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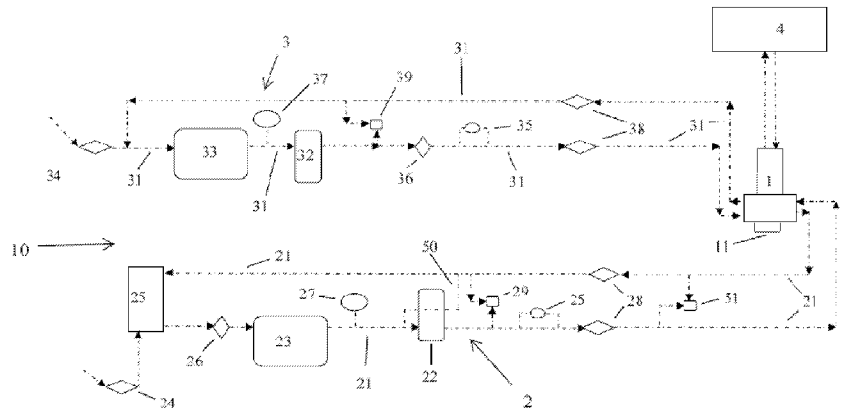
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(54) Title: FLUID MIXING AND DISPENSING APPARATUS AND PROCESS

FIGURE 1



(57) Abstract: A mixing and dispensing apparatus and process useful for process two-part polyurethane or epoxy resin systems includes a first circulation loop (2) and second circulation loop (3), each in fluid communication with a circulating- type mix head (1). The circulating- type mix head (1) includes separate first and second fluid circulation paths, a mixing and dispensing chamber, and an actuator which, upon actuation, allows a predetermined quantity of fluid from the first circulation path and a predetermined quantity of fluid from the second circulation path to each enter the mixing and dispensing chamber, mix and become dispensed together out of the mix head (1).

FLUID MIXING AND DISPENSING APPARATUS AND PROCESS

This application claims benefit of United States Provisional Application No. 61/264,007, filed 24 November 2009.

This invention relates to an apparatus for mixing and dispensing fluids, and to a method for using same.

Many resin systems are designed to be dispensed as liquids which are then cured. These resin systems often include some type of resin precursor and a curing agent. The resin precursor is generally a low molecular weight oligomeric or monomeric material, although in some cases it can be a higher molecular weight polymer. The curing agent is a material that reacts with functional groups on the resin precursor to form a high molecular weight and/or crosslinked material. Many polyurethane and epoxy resin systems are two-part systems that are dispensed as liquids and cured in this way.

Many types of processing equipment have been designed to handle these systems in an industrial or automotive manufacturing settings. The main functions of this processing equipment are mixing, metering (to obtain proper mix ratios between the components and to control shot weights based upon material flow rates) and, in most cases, temperature control. Temperature control is often important for two reasons. First, temperature affects the rate of reaction between the resin precursor and the curing agent, and therefore directly affects cure rates and, when the foam is produced, the density of the foam. In addition, the viscosity of the components is in many cases highly dependent on temperature. In such cases, temperatures are often controlled so that the viscosity of one or more of the starting materials is within a workable range. Component temperatures are normally adjusted to close to the operating temperature before the components are introduced into the dispensing equipment, because, for cost reasons, the dispensing equipment typically is not designed to have the needed heating capacity or because the dispensing equipment is not designed to handle the high viscosities of the cold materials.

The processing equipment typically will draw the starting materials from so-called "bulk storage" units, which are large capacity storage vessels. If large volumes of materials are processed over short periods of time, it is sometimes efficient to at least partially control temperatures at the bulk storage units. However, this practice becomes more wasteful when the bulk stored material is consumed slowly, as this

requires that large volumes of material be maintained for extended periods at or near the processing temperature, until they are consumed. Therefore, "day tanks" are commonly used to bring smaller volumes of material up to near the operating temperature. The day tanks are interposed between the processing equipment and bulk storage. The day tanks are typically sized to handle volumes of material that will be consumed within a few hours up to one day. Material is transferred from bulk storage to the day tanks where the temperature is adjusted to the needed temperature, and is transferred on demand to the processing equipment.

There are capital costs associated with the use of day tanks, as well as operating costs such as power requirements for the heaters and the need to continuously maintain a dry air pad on these day tanks. Greater economic efficiencies potentially could be realized if these costs were to be reduced or eliminated. However, this would require the development of an alternative method of controlling component temperatures.

This invention is in one aspect a mixing and dispensing system, comprising a first circulation loop b) and second circulation loop c), each in fluid communication with a circulating-type mix head a). The circulating-type mix head a) includes separate first and second fluid circulation paths, a mixing and dispensing chamber, and an actuator which, upon actuation, allows a predetermined quantity of fluid from the first circulation path and a predetermined quantity of fluid from the second circulation path to each enter the mixing and dispensing chamber, mix and become dispensed together out of the mix head. The first circulation loop b) includes

b-1) conduit means that define a closed loop that includes the first fluid circulation path of the mixing head;

b-2) pumping means for pumping fluid around the first circulation loop;

b-3) heating means, upstream of the first circulation path of the mix head, for heating fluid in the first circulation loop to a predetermined temperature;

b-4) an inlet, downstream of the mix head and upstream of heating means b-3), for introducing additional fluid to fluid already circulating in the first circulation loop;

b-5) dispersing means, upstream of heating means b-3), for dispersing additional fluid introduced into the first circulation loop through inlet b-4) into fluid already circulating in the first circulation loop and equilibrating the temperature of the resulting fluid mixture;

b-6) measurement means for monitoring the fluid flow in the first circulation loop; and

b-7) detection means for detecting at least one of pressure, temperature and air bubbles in the fluid flow in the first circulation loop.

The second circulation loop c) includes

c-1) conduit means that define a closed loop that includes the second fluid circulation path of the mixing head;

c-2) pumping means for pumping fluid around the second circulation loop;

c-3) heating means, upstream of the mix head, for heating fluid in the second circulation loop to a predetermined temperature;

c-4) an inlet, downstream of the second circulation path of the mix head and upstream of heating means c-3), for introducing additional fluid to fluid already circulating in the second circulation loop;

c-5) measurement means for monitoring the fluid flow in the second circulation loop; and

c-6) detection means for detecting at least one of pressure, temperature and air bubbles in the fluid flow in the second circulation loop.

Second circulation loop c) may further include a dispersing means c-7) upstream of heating means c-3), for dispersing additional fluid introduced into the second circulation loop via inlet c-4) into fluid already circulating in the second circulation loop and equilibrating the temperature of the resulting fluid mixture.

First circulation loop b) is adapted to receive and mix a liquid component from an outside source such as a bulk storage unit, mix the incoming liquid with a fluid already circulating within the circulation loop and quickly equilibrate the temperature of the mixed fluids. This allows first circulation loop b) to accommodate an incoming liquid that may, often due to its significantly lower temperature, have a viscosity that is significantly higher than the viscosity of the fluid already circulating within the loop. The mixed fluid is then heated to the necessary processing temperature within the first circulation loop, and can be mixed with fluid from the second circulation loop c) and dispensed upon demand.

Second circulation loop c), when it contains optional dispersing means c-7), is similarly capable of receiving and mixing a liquid component from an outside source.

This invention is also a process for mixing and dispensing at least two fluids, comprising

A. circulating a first fluid through the first circulation loop of the mixing and dispensing system of the invention;

B. circulating a second fluid through the second circulation loop of the mixing and dispensing system of the invention;

C. mixing and dispensing a portion of said first and second fluids through the mix head of the mixing and dispensing system of the invention by actuating the actuator thereof; then

D. replenishing the first fluid in the first circulation loop by introducing additional fluid through inlet b-4) of the first circulation loop, dispersing the additional fluid into fluid already circulating in the first circulation loop and then heating the replenished first fluid within the first circulation loop by means of heating means b-3); and

E. replenishing the second fluid in the second circulation loop by introducing additional fluid through inlet c-4) of the second circulation loop and then heating the replenished second fluid within the second circulation loop by means of heating means c-3).

Figure 1 is a schematic diagram of an embodiment of a mixing and dispensing system of the invention.

Figures 2 and 2B are schematic diagrams of circulating-type mix head useful with the invention.

Figure 3 is a schematic diagram of an embodiment of a dispersing tube that is useful as the dispersing means in this invention.

Turning to Figure 1, mixing and dispensing system 10 includes as major components circulating-type mix head 1, first circulation loop 2, second circulation loop 3 and optional but preferred hydraulic activation unit 4.

Circulating-type mix head 1 includes a first and a second circulation path, which respectively permit fluids in the first and second circulation loops to be circulated through the mix head during operation, except at times of shot delivery. Figures 2A and 2B illustrate an embodiment of such a mix head. In Figures 2A and 2B, casing 11 defines a central bore 13 which extends to outlet 19. Actuator pin 12 fits within central bore 13. Casing 11 includes exit port 14A and entry port 15A, which are in fluid communication with second circulation loop 3 via lines 31. Casing 11 also includes exit port 14B and entry port 15B, which are in fluid communication with first circulation loop 2 via lines 21.

In the embodiments shown, actuator pin 12 is moveable between a closed position, as shown in Figure 2A, and an open position, as shown in Figure 2B. Actuator

pin 12 includes a narrowed central section 12A and a distal thicker section 12B. Distal thicker section 12B preferably is fitted to a close tolerance within central bore 13, to minimize or prevent leakage of fluids from bore 13 when the actuator is in the closed position. Alternatively, seals, gaskets or other similar devices may be used to control such leakage.

In the closed position, narrowed central section 12A defines, together with the wall of central bore 13, a conduit from entry port 15B to exit port 14B. This conduit, together with entry port 15B and exit port 14B, defines a first circulation path through mix head 1. Central section 12A also defines, together with the wall of central bore 13, a conduit from entry port 15A to exit port 14A. This conduit, together with entry port 15A and exit port 14A, defines a second circulation path through mix head 11. The first and second circulation paths are separated by central section 12A of actuator pin 12 when actuator pin 12 is in the closed position. Because of this, fluids in the first and the second circulation loops circulate separately through mix head 1 without becoming mixed with each other, when actuator pin 12 is in the closed position.

When mix head 1 is actuated, actuator pin 12 is retracted to the open position shown in Figure 2B. In that position, distal thicker section 12B is raised to a position that is intermediate to entry port 15A and exit port 14A, and intermediate to entry port 15B and exit port 14B. This removes the barrier separating the incoming flows from the respective circulation loops. As a result, fluid can enter central bore 13 through entry ports 15A and 15B, but their access to exit ports 14A and 14B is blocked by distal thicker section 12B of actuator pin 12. Fluids entering central bore 13 from entry points 15A and 15B therefore mix together in central bore 13 and become expelled through outlet 19. Outlet 19 may pour directly into a cavity, or feed a spray nozzle, wand or other apparatus for directing the fluid mixture to a desired location or direction.

Figure 1 illustrates a preferred embodiment in which mix head 1 is equipped with a hydraulic actuator system, shown generally as 4. Hydraulic actuator system 4 hydraulically actuates actuator pin 12 between the open and closed positions upon receiving a manual or automated signal to do so.

Other circulating-type mix head designs can be used instead of the particular design illustrated in Figures 2A and 2B.

First circulation loop 2, together with the first circulation path in mix head 1, defines a fluid path through which a fluid can be circulated. By "circulated" and its variations, it is meant simply that a fluid travels in a fixed direction through a

circulation loop any number of times, sequentially passing each successive point in the loop during each time it is circulated. First circulation loop 2 therefore includes one or more conduit means which, together with the first circulation path in mix head 1, define a closed loop. In Figure 1, these conduit means include various pipes, tubes and/or hoses that are indicated generally by reference numerals 21. The various conduit means are of course in fluid communication with each other and with the first circulation path in mix head 1 to define the closed loop.

First circulation loop 2 further includes pumping means for pumping a fluid around the first circulation loop. In Figure 1, such pumping means is indicated generally by reference numeral 22. The location of pumping means 22 within first recirculation loop 2 is not considered to be critical. As shown, pumping means 22 is downstream from heating means 23 and upstream of mix head 1, but pumping means 22 can be located at other positions in first circulation loop 2 if desired. Multiple pumping means can be included with first circulation loop 2.

The pumping means in first circulation loop 2 can be of any type that is adapted to the particular flow rates, operating pressures and fluid viscosities encountered in first circulation loop 2. Gear pumps, radial piston pumps, axial piston pumps, screw pumps, rotary pumps, continuous delivery pumps, double ball reciprocating pumps and bent axis pumps may all be suitable. Bent axis pumps are preferred on the basis of their high efficiency.

First circulation loop 2 further includes heating means for heating fluid in the first circulation loop to a predetermined temperature before the fluid enters the first circulation path of the mix head. In Figure 2, the heating means is shown generally by reference numeral 23. As shown, heating means 23 is located upstream (i.e., in the direction opposite of the fluid flow direction through first circulation loop 2) of pumping means 22, but the relative positions of heating means 23 and pumping means 22 may be reversed from that shown in Figure 1.

A preferred type of heater for many applications is a counterflow fluid heat exchanger, which uses a heated waterless thermal fluid to transfer heat to the fluid circulating within first circulation loop 2. Counterflow heat exchangers typically include an inlet and an outlet for each of a heating/cooling fluid and the circulating fluid. The fluids generally do not mix and follow separate flow paths within the heat exchanger. Suitable types of counterflow heat exchangers include flat plate, tube in tube and shell and tube heat exchangers. Shell and tube heat exchangers generally have a

series of small tubes within a larger pressure vessel or shell. Heat is transferred between a fluid flowing within the small tubes and another fluid flowing within the shell. In a flat plate heat exchanger, heat is transferred between two fluids flowing in opposite directions along separate flow paths created between a series of parallel plates. The plates are typically made of stainless steel and may contain channels to increase heat transfer efficiency. The plates may be sealed at their joints by using elastomer gaskets or by a brazing process. The large surface area of the plates provides for greater heat transfer efficiency when compared to a shell and tube design. The nominal pressure drop across the heat exchanger is suitably between 1.3 to 1.5 psi at the heated temperature.

The maximum flow rate through the heat exchangers is a function of the maximum acceptable pressure drop. Therefore, the maximum flow capacity is dependent upon the pressure drop that is permissible in the system.

Flat plate heat exchangers are usually lighter and more compact than shell and tube heat exchangers. However, to achieve the higher heat transfer efficiency, the fluid flowing through a flat plate heat exchanger must be in contact with the plates for a sufficient amount of time, meaning that the plates have to be of a certain length. In practice, this requirement limits the applicability of flat plate heat exchangers in this apparatus. Therefore, thermal fluid heaters are preferred mainly on the basis that they tend not to expose the circulating fluids to extremely high temperatures which can cause scorching or other thermal degradation. A flat plate heater or similar type of heater is preferred over mass heaters.

The first circulation loop contains an inlet for introducing additional fluid into the first circulation loop. Typically, this inlet will include a valve of some type, typically a ball valve or diaphragm valve, which is opened when additional fluid is needed in the circulation loop. Generally, additional fluid is introduced into the first circulation loop to replace fluid discharged from the mix head during a "shot", and to replace other amounts of fluid that may be lost due to leakage, the taking of samples for analysis or other purposes, or for similar reasons. The inlet may operate in response to the loss of fluid from the first circulation loop. For example, a valve included within the inlet may be automated to open in response to the operation of the mix head to replace the discharged fluid. Alternatively, such a valve may open in response to a pressure drop of predetermined magnitude within first circulation loop to replace fluid that is discharged through the mix head or which is otherwise removed from the first circulating loop.

The inlet is shown in Figure 1 generally by reference numeral 24. Inlet 24 in the embodiment shown in Figure 1 includes a valve and a conduit which is in fluid communication with the conduits 21 that make up circulation loop 2. The inlet is positioned downstream of the first circulating path of the mixing head 1 and upstream of heating means 23. The inlet is also in fluid communication with a source of the additional fluid, such as a bulk storage unit.

The first circulating loop additionally includes a dispersing means in which dispersed fluid entering the loop through the inlet into the fluid that has already been circulating within the first circulating loop. In Figure 1, the dispersing means in first circulation loop 2 is indicated generally by reference numeral 25. The dispersal of the additional fluid serves to equilibrate the temperature of the fluid mixture that is formed when the additional fluid enters the first circulating loop during the dispensing of material from the first circulation loop, via the mix head. This permits a more uniform temperature and viscosity to be achieved when the fluid subsequently passes through the heating means which is located downstream of the dispersing means.

Various devices can be used as the dispersing means, including, for example, various types of static or mechanical mixing devices, as well as various heat exchangers as described above. A preferred type of dispersing means is a disperser tube, which is shown schematically in Figure 3. In Figure 3, disperser tube 25 includes vessel 251.

Vessel 251 holds a quantity of the recirculating fluid, which is continuously or intermittently being introduced and removed through conduits 21 as the fluid is circulated through circulation loop 2. Inlet 24 is in fluid communication with tube 241, which extends into the interior of vessel 251. Inside vessel 251, tube 241 branches into multiple open-ended tubes 242. Fluid entering first circulation loop 2 via inlet 24 travels through tube 241 and through open-ended tubes 242, entering vessel 251 through openings in open-ended tubes 242 and mixing with the circulating fluid that is flowing through vessel 251. This design permits rapid and uniform mixing of additional fluid with the circulating fluid already in circulation loop 2. This facilitates a rapid equilibration of temperature. In cases in which the viscosity of the fluid varies greatly with temperature, this also facilitates a rapid equilibration of viscosity. The volume of vessel 251 relative to the inflow of material through open-ended tubes 242 is preferably that the temperature drop across disperser tube 25 is no greater than 6°C and preferably no greater than 3°C.

First circulation loop further includes sensors, such as pressure, temperature and/or bubble detection sensors 29 in Figure 1. Bubble detection sensors detect the presence of air that may be entrapped in the circulation loop. For example, a repair such as filter replacement, orifice change or of other critical components that require the material lines to be opened may pose a risk of trapping air into the closed loop system, therefore requiring the system to be bled of all air trapped within the circulation loop. The presence of gasses in the circulating loops can be detected visually or through a bubble detection sensor. Other devices that may be present include, for example, other process control monitors and controls.

Second circulation loop 3, together with the second circulation path in mix head 1, defines a second, separate, fluid path through which a fluid can be circulated. As before, second circulation loop 3 includes one or more conduit means which, together with the first circulation path in mix head 1 and other components, define a closed loop. In Figure 1, these conduit means include various pipes, tubes and/or hoses that are indicated generally by reference numerals 31. The various conduit means are of course in fluid communication with each other and with second circulation path in mix head 1 to define the closed loop.

Second circulation loop 3 includes pumping means for pumping a fluid around the second circulation loop. In Figure 1, such pumping means is indicated generally by reference numeral 32. As before, the location of pumping means 32 within second circulation loop 3 is not considered to be critical, and multiple pumping means can be included with second circulation loop 3. As shown, pumping means 32 is downstream from heating means 33 and upstream of mix head 1. The specific design of the pumping means in second circulation loop 3 can be of any type that is adapted to the particular flow rates, operating pressures and fluid viscosities encountered in second circulation loop 3, including any of the specific types described before.

Second circulation loop 3 further includes heating means for heating fluid in the second circulation loop to a predetermined temperature before the fluid enters the second circulation path of the mix head. In Figure 2, the heating means is shown generally by reference numeral 33. As shown, heating means 33 is located upstream (*i.e.,* in the direction opposite of the fluid flow direction through second circulation loop 3) of pumping means 32, but the relative positions of heating means 33 and pumping means 32 may be reversed from that shown in Figure 1. As before, a preferred type of heater for many applications is a thermal fluid heater.

The second circulation loop contains an inlet for introducing additional fluid into the second circulation loop. The design and operation of such an inlet will generally be as described with respect to the inlet of the first circulation loop. As before, additional fluid generally is introduced to replace fluid discharged from the mix head during a "shot", or to replace other amounts of fluid that may be lost for similar reasons as described before. The inlet may operate in response to the loss of fluid from the second circulation loop, though automation or in response to a pressure drop of predetermined magnitude within the second circulation loop.

The inlet is shown in Figure 1 generally by reference numeral 34. Inlet 34 in Figure 1 includes a valve and a conduit which is in fluid communication with the conduits 31 that make up second circulation loop 3. The inlet to second circulation loop 3 is positioned downstream of the first circulating path of mixing head 1 and upstream of heating means 33.

The second circulating loop may include a dispersing means such as is described with respect to the first circulation loop. Such a dispersing means is generally preferred when the viscosity of additional fluid entering second circulation loop 3 and/or that of the circulating fluid are somewhat high, such as about 500 cps or more at the respective temperatures at the time they are mixed.

Second circulation loop further includes sensors, such as pressure, temperature and/or bubble detection sensors 39 in Figure 1. Other devices that may be present include, for example, other process control monitors and controls.

Fluids are mixed and dispensed using the foregoing apparatus as follows.

A first fluid is charged to the first circulation loop of the system and circulated through the first circulation loop (including the first circulation path in the mix head) via operation of the pumping means. A second fluid is charged to the second circulation loop of the system and separately circulated through the second circulation loop (including the second circulation path in the mix head) via operation of the pumping means. As the fluids circulate through the respective circulation loops, they each pass separately through the mix head without coming into contact with each other. The circulating fluids are separately adjusted as necessary to their respective operating temperatures by operation of the heating means on the respective circulation loops. After operating conditions are established within the two circulation loops, the actuator of the mix head is actuated. This allows a portion of the first and second fluids to become mixed in the mix head and then to be dispensed out of the mix head.

When a desired amount of material has been dispensed in this manner, the fluids in the first and second circulation loops become somewhat depleted. The first fluid in the first circulation loop is replenished by introducing additional fluid through inlet b-4) of the first circulation loop, dispersing that additional fluid into fluid that is already circulating through the first circulation loop, and then heating the replenished first fluid to the operating temperature by means of heating means b-3). Fluid levels in the second circulation unit are replenished in an analogous manner by introducing additional fluid through inlet c-4), dispersing it within the fluid that is already circulating as necessary, and then heating the replenished second fluid within the second circulation loop by means of heating means c-3).

The replenishment of the fluids in the respective circulation loops may be performed during each "shot", i.e., at the same time each time material is discharged from the mix head, or after each shot.

The mixing and dispensing system may further include various optional elements, some of which are illustrated in Figure 1. For example, either or both circulation loops may include one or more flow meters, which measure and/or control flow rates through the respective circulation loops. In Figure 1, such flow meters are indicated by reference numerals 25 and 35, respectively. The design of such flow meters is not considered to be critical; generally a particular flow meter will be selected in consideration of the expected operating pressures, flow rates and fluid viscosities.

Various filters, such as filters 26 and 36 in Figure 1, may be present to remove particulate matter from the circulating fluid. Various pressure switches and/or transducers such as pressure switches 27 and 37 may be included to help monitor or control material pressures. Valves such as valves 28 and 38 may be included at various points along each circulation loop. Either or both circulation loops may be equipped with an auto-startup valve (reference numeral 51 in Figure 1) or other diversion valve, which allows flows to be diverted to only a part of the respective loop when necessary or desirable. For example, it may be desirable to by-pass the mix head during start-up, when the circulating fluid may be cold and highly viscous, in order to avoid clogging or fouling the mix head or to simply avoid high operating pressures during start-up. As shown at reference numeral 50 in Figure 1, a portion of the circulating fluid can be diverted from the main flow and used as a coolant for the pumping means in the circulation loop.

The mixing and dispensing system of the invention is preferably automated, but can also be manually controlled. An automated process often makes it easier control the shot size and to communicate with the registering of data during and after the dispensing of material from circulation loops 2 and 3, though the mix head. It is also possible that the controls of the mixing and dispensing system may be controlled entirely by means of an external control, therefore reducing the floor space and cost of redundant controls, and eliminating interface cables. A computerized process control preferably maintains the flow rates of circulation loop 2 and 3 independently within a tolerance of 0.5 g/s. The flow rate is verified through the use of the flow meters 25 and 35.

The temperature of the materials circulating in circulation loops 2 and 3 preferably is controlled within a tolerance of 0.5 °C, preferably to within a tolerance of 0.3°C.

The mixing and dispensing system of the invention is useful in a wide range of applications which require two or more fluids to be mixed and dispensed together. It is well-adapted for processing two-part resin systems, in which a resin precursor and a curing agent are mixed and dispensed together. It is especially useful for processing two-part resin systems in which one of the components is significantly more viscous than the other.

Examples of two-part resin systems that can be processed with the mixing and dispensing system of the invention are two-part epoxy resins and two-part polyurethane resin systems. Both types of systems are well-known. Two-part epoxy resins systems that can be processed with this invention include those described, for example, in US 5,414,067. Two-part polyurethane systems that can be processed with the mixing and dispensing system of this invention are described, for example, in U. S. Patent Nos. 5,817,860, 6,541,534 and 6,423,755, WO 02/079340A1, WO 03/037948A1.

Applications of particular interest include the mixing and dispensing of polyurethane foams. Examples of these are foams that are applied to vehicles for noise and vibration abatement (so-called "acoustical foams"). The acoustical foams are frequently applied to parts of automobiles and other vehicles in order to reduce the amount of noise and vibration that are transmitted through the part into the passenger compartments of those vehicles. Another example of these is a foamed sealant, which may be applied to a cavity in a part of an automobile or other vehicle to prevent fluids or particulates (typically water and dust) from entering and/or escaping from the part.

These applications are characterized in that (1) the volume of the foaming composition that is needed at any particular place is generally small (typically less than 2 kg and more typically less than 0.5 kg) and (2) the foam is generally formed in place, rather than being manufactured beforehand and then assembled onto the part.

Polyurethane foam systems that are useful in such applications tend to fall within two broad categories. The first type is based on an isocyanate-terminated prepolymer that contains urethane and possibly urea groups. The prepolymer in this instance is the more viscous, higher molecular weight component of the system. Typically, it would be the fluid that circulates in the first recirculation loop of the system of the invention. The second component of this type of system is typically water, or a mixture of water and one or more low molecular weight polyol or polyamine crosslinkers or chain extenders. The second component in this case is generally much lower in viscosity than the prepolymer, and generally would be circulated in the second circulation loop of the system of the invention. Either component may contain additives such as surfactants, catalysts and the like as may be desirable to produce a good quality foam and/or to obtain a suitable curing rate.

The second category of polyurethane foam systems is based on a polyol component and a separate isocyanate component. In this system, the polyol component is usually the higher viscosity material, and is preferable circulated in the first circulation loop of the system. The polyol component will contain a blowing agent (typically including water), and may contain surfactants, catalyst and the like. The isocyanate component in this case is typically the lower viscosity material, and is preferably circulated in the second circulation loop of the system. In this case, the isocyanate component typically has a low (less than 350) isocyanate equivalent weight.

WHAT IS CLAIMED IS:

1. A mixing and dispensing apparatus, comprising a first circulation loop b) and second circulation loop c), each in fluid communication with a circulating-type mix head a), wherein:

the circulating-type mix head a) includes separate first and second fluid circulation paths, a mixing and dispensing chamber, and an actuator which, upon actuation, allows a predetermined quantity of fluid from the first circulation path and a predetermined quantity of fluid from the second circulation path to each enter the mixing and dispensing chamber, mix and become dispensed together out of the mix head;

the first circulation loop b) includes

b-1) conduit means that define a closed loop that includes the first fluid circulation path of the mixing head;

b-2) pumping means for pumping fluid around the first circulation loop;

b-3) heating means, upstream of the first circulation path of the mix head, for heating fluid in the first circulation loop to a predetermined temperature;

b-4) an inlet, downstream of the mix head and upstream of heating means b-3), for introducing additional fluid to fluid already circulating in the first circulation loop;

b-5) dispersing means, upstream of heating means b-3), for dispersing additional fluid introduced into the first circulation loop through inlet b-4) into fluid already circulating in the first circulation loop and equilibrating the temperature of the resulting fluid mixture;

b-6) measurement means, upstream of the first circulation path of the mix head, for monitoring the fluid flow in the first circulation loop; and

b-7) detection means, upstream of the first circulation path of the mix head, for detecting at least one of pressure, temperature and air bubbles in the fluid flow in the first circulation loop; and

the second circulation loop c) includes

c-1) conduit means that define a closed loop that includes the second fluid circulation path of the mixing head;

c-2) pumping means for pumping fluid around the second circulation loop;

c-3) heating means, upstream of the second circulation path of the mix head, for heating fluid in the second circulation loop to a predetermined temperature;

c-4) an inlet, downstream of the second circulation path of the mix head and upstream of heating means c-3), for introducing additional fluid to fluid already circulating in the second circulation loop;

c-5) measurement means for monitoring the fluid flow in the second circulation loop; and

c-6) detection means for detecting at least one of pressure, temperature and air bubbles in the fluid flow in the second circulation loop.

2. The apparatus of claim 1, wherein said dispersing means b-5) is a disperser tube.

3. The apparatus of claim 1 or 2, wherein said second circulation loop includes c-7) dispersing means, upstream of heating means c-3), for dispersing additional fluid introduced into the second circulation loop into fluid already circulating in the second circulating loop and equilibrating the temperature of the resulting fluid mixture.

4. The apparatus of claim 4, wherein said dispersing means c-7) is a disperser tube.

5. The apparatus of any preceding claim, wherein said mix head comprises a casing which defines a central bore which extends to an outlet, an actuator pin fitting within said central bore, a first exit port and a first entry port which are in fluid communication with the first circulation loop, and a second exit port and a second entry port which are in fluid communication with said second circulation loop, wherein said actuator pin is moveable between a closed position and an open position, and said actuator pin includes a narrowed central section and a distal thicker section such that when said actuator pin is in a closed position, narrowed central section defines, together with the wall of said central bore, a conduit from said first entry port to said first exit port and a separate conduit from said second entry port to said second exit port, and when said actuator pin is retracted to an open position, said distal thicker section is raised to a position that is intermediate to said first entry port and said first exit port and intermediate to said second entry port and said second exit port such that fluid can enter said central bore through said first and second entry ports where they mix together and become expelled through said outlet.

6. The apparatus of any preceding claim wherein said mix head is hydraulically activated.

7. The apparatus of any preceding claim wherein said heating means b-3) is a counterflow fluid heat exchanger.

8. The apparatus of any preceding claim wherein said heating means c-3) is a counterflow fluid heat exchanger.

9. A process for mixing and dispensing at least two fluids, comprising

A. circulating a first fluid through the first circulation loop of the mixing and dispensing apparatus of claim 1;

B. circulating a second fluid through the first circulation loop of the mixing and dispensing apparatus of claim 1;

C. mixing and dispensing a portion of said first and second fluids through the mix head of the mixing and dispensing apparatus of claim 1 by actuating the actuator thereof; then

D. replenishing the first fluid in the first circulation loop by introducing additional fluid through inlet b-4) of the first circulation loop and then heating the replenished first fluid within the first circulation loop by means of heating means b-3); and

E. replenishing the second fluid in the second circulation loop by introducing additional fluid through inlet c-4) of the second circulation loop and then heating the replenished second fluid within the second circulation loop by means of heating means c-3).

10. The process of claim 9 wherein said first and second fluids together form a two-part polyurethane resin system.

11. The process of claim 9 wherein said first and second fluids together form a two-part epoxy resin system.

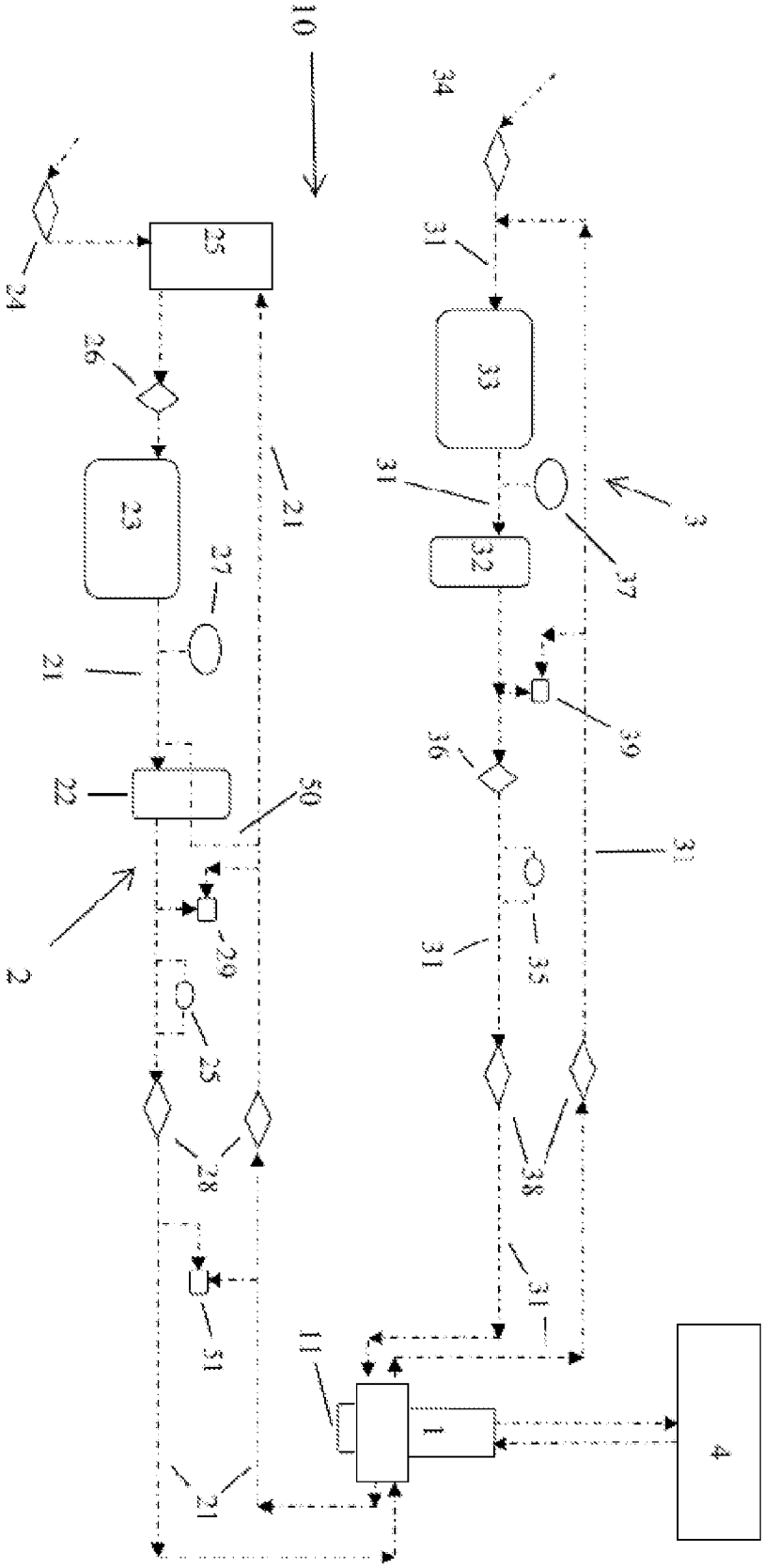

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FIGURE 1

Figure 2A

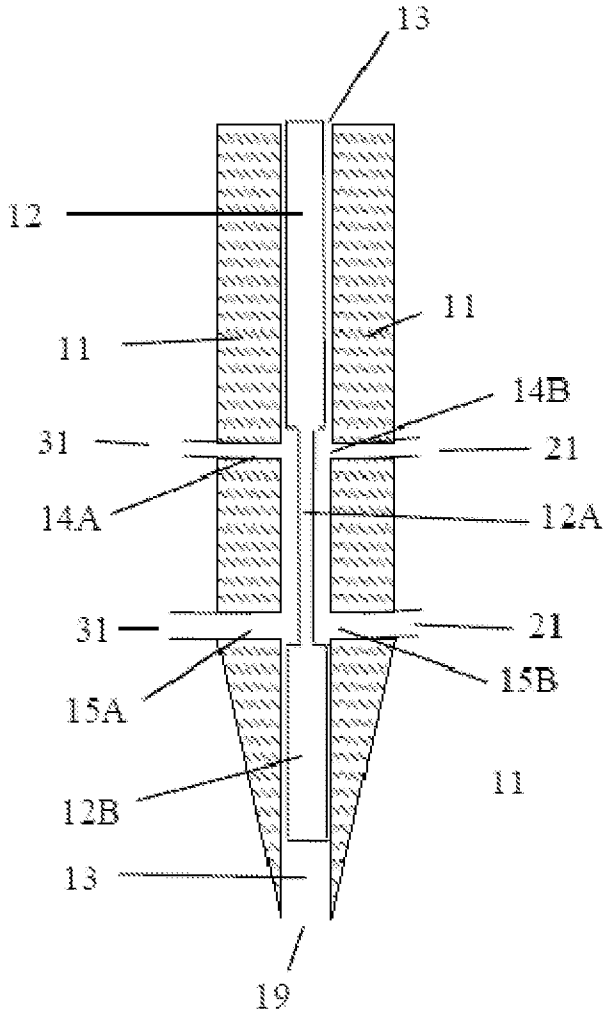


Figure 2B

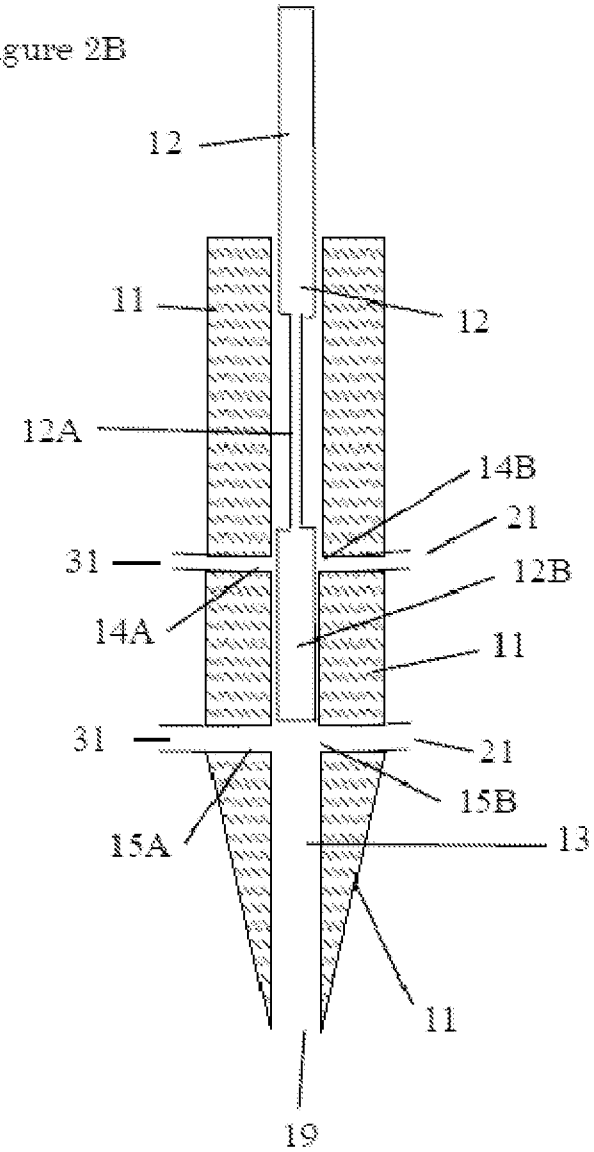
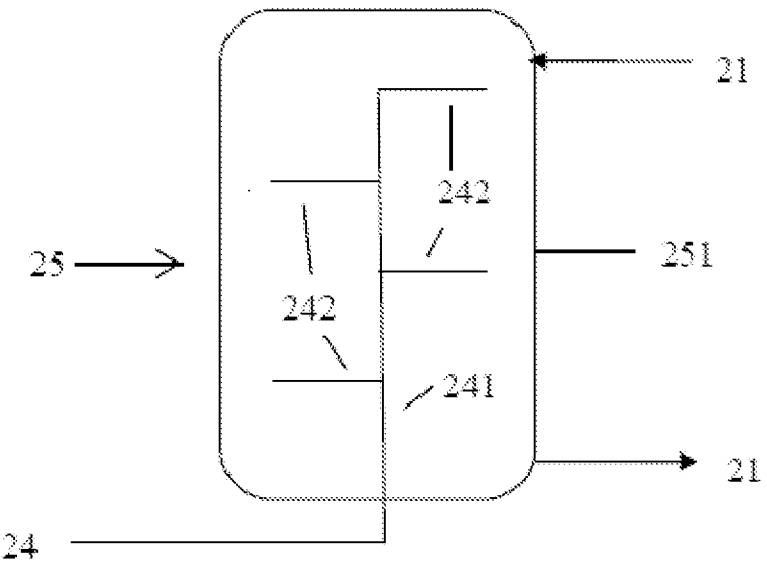


Figure 3



INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/055945

A. CLASSIFICATION OF SUBJECT MATTER
INV. B29B7/76 B29B7/74 B01F3/20 B01F5/10 B01F13/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B29B B01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 090 695 A (STONE KIRBY LEE ET AL) 23 May 1978 (1978-05-23)	1-4,6-10
Y	figure 1	11
A	column 8, line 31 - column 9, line 30	5

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A	figure 1 paragraph [0026] * abstract	7,8,11

Y	US 4 379 122 A (TAUBENMANN PETER [DE]) 5 April 1983 (1983-04-05) column 1, line 17 - line 24 figure 1a	11

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
3 February 2011	15/02/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Krasenbrink, B

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/055945

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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