.

20 The heat exchanger system according to the invention may have according to one alternative embodiment one or more injection ports connected to for instance one or more corners or along the sides of one or more connection plates. The injection ports may be used for additives, reactants, etc. or for test sampling, monitoring of the flow of fluids etc. According to one alternative may
25 an injection port be connected to a blind passage corner, a through passage corner, a single passage corner, or a double passage corner.

The heat exchanger system may be brazed, welded or both, or parts of the system may be brazed, welded or both, and the system may be clamped in a
30 framework having at least two end plates, but it is not necessary that the system is clamped in a framework.

The present invention also relates to a heat exchanger mixing system, which may be used as a reactor, which system comprises one or more heat exchanger mixing systems and at least one reactor zone. The heat exchanger mixing reactor may comprise up to 10 heat exchanger mixing systems.

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The heat exchanger mixing system may be used for chemical synthesis or reactions, unit operations such as dilutions of acids etc., food applications, agrochemicals, biochemicals etc. The heat exchanger mixing system may be used as a reactor.

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The present invention also relates to a continuous process for mixing fluids, which comprises transferring of at least one first process fluid and at least one second process fluid. The fluids may be solvents, dilution fluids, etc. or may be reacting fluids or fluids having added reactants, catalysts or the like. The fluids may be led through at least one first corner into at least one internally connected mixing unit of a connection plate of a heat exchange mixing system or may the fluids be transferred through at least one first corner into at least one externally connected mixing unit. The first and the second process fluids may be mixed together, heat may be transferred to or from the mixing unit. The mixed process fluid may be transferred out of the mixing unit through at least one second corner for further processing in a heat exchanger zone or in a reactor zone of another heat exchange mixing system. The process may comprise transferring internal heat exchanger fluids through at least two corners to external heat exchanger plates, or the process may comprise transferring internal heat exchanger fluids into the connection plate through at least one first corner and transferring the internal heat exchanger fluids out of the connection plate through at least one second corner for further heat exchanging. Another alternative may the process comprise transferring external heat exchanger fluids into the connection plate through at least one first corner and transferring the external heat exchanger fluids out of the connection plate through at least one second corner. According to a further alternative may the process comprise transferring external heat exchanger fluids into at least one external temper unit

of the external mixing unit and transferring the external heat exchanger fluids out of at least one external temper unit of the external mixing unit.

Further alternative embodiments of the present invention are defined in the claims. The invention will further be described in more details by the aid of
5 Figures 1 to 15. The Figures are only for the purpose of illustrating the invention and not to limit its scope.

Brief description of the drawings

- 10 Figure 1 is schematically showing one alternative example of a heat exchanger mixing system of the invention.
- Figure 2 is showing a simplified schematic representation of a connection plate of the invention.
- Figure 3 is showing a connection plate having four corners for process
15 fluids, heat exchanger fluids etc.
- Figure 4 is showing a blind passage corner.
- Figure 5 is showing a through passage corner.
- Figure 6 is showing a single passage corner.
- Figure 7 is showing a double passage corner.
- 20 Figure 8 is showing another alternative example of a heat exchanger mixing system of the invention arranged with corners.
- Figure 9 is showing another alternative example of a heat exchanger mixing system of the invention having the connection plates spaced apart.
- Figure 10 is schematically showing a connection plate having single corners
25 and through passage corners.
- Figure 11 is schematically showing a connection plate having an internal static mixing unit.
- Figure 12 is schematically showing a connection plate having an internal tempering device connected to a internal mixing unit.
- 30 Figure 13 is schematically showing an internal mixing unit having an external temper device.

Figure 14 is schematically showing an external mixing unit connected to a connection plate and an internal tempering device.

Figure 15 is schematically showing an external mixing unit having external tempering device connected to a connection plate.

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Detailed description of the invention and alternative embodiments.

In Figure 1 the invention is schematically represented for the purpose of defining and visualising the parts of the heat exchanger mixing system according to one alternative embodiment of the present invention. The system comprises heat exchanger plates 1 and connection plates 2a, 2b and 2c. Connection plate 2a is representing a connection plate having for instance an internal mixing unit and internal tempering device not shown. Connection plate 2b has external connections 3 for flow of additives, reactants etc., for an external mixing unit, for an external tempering device, or for additional heat exchanger fluids for internal tempering of for instance a mixing unit. Connection plate 2c has corners 4 for additional process fluids, reactants or for heat exchanger fluids. Each connection plate 5 has at least four corners 6, see Figure 2, which are connected to one or more mixing units 7 or are connected to a tempering device having a flow of heat exchange fluids not seen in Figure 2. The mixing units 7 may either be incorporate internally in connection plate 5 or be externally connected to the connection plate, according to one alternative embodiment of the invention may the mixing units be connected both externally and internally on the same connection plate. The mixing units are constructed with mixing elements 8, which either are part of the mixing unit or a separate part to be added into the mixing unit or connection plate.

Figure 3 is showing an alternative connection plate 5 having four different corners 9, 10, 11 and 12 arranged to connection plate 5. Corner 9 in Figure 4 is a blind corner, which may act as a stopper when connected to a connection plate. Corner 10 in Figure 5 is a through passage corner having a hole 13 for passage of fluids, which corner may pass fluids through a connection plate

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without mixing the fluids with any fluids in the connection plate. Corner 10 may also connect fluids within a connection plate with any kind of external fluid device, or may connect a connection plate to an additional fluid to be added to a mixing system of the invention. Single corner 11 in Figure 6 is directing one fluid flow through hole 13 into tube 14 and out, or is directing the fluids through tube 14 and out of hole 13, that means that single corner may transfer fluids from a neighbouring plate into or out of a connection plate or into or out of a mixing unit. A single corner may also be used to add fluids to a mixing system according to the invention. Double corner 12 in Figure 7 is having a wall 15 separating two fluids from each other. Double corner 12 is directing two fluid flows without mixing them. Double corners 12 may add multi-functions to a connection plate or a mixing system. The flow of fluids through double corner may be in any direction suitable for the system.

Figure 8 is showing a mixing system having heat exchanger plates 1 and connection plates 5 within a frame 16. Two end plates 17 are stabilising the system within frame 16. Different corners are arranged to direct fluids into or out of the connection plates and thus add to the multi-function of the mixing system of the invention. The mixing system seen in Figure 9 shows connection plates 5 spaced apart within a frame 16. In this figure it can be seen that for instance single corners 11 are stopping flows of fluids from one side of a connection plate or heat exchanger plate 1, and are adding fluid flows from the outside of the connection plate or heat exchanger plate into the connection plate or heat exchanger plate.

Figures 10 to 15 are all schematically presentations of different possibilities of mixing internally or externally of the mixing system according to the invention. The connection plate in Figure 10 is equipped with single corners 11 for connecting fluids to an outside source, which could be an external mixing unit or could be additional fluids to be treated within a heat exchanger mixing system of the invention. The connection plate is also equipped with two corners, which could be either blind corners 9 or through passage corners 10, or one of each.

The connection plate in Figure 11 is equipped with an internal mixing element 8. Figure 12 is showing a connection plate in which one flow of fluids 18 is directed into a mixing unit or an open space, and another flow of fluids 19 is directed into the connection plate to an internal temper device to internally temper flow 18, without mixing flow 18 with flow 19. An external flow of tempering fluids is led through connections 20, see Figure 13, which connections 20 may be through passage corners 10. The external flow of tempering fluids is led into an internal temper device within the connection plate having single corners in Figure 13, to temperate fluids in the mixing unit or the open space, which may be used as reaction space without mixing. An external mixing unit 21 is connected to a connection plate in Figure 14 and in Figure 15 is mixing unit 21 equipped with an external temper device 22.

One or more injection ports 23 may be connected to one or more corners or to one or more sides of a connection plate. In Figure 11 and 12 are injection port 23 connected to a corner. Figure 13 shows several injection ports 23 connected along one side of a connection plate. Injection ports 23 may be connected to a corner which can be seen in Figures 5, 6 or 7.

Claims

1. A heat exchanger mixing system comprising at least one heat exchanger zone, at least one connection plate having one or more mixing units, at least four corners per connection plate, wherein each corner being either
 5 blind passage corner, a through-passage corner, a single passage corner, or a double passage corner, the one or more mixing units are provided with mixing elements, and wherein the mixing elements of the mixing units are selected from the group consisting of static mixers, helical mixers, combination of right- and left-turned mixer blades, vortex mixers, dynamic
 10 mixing elements, metallic foams, mesh.
2. The heat exchanger mixing system according to claim 1, wherein one or more injection ports are connected to one or more corners, along one or more sides of one or more connection plates, or combinations thereof.
3. A heat exchanger mixing system comprising at least one heat exchanger zone, at least one connection plate having one or more mixing units, at
 15 least four corners per connection plate, wherein each corner being either blind passage corner, a through-passage corner, a single passage corner, or a double passage corner, wherein the at least one connection plate has one or more mixing units connected externally, arranged internally or both
 20 of the at least one connection plate, the one or more mixing units are provided with mixing elements, and one or more injection ports are connected to one or more corners, along one or more sides of one or more connection plates, or combinations thereof.
4. The heat exchanger mixing system according to claim 3, wherein the
 25 mixing elements of the mixing units are selected from the group consisting of static mixers, helical mixers, combination of right- and left-turned mixer blades, vortex mixers, dynamic mixing elements, flow controlling inserts, metallic foams, mesh
5. The heat exchanger mixing system any one of the preceding claims,
 30 wherein the at least one heat exchanger zone is heat exchanger plates arranged on one or both sides of the at least one connection plate.

6. The heat exchanger mixing system any one of the preceding claims, wherein the at least one heat exchanger zone placed inside, outside, or both of the at least one connection plate.
7. The heat exchanger mixing system any one of the preceding claims,
5 wherein the at least one heat exchanger zone is placed as a combination of heat exchanger plates arranged on one or both sides of the at least one connection plate and of heat exchanger zones placed inside, outside, or both of the at least one connection plate.
8. The heat exchanger mixing system any one of the preceding claims,
10 wherein the at least one connection plate has a shape, which is essentially square or rectangular.
9. The heat exchanger mixing system according to any one of the preceding claims, wherein the at least one connection plate has one or more mixing units connected externally, arranged internally or both of the at least one
15 connection plate.
10. The heat exchanger mixing system according to any one of the preceding claims, wherein the at least one connection plate has at least one inlet and at least one outlet for fluids.
11. The heat exchanger mixing system according to any one of the preceding
20 claims, wherein the at least one connection plate has one or more mixing units connected externally.
12. The heat exchanger mixing system according to any one of the preceding claims, wherein the at least one connection plate has one or more mixing units arranged internally.
- 25 13. The heat exchanger mixing system according to claim 12, wherein the at least one connection plate has one or more mixing units arranged internally and at least one inlet and at least one outlet for heat exchanger fluids.
14. The heat exchanger mixing system according to claim 12 or 13, wherein
30 the at least one connection plate is hermetically sealed.
15. The heat exchanger mixing system according any of the preceding claims, wherein the corners are integrated in the at least one connection plate.

16. The heat exchanger mixing system according to any one of the preceding claims, wherein the mixing unit and the mixing elements are manufactured of any suitable alloy, stainless steel, Hastelloy®, Inconel®, fluoropolymer, polyester, plastics, polyvinyl chloride (PVC), nylon, glassfibers, ceramics,
5 polypropylene, polystyrene, polycarbonate, polyethylene, poly(methyl) (met)acrylate, poly ether etherketone (PEEK), or combinations thereof.
17. The heat exchanger mixing system according to any one of the preceding claims, wherein one or more injection ports are connected to one or more corners, along one or more sides of one or more connection plates, or
10 combinations thereof.
18. The heat exchanger mixing system according to any one of the preceding claims, wherein two or more connection plates are directly connected to each other.
19. A heat exchanger mixing reactor comprising one or more heat exchanger
15 mixing system according to any one of the preceding claims, comprising at least one reactor zone.
20. The heat exchanger mixing reactor according to claim 19, wherein the heat exchanger mixing reactor comprises up to 10 heat exchanger mixing systems.
- 20 21. Use of a heat exchanger mixing system according to any of claims 1 to 18, for chemical synthesis or reactions, unit operations such as dilutions of acids etc., food applications, agrochemicals, biochemicals.
22. Use of a heat exchanger mixing reactor according to claims 19 or 20, for chemical synthesis or reactions.
- 25 23. A continuous process for mixing fluids comprising steps of transferring at least one first process fluid and at least one second process fluid or at least one reactant through at least one first corner into at least one internally connected mixing unit of a connection plate of a heat exchange mixing system according to any one of claims 1 to 18, or transferring at
30 least one first process fluid and at least one second process fluid or at least one reactant through at least one first corner into at least one externally connected mixing unit, mixing the at least one first process fluid

and the at least one second process fluid or the at least one reactant, transferring heat to or from the mixing unit, transferring the mixed process fluid out of the mixing unit through at least one second corner for further processing in a heat exchanger zone or a reactor zone of another heat exchange mixing system according to any one of claims 1 to 18.

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24. The process according to claim 23, wherein the process comprises transferring internal heat exchanger fluids through at least two corners to external heat exchanger plates.
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25. The process according to claim 23, wherein the process comprises transferring internal heat exchanger fluids into the connection plate through at least one first corner and transferring the internal heat exchanger fluids out of the connection plate through at least one second corner for further heat exchanging.
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26. The process according to claim 23, wherein the process comprises transferring external heat exchanger fluids into the connection plate through at least one first corner and transferring the external heat exchanger fluids out of the connection plate through at least one second corner.
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27. The process according to claim 23, wherein the process comprises transferring external heat exchanger fluids into at least one external temper unit of the external mixing unit and transferring the external heat exchanger fluids out of at least one external temper unit of the external mixing unit.