can have an opening that serves as both the inlet and the outlet. In some embodiments, a material tank can be the tank used by a manufacturer for supplying a component.

In some embodiments, when the system is used to manufacture a polishing composition, each material tank 12, 14, 16, and 18 can receive one or more of the following materials: a diluent, an acid, a base, and an abrasive particle composition (e.g., an abrasive particle dispersion) containing abrasive particles. In such embodiments, each material tank 12, 14, 16, or 18 can optionally receive one or more of the following additional materials: corrosion inhibitors (e.g., benzotriazoles, triazoles, and azoles), oxidizers (e.g., hydrogen peroxide, ammonium persulfate, silver nitrate, ferric nitrates or chlorides, per acids or salts, ozone water, potassium ferricyanide, potassium dichromate, potassium iodate, potassium bromate, vanadium trioxide, hypochlorous acid, sodium hypochlorite, potassium hypochlorite, calcium hypochlorite, magnesium hypochlorite, ferric nitrate, $KMnO_4$, other inorganic or organic peroxides, or mixtures thereof), complexing agents, biocides, pH adjusters, and surfactants (e.g., cationic surfactants, anionic surfactants, nonionic surfactants, and amphoteric surfactants).

In some embodiments, a single raw material can be introduced through more than one of material tanks 12, 14, 16, and 18 (e.g., to improve mixing quality). In some embodiments, any number (e.g., two, three, or four) of material tanks 12, 14, 16, and 18 can be used to introduce the components to mixing tank 20. In some embodiments, only two material tanks 12 and 14 can be used in the system shown in FIG. 1. For example, the diluent, the acid, and the base can be pre-mixed and the mixture can be introduced through material tank 12, while the abrasive particle composition can be introduced through material tank 14. In certain embodiments, more than four (e.g., five, six, seven or more) material tanks can be used in the system shown in FIG. 1 to introduce the components to mixing tank 20.

As shown in FIG. 1, each pump 13a,b,c,d is disposed between and in fluid communication with a respective material tank 12, 14, 16, and 18 and a respective mass flow controller 15a,b,c,d. Each pump 13a,b,c,d is configured to move (e.g., continuously) a raw material from a respective material tank 12, 14, 16, and 18 through a respective mass flow controller 15a,b,c,d to mixing tank 20. In some embodiments,

In some embodiments, while mass flow controllers are described in connection with the systems shown in FIGs. 1 and 4, other fluid flow controller units (such as volume flow controllers) can also be used in the blending systems described in this disclosure.

The contents of all publications cited herein (e.g., patents, patent application publications, and articles) are hereby incorporated by reference in their entirety.

The following examples are illustrative and not intended to be limiting.

Examples

Overview of Examples 1, 2 & 3:

Three representative examples are shown below. These examples compare an ACP process described in this disclosure with a conventional Batch process (also referred below as "Batch process" as shown in FIG. 2) and a convention Continuous process (also referred below as "Continuous process" as shown in FIG. 3). For each of the three examples, test results were collected over 100 production lots.

Example 1: Production Throughput Experiment

A detailed study for throughput analysis was performed on an ACP process, a conventional Batch process, and a conventional Continuous process. The procedures for these three processes are described below.

Batch process (Comparative)

100 lots of a polishing composition were made using a batch manufacturing process. The polishing composition contained chemicals, water and silica abrasive particles. The chemicals included a carboxylic acid (Acid 2), an organic base (Base 2), and other chemicals. As illustrated in FIG. 2, for each lot, the above chemicals and water were pumped from materials tank 12, 14, and 16 into a 3000 gallon tank 20 (which serves both as a mixing tank and a holding tank) one by one through pumps 13a,b,c and mass flow controllers 15a,b,c. The silica abrasive dispersion was then pumped from material tank 18 into the tank 20 through pump 13d and mass flow controller 15d. Tank 20

contained a paddle type mixer 17, which was activated to mix all the components. After several hours of mixing, filtration and packaging operations were initiated. Specifically, the mixed polishing composition from the tank 20 was pumped through a filter apparatus 22 (which contained several filter banks) into a packaging station 24 (which included drums or totes) that hold the finished product. Quality control was performed on the packaged polishing composition. The production throughput was measured by dividing the number of gallons packaged by the total time used to make that particular lot of polishing composition. The total time included the time to introduce all the chemicals, water and abrasive dispersion, the mixing time, and the filtration and packaging time. The normalized throughput data are summarized in FIG. 5.

Continuous process (Comparative)

100 lots of the polishing composition were made using a continuous static mixer blending process. The polishing composition is similar to the polish composition made from the Batch process except that it contained Acid 1 and Base 1 (instead of Acid 2 and Base 2). In this process, raw materials such as chemicals, water, and abrasive dispersion were mixed using a number of in-line static mixers. This was done sequentially as follows:

As illustrated in FIG. 3, raw material 1 and raw material 2 were pumped from material tanks 12 and 14 into the first in-line static mixer 17a through pumps 13a,b and mass flow controller 15a,b. This mixture in mixer 17a and raw material 3 from material tank 16 were then pumped into the second in-line static mixer 17b. This mixture in mixer 17b and raw material 4 from material tank 18 were then pumped into the third in-line static mixer 17c. Materials 3 and 4 were pumped into in-liner mixers 17b,c by using pumps 13c,d and mass flow controllers 15c,d. This continuous flow process continued until all the raw materials were mixed. Finally, the mixture thus obtained was introduced into a holding tank 21. A quick quality control step 19of selected parameters (e.g., conductivity) was performed and the mixed polishing composition was sent to a filter station 22 and then to a packaging station 24. The continuous process continued until a certain number of drums or totes where filled. The production throughput was measured

CLAIMS

1. A method of forming a chemical composition, the method comprising:

mixing a plurality of continuous material flows in at least one mixing tank to form a chemical composition, each continuous material flow comprising at least one component of the chemical composition, wherein the mixing tank does not include a stirrer or a baffle; and

moving a continuous flow of the chemical composition to a packaging station downstream of the at least one mixing tank;

wherein the mixing and moving steps are performed continuously,

wherein the material and chemical composition flows are in an in-process steady state; and

wherein the mixing step in the at least one mixing tank comprises at least one mixing method selected from the group consisting of turbulent mixing of the material flows, recirculation of the chemical composition, and a combination thereof.

2. The method of claim 1, further comprising obtaining a material flow having a substantially constant flow rate prior to the mixing step.

3. The method of claim 2, wherein obtaining a material flow having a substantially constant flow rate comprises continuous recirculation of the material flow in a material tank through at least one fluid transfer unit and at least one flow control unit until a predetermined flow rate is reached.

4. The method of claim 1, further comprising performing an in-process quality control measurement of the chemical composition in the mixing tank without interrupting the continuous process.

5. The method of claim 1, wherein the mixing tank has a volume of from about 40 liters to about 1500 liters.

6. The method of claim 1, wherein the chemical composition is a polishing composition prepared from components comprising a diluent, an acid, a base, a salt, and abrasive particles.

7. The method of claim 6, wherein the diluent comprises deionized water.

8. The method of claim 6, wherein the acid comprises an organic acid, an inorganic acid, or a mixture thereof.

9. The method of claim 6, wherein the base comprises potassium hydroxide, ammonium hydroxide, monoethanol amine, diethanol amine, triethanol amine, quaternary ammonium compounds or a mixture thereof.

10. The method of claim 6, wherein the salt comprises potassium citrate, potassium carbonate, ammonium nitrate, ammonium sulfate, ammonium citrate, ammonium oxalate, potassium nitrate, potassium sulfate, potassium chloride, or a mixture thereof.

11. The method of claim 6, wherein the abrasive particles comprise silica, ceria, titania, alumina, or a mixture thereof.

12. The method in claim 6, where the abrasive particles comprise colloidal silica.

13. The method of claim 12, wherein the continuous flow of the chemical composition comprises at most about 50 wt% silica.

14. The method of claim 1, wherein the continuous flow of the chemical composition has a pH of from about 2 to about 11.

15. The method of claim 14, wherein the continuous flow of the chemical composition has a pH of from about 2 to about 9.

16. The method of claim 1, further comprising continuously moving the chemical composition into a holding tank prior to packaging.

17. The method of claim 1, further comprising filtering the continuous flow of the chemical composition before moving the continuous flow of the chemical composition to the packaging station.

18. The method of claim 1, wherein the continuous flow of the chemical composition exiting the mixing tank has a volume flow rate of at least about 20 liters per minute.

19. The method of claim 1, wherein the method forms a chemical composition having a total lot-to-lot variation of at most about 1% in the weight of a component.

20. The method of claim 1, wherein the method forms a chemical composition having a total within lot variation of at most about 1% in the weight of a component.

21. A system, comprising:

a plurality of material tanks, each material tank being configured to receive a material used to form a chemical composition;

at least one mixing tank in which the materials from the material tanks are mixed to form a chemical composition, wherein the mixing tank does not include a stirrer or a baffle, the mixing tank is in fluid communication with the plurality of material tanks, the mixing tank is configured to continuously receive the materials from the material tanks and to continuously deliver the chemical composition downstream, and the mixing tank optionally comprises a recirculation loop in fluid communication with the mixing tank;

optionally, at least one holding tank downstream from the mixing tank and in fluid communication with the mixing tank; and

optionally, at least one filter apparatus in fluid communication with the mixing tank or the optional holding tank, the filter apparatus being configured to receive and filter the chemical composition;

wherein the system does not include an in-line static or dynamic mixer between each material tank and the mixing tank.

22. The system of claim 21, wherein the mixing tank comprises at least one mixing system.

23. The system of claim 22, wherein the mixing system comprises a vortex, a turbulent mixer, a recirculation loop, or a combination thereof.

24. The system of claim 21, further comprising at least one quality determination unit that is attached integrally to a system component.

25. The system of claim 24, wherein the quality determination unit comprises a pH meter, a conductivity meter, a concentration meter, or a LPC (Large Particle Count) meter.

26. The system of claim 21, wherein the mixing tank has a volume of from about 40 liters to about 1500 liters.

27. The system of claim 21, further comprising a fluid transfer unit in fluid communication with each material tank, the fluid transfer unit being configured to continuously transfer the material in each material tank to the mixing tank.

28. The system of claim 21, further comprising a fluid flow controller unit between each material tank and the mixing tank, the fluid flow controller unit being configured to adjust the flow rate of the material transferred from each material tank to the mixing tank.

29. The system of claim 21, wherein the system comprises a load cell in contact with each material tank, the load cell being configured to measure the content weight in each material tank.

30. The system of claim 21, wherein the system comprises the holding tank, the holding tank being configured to continuously receive the chemical composition from the mixing tank.

31. The system of claim 30, wherein the holding tank has a volume of from about 1,500 liters to about 20,000 liters.

32. The system of claim 21, wherein the system comprises the filter apparatus.

33. The system of claim 21, further comprising a packaging station downstream of the mixing tank, the packaging station being configured to package the chemical composition.

34. The system of claim 21, further comprises a plurality of fluid transfer units, wherein each fluid transfer unit is configured to continuously transfer a material from a system component to another system component.

35. The system of claim 21, further comprising at least one heating unit, wherein the heating unit is configured to independently heat a system component.

36. The system of claim 21, wherein the system comprises the recirculation loop, the recirculation loop being configured to recirculate the chemical composition back to the mixing tank.