

BLENDING SYSTEM AND METHOD FOR PREPARING EMULSIONS

FIELD OF THE APPLICATION

[0001] The current application is generally related to a system and method for preparing emulsions. In particular, the current application is related to a blending system and method for preparing aqueous-hydrocarbon emulsions on-site of a wellsite in relation to a well service procedure, such as an acid stimulation and the like.

BACKGROUND

[0002] At the outset, it should be noted that statements made herein merely provide information related to the present disclosure and do not constitute any admission of prior art.

[0003] In the oil and gas industry, a subterranean formation (i.e. a “reservoir”) often needs to be treated (or “stimulated”) to enhance or restore the productivity of a well. Generally speaking, stimulation treatments fall into two main groups, hydraulic fracturing treatments and matrix treatments. Fracturing treatments are performed above the fracture pressure of the reservoir formation and create a highly conductive flow path between the reservoir and the wellbore. Matrix treatments are performed below the reservoir fracture pressure and generally are designed to restore the natural permeability of the reservoir following damage to the near-wellbore area.

[0004] A commonly used method to treat the matrix is “matrix acidizing”, which is generally understood in the industry to mean the treatment of a reservoir formation with a stimulation fluid containing a reactive acid. In sandstone formations, the acid reacts with the soluble substances in the formation matrix to enlarge the pore spaces. In carbonate formations, the acid dissolves the entire formation matrix. In each case, the

matrix acidizing treatment improves the formation permeability to enable enhanced production of reservoir fluids. Matrix acidizing operations are ideally performed at high rate, but at treatment pressures below the fracture pressure of the formation. This enables the acid to penetrate the formation and extend the depth of treatment while avoiding damage to the reservoir formation.

[0005] Typically, the reactive acid comprises hydrochloric acid (HCl) and a blend of acid additives. It is also common for acid treatments to include a range of acid types or blends, such as acetic, formic, hydrochloric, hydrofluoric and fluoboric acids. A few examples are set forth in commonly assigned US letters patents nos. US6350721, 6828280, 6938693, 7306041, 7066260, 7318475.

[0006] Depending on the characteristics of the formation and the treatment fluid, it may be helpful to first emulsify the acid before pumping it down the wellbore. The preparation of acid emulsion is traditionally performed off-site, i.e. at a location that is away from the wellsite, and is generally based on a batch mixing method. An example of the prior art system **100** is shown in **FIG. 1**. There, a large tank (not shown) is employed to re-circulate an acid mixture until a complete homogenous state is achieved. The emulsifying agent is transferred into a batch tank **140** and then the blended acid is added to the batch tank **140**. A centrifugal pump **180** (i.e. c-pump) is then used to re-circulate the tank **140** until the desired emulsion is created. Once the emulsion is created, the contents of the batch tank **140** can be delivered to the wellsite as a finished product.

[0007] Batch mixing is disadvantageous for several reasons. First, it is often challenging to plan the logistics such as storage and transportation beforehand to ensure sufficient acid is available at the wellsite when an acid treatment needs to be performed on a wellbore. Second, batch-to-batch variations may occur, which could result in inconsistencies in treatment result. Third, degradations may occur during the process of storage and transportation. Fourth, while batch mixing a small volume of acid emulsions is not a significant issue, it can become very difficult when the volumes

needed is very large. Accordingly, there is a need to improve the current batch mixing method for preparing acid emulsions.

SUMMARY

[0008] According to one aspect of the current application, there is disclosed an on-site emulsifying system comprising a first fluid tank, a second fluid tank, a circulation loop comprising a buffer tank and a pump, wherein the first fluid tank and the second fluid tank are in fluid communication with the circulation loop via a first fluid inlet pipe and a second fluid inlet pipe, respectively, and an outlet pipe that is in fluid communication with the circulation loop. In some embodiments, the on-site emulsifying system further comprises a feeding pipe to a wellbore, where the feeding pipe is in fluid communication with the outlet pipe. In some embodiments, the first fluid and the second fluid are non-miscible.

[0009] The first fluid can be an aqueous fluid. The second fluid can be an organic fluid selected from the group consisting of hydrocarbon, diesel oil, kerosene, paraffinic oil, crude oil, LPG, toluene, xylene, ether, ester, mineral oil, biodiesel, vegetable oil, animal oil, and mixtures thereof. In some embodiments, the aqueous fluid tank contains an acid or a blended acid and the organic fluid tank contains an organic fluid mixed with an appropriate amount of an emulsifying agent. In some embodiments, at least one of the first fluid inlet pipe and the second fluid inlet pipe contains a metering valve.

[0010] The pump in the on-site emulsifying system can be a centrifugal pump. In some cases, at least one of the first fluid inlet pipe and the second fluid inlet pipe contains a centrifugal pump. In some cases, at least one of the first fluid inlet pipe and the second fluid inlet pipe contains a pre-dispersing device. In a specific embodiment, the outlet pipe contains an electric conductivity meter for monitoring an emulsifying status of an emulsion.

[0011] According to another aspect of the current application, there is disclosed an on-site emulsifying system comprising a first fluid tank, a second fluid tank, a circulation loop comprising a venturi and a pump, wherein the first fluid tank and the second fluid tank are in fluid communication with the circulation loop at a feeding end of the pump via a first fluid inlet pipe and a second fluid inlet pipe, respectively; and an outlet pipe connected to a discharge end of the pump for withdrawing finished emulsions from the circulation loop.

[0012] In some embodiments, the system may further comprise a feeding pipe to a wellbore, wherein the feeding pipe is in fluid communication with the outlet pipe. In some embodiments, the first fluid and second fluid are non-miscible. In some embodiments, the first fluid can be an aqueous fluid. In some embodiments, the second fluid can be a hydrocarbon fluid. In some embodiments, the circulation loop can be formed by pipes.

[0013] According to a further aspect of the current application, there is disclosed a method for on-site mixing an aqueous fluid and an hydrocarbon fluid. The method comprises feeding the aqueous fluid to a circulation loop, feeding the hydrocarbon fluid to the circulation loop, circulating the mixture of aqueous fluid and hydrocarbon fluids in the circulation loop, withdrawing a mixed fluid from the circulation loop; and feeding the mixed fluid to a wellbore.

[0014] In some embodiments, at least one of the steps of (a) feeding the aqueous fluid to a circulation loop and (b) feeding the hydrocarbon fluid to the circulation loop comprises measuring a flow rate by a metering device. In some embodiments, the circulation loop comprises a buffering tank.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] These and other features and advantages will be better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings.

[0016] **FIG. 1** is a schematic illustration of a batch mixing system according to a prior art embodiment.

[0017] **FIG. 2A** is a schematic illustration of an on-site mixing system according to an embodiment of the current application, where hydrocarbon fluid is being transferred into the mix tank and the circulation is started.

[0018] **FIG. 2B** is a schematic illustration of an on-site mixing system according to an embodiment of the current application, where acid is added in during circulation and emulsified acid is obtained and then pumped downhole while the system continues to mix the acid and hydrocarbon.

[0019] **FIG. 3A** is a schematic illustration of an on-site mixing system according to an embodiment of the current application, where no buffer tank is provided for the mixing, but instead, mixing is achieved within the pipes and c-pump, etc. of the circulation loop.

[0020] **FIG. 3B** is a schematic illustration of an on-site mixing system according to an embodiment of the current application, which is an alternative embodiment to **FIG. 3A**.

DETAILED DESCRIPTION OF SOME ILLUSTRATIVE EMBODIMENTS

[0021] The following description illustrates embodiments of the current application by way of example and not by way of limitation. All numbers disclosed herein are approximate values unless stated otherwise, regardless whether the word "about" or "approximately" is used in connection therewith. The numbers may vary by up to 1%, 2%, 5%, or sometimes 10 to 20%. Whenever a numerical range with a lower limit and

an upper limit is disclosed, any number falling within the range is specifically and expressly disclosed.

[0022] Embodiments of the current application are illustrated below in the context of an oilfield operation commonly known as matrix acidizing. However, it should be noted that the principles of the current application may be readily applicable to other operations in the oil and gas industry as well. Similarly, although embodiments of the current application are illustrated below in the context of oil and gas exploration and production, the principles of the current application can also be used in the field other than the oil and gas industry, such as construction, automobile, mining, just to name a few. With the benefit of the information disclosed herein, people skilled in the art can readily appreciate various features and advantages of the current application and make changes and modifications accordingly. All such changes and modifications should be considered within the spirit of the current application.

[0023] In some embodiments, the current application discloses a number of systems and methods that allow an emulsion, especially an emulsified acid, to be created “on-site” while being continuously mixed for a given purpose. As used herein, the term “on-site” means that substantially all equipments are located at a single geographic location, such as a wellsite, or substantially all steps are performed at a single geographic location, such as a wellsite.

[0024] According to **FIGs. 2A** and **2B** of the current application, the on-site emulsifying system **200** may comprise an aqueous fluid tank **210**, an hydrocarbon fluid tank **220**, and a circulation loop comprises a buffer tank **240** and a centrifugal pump **230**, wherein the aqueous fluid tank **210** and the hydrocarbon fluid tank **220** are in fluid communication with the circulation loop via an aqueous fluid inlet pipe **215** and an hydrocarbon fluid inlet pipe **225**, respectively. The aqueous fluid and the hydrocarbon fluid are mixed in the circulation loop (particularly in the buffer tank) to achieve an emulsion. The emulsion can then be withdrawn as a finished product by a c-pump **280** to an outlet pipe **285** that is connected to a side of the circulation loop. The side-

withdrawn emulsion can then be fed into a triplex pump (not shown) for immediate application down the wellbore.

[0025] In one embodiment, the aqueous fluid is an acid, such as hydrochloric acid (HCl), or a blended acid, and the hydrocarbon fluid is an organic fluid e.g. hydrocarbon (such as diesel) mixed with an appropriate amount of an emulsifying agent.

[0026] Optionally, metering valves **212**, **222** can be provided on one or both of the aqueous fluid inlet pipe **215** and the hydrocarbon fluid inlet pipe **225** to control the flow rates of the fluids into the circulation loop. Also optionally, c-pumps **221**, **221** can be provided on one or both of the aqueous fluid inlet pipe **215** and the hydrocarbon fluid inlet pipe **225** to provide more mixing energy to the fluids before they are introduced into the circulation loop. In some embodiments, pre-dispersion devices (not shown) or configurations can be provided on one or both of the aqueous fluid inlet pipe **215** and the hydrocarbon fluid inlet pipe **225** to pre-disperse the aqueous and/or hydrocarbon fluids, respectively, before they enter into the circulation loop.

[0027] In some embodiments, an electric conductivity meter (not shown) is provided on the outlet pipe **285** to monitor the emulsion status of the emulsion that is side-withdrawn from the circulation loop. The electric conductivity meter can produce a positive signal when the emulsion in the outlet pipe **285** is in the correct configuration, and a negative signal when the emulsion in the outlet pipe **285** is "inverted" or otherwise in an incorrect configuration. The negative signal can trigger an auto-shutdown procedure for automatically turning off the outlet pipe **285** so as to prevent the incorrectly formed emulsion from entering into the wellbore.

[0028] In operation, the acid mixture can be either pre-blended or blended continuously for the purpose of creating the emulsion. The acid mixture can be metered into a blend of the emulsifying agent, which can then be imparted with mixing energy by a device designed to increase the shear energy of the blend. This mixture is then pumped into a buffering tank **240** that allows a portion of the pre-mixed emulsion to be blended with a new emulsion blend. This mixture of old and new blends re-undergo the

mixing process to create a new blend of emulsified acid. During this process a portion of the buffering tank volume is pulled off for the use as a finished product. The ratio of the emulsified acid recirculation to the finished product delivery rate should be such that a quality emulsion can be maintained during the product delivery process. Because a portion of the blend is continually re-circulated through the mixing process that portion of the blend's emulsion becomes more stable.

[0029] In one specific embodiment, the HCl was fed into the circulation loop at a rate of about 14 barrel-per-minute (bpm), the hydrocarbon fluid containing emulsifying agent was fed into the circulation loop at a rate of about 6 bpm, the mixing c-pump **230** circulated the acid/hydrocarbon mixture in the circulation loop at a rate of about 60 bpm, and the finished emulsion was withdrawn from the outlet pipe **285** at a rate of about 20 bpm.

[0030] In some embodiments, the initial batch of emulsion is mixed before being delivered downhole. While being delivered downhole, additional emulsifying agent and acid can be mixed into the existing emulsion. The combination point is around the inlets and the circulating c-pump **230** so that incoming hydrocarbon and acid disperse into the previously-created emulsion.

[0031] Some of the emulsion is delivered downhole after only one pass through the mixing tank, but most of the fluid makes multiple passes through the circulating c-pump before going downhole. One parameter that can be adjusted during operation is the ratio of re-circulating flow to discharge flow. By controlling the ratio of re-circulated emulsion to single pass emulsion the quality of the emulsion can be controlled. In some instances the re-circulated emulsified fluid may make multiple passes through the buffering tank **240** before being discharged which can improve the emulsion quality.

[0032] Shearing energy is put into the fluid at the circulating c-pump **230** and also at the jets which mixes the tank. In some cases, there is a provision for a mixer **250** as shown in **FIG. 2**, but in some other cases, an additional mixing device is not used because a lot of mixing energy is added by the mixing c-Pump **230**.

[0033] FIGs. 3A and 3B illustrate another aspect of the on-site blending method and system according to the disclosure of the current application. There, the on-site emulsifying system **300, 300'** may comprise an aqueous fluid tank **310**, an hydrocarbon fluid tank **320**, a circulation loop formed by pipes and comprising a centrifugal pump **330**, wherein the aqueous fluid tank **310** and the hydrocarbon fluid tank **320** are in fluid communication with the circulation loop (sometimes at the feeding end of the centrifugal pump **330**) via an aqueous fluid inlet pipe **315** and an hydrocarbon fluid inlet pipe **325**, respectively, and an outlet pipe **285** connected to the discharge end of the centrifugal pump **330** for withdrawing finished emulsions from the circulation loop. The aqueous fluid and the hydrocarbon fluid is mixed in the circulation loop to produce an emulsion, which can then be withdrawn from the outlet pipe **285** and fed into a triplex pump (not shown) for immediate application down the wellbore.

[0034] In one embodiment, the aqueous fluid is an acid, such as hydrochloric acid (HCl), or a blended acid, and the hydrocarbon fluid is a hydrocarbon (such as diesel) mixed with an appropriate amount of an emulsifying agent.

[0035] Optionally, metering valves **312, 322** are provided on one or both of the aqueous fluid inlet pipe **315** and the hydrocarbon fluid inlet pipe **325** to control the flow rates of the fluids into the circulation loop. Also optionally, c-pumps **311, 321** are provided on one or both of the aqueous fluid inlet pipe **315** and the hydrocarbon fluid inlet pipe **325** to increase the pressure the fluids before they pass the metering valves **312, 322**, if any, and are introduced into the circulation loop. In one embodiment, a c-pump **311** and a metering valve **312** are provided on the hydrocarbon fluid inlet pipe.

[0036] In some embodiments, pre-dispersion devices (not shown) or configurations are provided on one or both of the aqueous fluid inlet pipe **315** and the hydrocarbon fluid inlet pipe **325** to pre-disperse the aqueous fluid and/or hydrocarbon fluid, respectively, before they enter into the circulation loop.

[0037] In some embodiments, an electric conductivity meter (not shown) is provided on the outlet pipe **385** to monitor the status of the emulsion that is side-withdrawn from

the circulation loop. The electric conductivity meter can provide a positive signal when the emulsion in the outlet pipe **385** is in the correct configuration, and a negative signal when the emulsion in the outlet pipe **385** is “inverted” or otherwise in an incorrect configuration. The negative signal can trigger an auto-shutdown procedure to automatically turn off the outlet pipe **385** to prevent the wrongfully formed emulsion from entering into the wellbore.

[0038] In operation, an acid blend (not shown) can be introduced to the circulation loop just prior to the c-pump **330** designed to impart the necessary mixing energy. In some embodiments, the mix rate of the c-pump **330** is designed such that it exceeds the delivery rate of end product by a predetermined amount. The excess blended fluid is then fed directly back to the input end of the mixing device. This continuous re-circulation induces enough shear energy to create a stable emulsion in the acid blend. The flow rate feedback signal is shown in **FIG. 3** by dotted line **390**.

[0039] In one specific embodiment, the HCl is fed into the circulation loop at a rate of about 14 barrel-per-minute (bpm), the hydrocarbon fluid containing emulsifying agent is fed into the circulation loop at a rate of about 6 bpm, the mixing c-pump circulate the acid/hydrocarbon mixture in the circulation loop at a rate of about 40 bpm, and the finished emulsion is withdrawn from the outlet pipe at a rate of about 20 bpm.

[0040] In some cases, the hydrocarbon fluid is started at the beginning of the process with the acid metering valve closed. Hydrocarbon containing an appropriate amount of an emulsifying agent is circulated within the circulation loop, and flows towards the discharge point of the mixing c-pump **330** and purges water or other residual fluid out of the mixing c-pump **330** and the circulation pipes. Next, the acid metering valve **312** opens to achieve the correct concentration.

[0041] In some other cases, the aqueous fluid is started first and the hydrocarbon fluid is then started to achieve emulsions.

[0042] Both processes, i.e. first starting with the hydrocarbon fluid or first starting with the aqueous fluid, may optionally include a pre-wash step wherein 100% water is used to flush and prime up the circulation loop before the hydrocarbon fluid or aqueous fluid is introduced into the circulation loop.

[0043] The mixing c-pump **330** ingests hydrocarbon fluid (with emulsifying agent in some cases), aqueous fluid (acid in some cases) and circulated emulsion and mixes them to form and discharge new emulsion. In some cases, the circulating rate is several times (such as, in one aspect, 2x – 4x) the maximum downhole rate so that the fluid averages several circulations before flowing to the triplex pump.

[0044] The system shown in **Fig. 3** may further contain in the circulation loop a venturi e.g. a choke **350**, a metering device (not shown), or other devices such as static mixers (not shown) to create back pressure in the circulation line. In a specific embodiment, the mixing c-pump **330** produces about 50 psi for charging the triplex pump while circulating several times the downhole rate. In some embodiment, one c-pump **330** is used for mixing at low pressure and another c-pump (now shown) is used to charge the triplex pump.

[0045] In all of the forgoing embodiments, acid can be blended in a tank or by an acid blender using concentrated acid. In the case of HCl, the raw acid is typically at a concentration of about 32%-36%. The raw HCl can be mixed off-site with water and other chemicals to create the desired acid concentration, which is typically about 12-15% HCl. After mixing, the volume typically doubles thus increasing the amount of acid that needs to be stored or transported to the location. Therefore, it is another aspect of the current application to use an on-site acid mixing system that can blend 32-36% acid and the appropriate emulsifier on the location of application so that the storage and transportation requirements can be greatly reduced.

[0046] One intended use of the current systems and methods is the continuous matrix acidizing of a wellbore for the purpose of stimulating that wellbore for increased

production; however, the disclosure of the current application can be implemented in many other areas and industries as well.

[0047] The preceding description has been presented with reference to some embodiments. Persons skilled in the art and technology to which this disclosure pertains will appreciate that alterations and changes in the described structures and methods of operation can be practiced without meaningfully departing from the principle, and scope of this application. Accordingly, the foregoing description should not be read as pertaining only to the precise structures described and shown in the accompanying drawings, but rather should be read as consistent with and as support for the following claims, which are to have their fullest and fairest scope.

[0048] Furthermore, none of the description in the present application should be read as implying that any particular element, step, or function is an essential element which must be included in the claim scope: THE SCOPE OF PATENTED SUBJECT MATTER IS DEFINED ONLY BY THE ALLOWED CLAIMS. Moreover, none of these claims are intended to invoke paragraph six of 35 USC §112 unless the exact words “means for” are followed by a participle. The claims as filed are intended to be as comprehensive as possible, and NO subject matter is intentionally relinquished, dedicated, or abandoned.

CLAIMS

What is claimed is:

1. An on-site emulsifying system comprising,
 - a. a first fluid tank;
 - b. a second fluid tank;
 - c. a circulation loop comprising a buffer tank and a pump, wherein the first fluid tank and the second fluid tank are in fluid communication with the circulation loop via a first fluid inlet pipe and a second fluid inlet pipe, respectively; and
 - d. an outlet pipe that is in fluid communication with the circulation loop.
2. The system of claim 1, further comprising a feeding pipe to a wellbore, wherein the feeding pipe is in fluid communication with the outlet pipe.
3. The system of claim 1, wherein the first fluid and the second fluid are non-miscible.
4. The system of claim 1, wherein the first fluid is an aqueous fluid.
5. The system of claim 4, wherein the second fluid is an organic fluid selected from the group consisting of hydrocarbon, diesel oil, kerosene, paraffinic oil, crude oil, LPG, toluene, xylene, ether, ester, mineral oil, biodiesel, vegetable oil, animal oil, and mixtures thereof.
6. The system of claim 5, wherein the aqueous fluid tank contains an acid or a blended acid and the organic fluid tank contains an organic fluid mixed with an appropriate amount of an emulsifying agent.

7. The system of claim 1, wherein at least one of the first fluid inlet pipe and the second fluid inlet pipe contains a metering valve.
8. The system of claim 1, wherein the pump is a centrifugal pump.
9. The system of claim 1, wherein at least one of the first fluid inlet pipe and the second fluid inlet pipe contains a centrifugal pump.
10. The system of claim 1, wherein at least one of the first fluid inlet pipe and the second fluid inlet pipe contains a pre-dispersing device.
11. The system of claim 1, wherein the outlet pipe contains an electric conductivity meter for monitoring an emulsifying status of an emulsion.
12. An on-site emulsifying system comprising,
 - a. a first fluid tank;
 - b. a second fluid tank;
 - c. a circulation loop comprising a venturi and a pump, wherein the first fluid tank and the second fluid tank are in fluid communication with the circulation loop at a feeding end of the pump via a first fluid inlet pipe and a second fluid inlet pipe, respectively; and
 - d. an outlet pipe connected to a discharge end of the pump for withdrawing finished emulsions from the circulation loop.
13. The system of claim 12, further comprising a feeding pipe to a wellbore, wherein the feeding pipe is in fluid communication with the outlet pipe.
14. The system of claim 12, wherein the first fluid and second fluid are non-miscible.
15. The system of claim 12, wherein the first fluid is an aqueous fluid.

16. The system of claim 12, wherein the second fluid is a hydrocarbon fluid.

17. The system of claim 12, wherein the pump is a centrifugal pump.

18. The system of claim 12, wherein the circulation loop is formed by pipes.

19. A method for on-site mixing an aqueous fluid and an hydrocarbon fluid, the method comprising,

- a. feeding the aqueous fluid to a circulation loop;
- b. feeding the hydrocarbon fluid to the circulation loop;
- c. circulating the mixture of aqueous fluid and hydrocarbon fluids in the circulation loop;
- d. withdrawing a mixed fluid from the circulation loop; and
- e. feeding the mixed fluid to a wellbore.

20. The method of claim 19, wherein at least one of steps (a) and (b) comprises measuring a flow rate by a metering device.

21. The method of claim 19, wherein the circulation loop comprises a buffering tank.