This invention relates to the oil and gas industry, in particular, to methods affecting the formation productivity at the oil and gas production stage.

A method for fracture propping in a subsurface layer, which ensures a reliable protection of wells from the proppant carryover from the fracture, has been proposed. According to the proposed method, a fracturing fluid is mixed with a propping agent and particulate binding material wherein the particles have an average length-to-width ratio of less than or equal to about 10; thereafter, a formation fracturing process is implemented. Then, the particulate binding material hardens and forms a homogenous firm mass with the propping agent, which impedes the closing of the fracture and precludes proppant carryover from the fracture. Or, a fracturing fluid composition obtained by mixing a propping agent with a binding compound in the form of a powder whose size varies from about 1 to about 500 μm. A gravel-packed filter is then constructed; the said filter is based on the application of the working fluid comprising a propping filler and particulate binder with a length-to-width ratio of less than or equal to 10, or comprising a propping filler and a binding compound in the form of a powder with a size varying from about 1 to about 500 micrometers.
METHODS FOR PREVENTING PROPPANT CARRYOVER FROM FRACTURES, AND GRAVEL-PACKED FILTERS


FIELD OF THE INVENTION

[0002] This invention relates to the oil and gas industry, in particular, to methods affecting the production productivity at the oil and gas production stage.

BACKGROUND OF THE INVENTION

[0003] The statements in this section merely provide background information related to the present disclosure and may not constitute prior art.

[0004] A carryover of proppant from a fracture to the well at the post-fracturing period either during the initial cleaning or even after completion of the well construction is a crucial issue for the oil production sector. Up to 20% of proppant can be conveyed into the well, which, in turn, can lead to negative consequences. In marginal wells, proppant settles in a casing; thus, regular washings are required and the cost of well repair operations grows. Premature wear and failure of electrical submersible pumps is another consequence of the carryover of unbound proppant or other solid particles of rocks. Also, oil or gas production decreases occur due to a significant loss of the near wellbore conductivity caused as a result of a reduced fracture thickness or overlapping of a production zone.

[0005] At present, several methods to decrease in the carryover of proppant or other propping agents from the fracture are known.

[0006] The most common approach is based on the application of proppant with a hardening resin coating, which is injected into the fracture at the end of the treatment process. However, the use of this type of proppant produces undesired chemical reactions of the resin coating with the fracturing fluid. This reaction causes partial degradation and disintegration of the coating, thus reducing the contact strength among proppant particles and, therefore, decreasing the proppant pack strength. Further, the interaction between the resin coating components and fracturing fluid components causes uncontrolled changes in the rheological properties of the fluid, which also diminishes the fracturing process efficiency. Extended well closure periods could significantly reduce the proppant filler strength.

[0007] In another method, fibrous materials are mixed with a propping agent and added to limit proppant conveyance; in this process, the combination of fibers and proppant particles increase the proppant strength and restrict the back-flow conveyance of the proppant. The addition of fibers enables a more effective redistribution of loads of the proppant. A fibrous structure is more flexible as compared to cured resin proppant and allows movements of proppant-fibrous filler without deterioration of strength.

[0008] In another method, fiber bundles comprising about 5 to 200 separate fibers are used. In this process, the fiber bundle structure may be fixed on one side.

[0009] Mixing proppant with deformable beads or particles is also known. The deformable particles are polymeric and may have various shapes; however, a maximum length-to-base ratio of equal to or less than 5 is preferable. Deformable particles can be homogeneous spheres formed from one compound or may be composite particles containing a non-deformable core and a deformable coating. In another embodiment, the core consists of deformable materials and could include milled or crushed materials, e.g., nutshell, seed shell, fruits kernels and processed wood.

[0010] Mixtures of proppant with adhesive polymeric materials have also been used. The adhesive compositions contain and cover the particles with a thin sticky layer. As a result, particles adhere to each other as well as to sand particles or crushed fragments of the propping agent. This completely prevents the carryover of solid particles from the fracture. Adhesive materials can also be combined with other chemical agents used in the formation fracturing process, e.g., retarding agents, antimicrobial agents, polymer gel destructors, as well as antioxidant and wax-formation and corrosion retarding agents. Mixtures of adhesive materials with deformable particles have also been used.

[0011] Thermoplastic materials have also been used with propants. When mixed with a propping agent, the thermoplastic soften upon exposure to high temperatures, and thereafter they adhere to the propping agent to form aggregates. Thermoplastic agents may also be used with resin proppants.

[0012] Another method describes the application of a fracturing fluid which is a self-degrading cement comprising an acid, which interacts with other components to cause the formation of a cement material, as well as a degrading component, which could disintegrate under the fracture conditions and cause the formation of cavities in the cement.

[0013] Another method describes the formation fracturing process using a hydrated cement particles with average particle sizes ranging from 5 μm to 2.5 cm.

SUMMARY OF THE INVENTION

[0014] The invention provides methods for fracture propping in the oil and gas industry, in particular, to the development of a method for preventing carryover of proppant from fractures.

[0015] Specifically, the invention provides methods for fracture propping in a subterranean formation which provides reliable protection of the well from excess proppant conveyance from the fracture.

[0016] Specifically, the invention provides a method in which a formation fracturing fluid is mixed with a filler component comprising at least one propping agent and at least one particulate binder wherein the particulate binder particles have an average length-to-width ratio of equal to or less than about 10, and thereafter, a formation fracturing process is implemented. The particulate binding material is then solidified to form a homogeneous fluid mass with the propping agent, which obstructs the closure of the fracture and precedes the proppant carryover.

[0017] The invention further provides fracturing fluid compositions obtained by mixing a propping filler and a particulate binder with a length-to-width ratio of equal to or less than 10, which could solidify under underground formation conditions.

[0018] The invention further provides fracturing fluid compositions obtained by mixing a propping filler and a particulate binding composition in the form of a powder, whose size varies from about 1 μm to about 500 μm. In this case, powder-
like particles of the binder get into contact with the propping filler and are then solidified, increasing the propping filler pack strength.

[0019] In one embodiment, the fracturing fluid compositions are obtained by mixing a propping filler and a particulate or powder binding material as well as other components obstructing the proppant conveyance from the fracture, including deformable particles and adhesive and fiber-like materials.

[0020] The invention further provides a gravel-packed filter which is based on the application of a working fluid comprising a propping filler and a particulate binder with a length-to-width ratio of equal to or less than 10, or comprising a propping filler and a particulate binding composition in the form of a powder, whose size varies from about 1 μm to about 500 μm.

DETAILED DESCRIPTION OF THE INVENTION

[0021] At the outset, it should be noted that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developer’s specific goals, such as compliance with system related and business related constraints, which will vary from one embodiment to another. Moreover, it will be appreciated that such a development effort might be complex and time consuming but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure. The description and examples are presented solely for the purpose of illustrating the preferred embodiments of the invention and should not be construed as a limitation to the scope and applicability of the invention. While the compositions of the present invention are described herein as comprising certain materials, it should be understood that the composition could optionally comprise two or more chemically different materials. In addition, the composition can also comprise some components other than the ones already cited. In the summary of the invention and this detailed description, each numerical value should be read once as modified by the term “about” (unless already expressly so modified), and then read again as not so modified unless otherwise indicated in context. Also, in the summary of the invention and this detailed description, it should be understood that a concentration range listed or described as being useful, suitable, or the like, is intended that any and every concentration within the range, including the end points, is to be considered as having been stated. For example, “a range of from 1 to 10” is to be read as indicating each and every possible number along the continuum between about 1 and about 10. Thus, even if specific data points within the range, or even no data points within the range, are explicitly identified or refer to only a few specific, it is to be understood that inventors appreciate and understand that any and all data points within the range are to be considered to have been specified, and that inventors possession of the entire range and all points within the range.

[0022] The compositions may contain one or more than one of the below-listed materials as propping fillers: ceramic particles and sand particles having different shapes, solidified and curable prepartants and sands; swollen expanded clay, vermiculite, and agglomerite. Further, prepartants or polymer-coated sand can be used as a propping filler.

[0023] Granulated and powdered binders can be added in a fracturing fluid in a dry state, or in other forms such as suspensions in water, working fluids, gels or other suitable solvent containing forms, including those modified with various surfactants.

[0024] Useful binders for particulate binders include but are not limited to the following. The components may be hardened by hydraulic, air and autoclave hardening and may include acid-proof binding materials and mixtures of such materials.

[0025] Useful materials include those based on of crystalline hydrates CaSO4 and anhydrite (gypsum binding materials); materials based on CaO, CaO hydration and carbonization products (lime binding materials) and the like; materials based on MgO and saline sealers (magnesium binding materials); lime-silica binding materials comprising mixtures of CaO or Ca(OH)2, with fine-milled silica, which solidify at increased temperatures; lime-pozzolanic and lime-cinder binding materials comprising a lime-containing component and a reactive siliceous component in the form of amorphous silica or silicate glass, whose hardening occurs due to the interaction of a lime with an active silicate oxide or glass with the formation of calcium hydroxides.

[0026] Other useful materials include slag-alkali binding materials having a component comprising caustic alkali and slag, preferably in a vitreous state, whose hardening is connected with the formation of alkaline aluminum silicate.

[0027] Binding cements such as high-basic calcium silicates (portland cement clinker, natural cement, calcareous cement, hydraulic lime, and the like) are also useful. The binding properties of these materials are essentially predefined by hydration of tricalcium (Ca3SiO5) and dicalcium (Ca2SiO4) silicates, including slag-portland cement, cements based on low-basic calcium aluminate (CaA, CA2, C12A7) and derivatives, thereof, e.g., calcium sulfosilicates, calcium fluorosilicates (fluorocement, high-alumina cement, sulfosilicate cement); high iron oxide cements and sulfur high iron oxide cements. Cements based on calcium ferrites and their derivatives such as calcium sulfosilicates may also be used.

[0028] Phosphate binding materials (cement and binding materials), which harden due to phosphate formation are also useful.

[0029] Watersoluble silicate materials, including but not limited to alkali metal silicates (soluble glasses) and organic base silicates.

[0030] Also useful are polymer-cement compositions and polymer-silicate binding compositions containing organic compositions as modifying components and inorganic binding materials (cement, soluble glass) as the base;

[0031] Hydroxy salts of aluminum, chrome, zirconium, colloidal solution of silica and aluminum oxide, partially dehydrated crystalline hydrates of aluminum sulfates and calcium aluminates may also be used.

[0032] A particulate binder may comprise a single component, or have a multi-component composition. In addition to binders, the particulate binder may include components which improve required strength properties (e.g., polymers) and density properties (e.g., particles of barite, red iron ore, glass beads, porous particles).

[0033] The particulate binders can be provided in a variety of shapes, including but not limited to, spherical, cylindrical, sparry, cubic, oval, flaked, scaly, irregular shape, or a combination of the above-mentioned shapes, so long as the particles have a length-to-width ratio to be equal to or less than about 0.
0034. The content of particulate binding filler in the total volume of propping and particulate fillers varies in the range from about 0.1 to about 99.9% by weight. The actual density of the particulate binding agent varies in the range from about 0.3 to about 5 g/cm³.

0035. At least one of the following binders of the classes can be used, such components may be hardened by methods such as hydraulic, air and autoclave hardening as well as acid-proof binding materials as well as mixtures thereof, including but not limited to materials based on crystalline hydrates CaSO₄ and anhydrite (gypsum binding materials); materials based on CaO, CaO hydrates and carbonization products (lime binding materials); materials on the basis of MgO and salin sealers (magnesium binding materials)

0036. Useful materials include those based on of crystalline hydrates CaSO₄ and anhydrite (gypsum binding materials); materials based on CaO, CaO hydration and carbonization products (lime binding materials) and the like; materials based on MgO and saline sealers (magnesium binding materials); lime-silica binding materials comprising mixtures of CaO or Ca(OH)₂ with fine-milled silica, which solidify at increased temperatures; lime-pozzolanic and lime-cindery binding materials comprising a lime-containing component and a reactive siliceous medium in the form of amorphous silica or silicate glass, whose hardening occurs due to the interaction of lime with an active silicous oxide or glass with the formation of calcium hydroxides.

0037. Other useful materials include slag-alkali binding materials having a component comprising caustic alkali and slag, preferably in a vitreous state, whose hardening is connected with the formation of alkaline aluminum silicate.

0038. Binding cements such as high-basic calcium silicates (portland cement clinker, natural cement, calcareous cement, hydraulic lime, and the like) are also useful. The binding properties of these materials are essentially predefined by hydration of tricalcium (Ca₃SiO₅) and dicalcium (Ca₂SiO₄) Silicate, including slag-portland cement, cements based on low-basic calcium aluminates (Ca₆A₃, Ca₁₂A₅) and derivatives, thereof, e.g., calcium sulfoaluminates, calcium fluoride aluminates (aluminate cement, high-alumina cement, sulfoaluminate cement), high iron oxide cements and sulfur high iron oxide cements. Cements based on calcium ferrites and their derivatives such as calcium sulfoferrites may also be used.

0039. Phosphate binding materials (cement and binding materials), which harden due to phosphate formation are also useful.

0040. Water-soluble silicate materials, including alkali metal silicates (soluble glasses) and organic base silicates

0041. Also useful are polymer-cement compositions and polymer-silicate binding compositions containing organic compositions as modifying components and inorganic binding materials (cement, soluble glass) as the base;

0042. Hydroxy salts of aluminum, chrome, zirconium, colloidal solution of silica and aluminum oxide, partially dehydrated crystalline hydrates of aluminum sulfates and calcium aluminates may also be used.

0043. The average particle size of useful particulate binding materials or binders ranges from about 0.5 to about 500 µm. The concentration of the particulate binding materials in the propping filler varies from about 0.1 to about 99.9% by weight.

0044. The density of the powder-like binding materials can vary from about 0.5 to about 5 g/cm³.

0045. Such granulated or powder-like binding materials will be used in a mixture with a propping agent; the concentration of the propping agent in the mixture could vary in the range of about 0.1 to about 99.9%.

0046. The terms granulated, powder-like, and particulate are used interchangeably herein. Granulated or powder-like binding materials may be added to the propping fluid either in a dry state or in other forms such as suspensions in water, working fluids, gels or other suitable solutions including those modified by various surfactants.

0047. Embodiments of the invention may use other additives and chemicals that are known to be commonly used in oilfield applications by those skilled in the art. These include, but are not necessarily limited to, materials in addition to those mentioned hereinabove, such as breaker aids, oxygen scavengers, alcohols, scale inhibitors, corrosion inhibitors, fluid-loss additives, bactericides, iron control agents, organic solvents, and the like. Also, they may include a co-surfactant to optimize viscosity or to minimize the formation of stabilized emulsions that contain components of crude oil, or as described hereinabove, a polysaccharide or chemically modified polysaccharide, natural polymers and derivatives of natural polymers, such as cellulose, derivatized cellulose, guar gum, derivatized guar gum, or biopolymers such as xanthan, diutan, and scleroglucan, synthetic polymers such as polyacrylamides and polyacrylamide copolymers, oxidizers such as persulfates, peroxides, bromates, chlorates, chlorites, peroxides, and the like. Some examples of organic solvents include ethylene glycol monobutyl ether, isopropyl alcohol, methanol, glycerol, ethylene glycol, mineral oil, mineral oil without substantial aromatic content, and the like.

1. A method for preventing proppant carryover from a fracture in a subterranean formation, the method comprising the steps of:
   a) providing a treatment fluid,
   b) mixing the treatment fluid with a filler component comprising at least one propping agent and at least one particulate binder having an average particle length-to-width ratio of no more than about 10, and
   c) injecting the fluid into the formation,
   wherein the fluid solidifies under subterranean formation conditions.

2. The method of claim 1, wherein the particulate binder is present in the filler component in an amount of from about 0.1% to about 99.9%.

3. The method of claim 1, wherein the filler component comprises at least one material selected from the group consisting of particulates having been hardened by a hydraulic hardening, air hardening or autoclave hardening, acid-proof binding materials and mixtures thereof.

4. The method of claim 1, in which the filler component comprises gypsum binding materials.

5. The method of claim 4 wherein the filler component comprises CaSO₄ crystalline hydrates and anhydrites.

6. The method of claim 1, wherein the filler component comprises lime binding materials.

7. The method of claim 6, wherein the filler component comprises materials selected from calcium oxides and CaO hydration & carbonization products.

8. The method of claim 1, wherein the filler component comprises magnesium binding materials.

9. The method of claim 8, wherein the filler component comprises magnesium oxide or a saline sealer.
10. The method of claim 1, wherein the filler component comprises a lime-silica material comprising a mixture of CaO or Ca(OH)₂ with fine-milled silica which is capable of hardening at subterranean formation temperatures.

11. The method of claim 1, wherein the filler component comprises lime-pozzolanic and lime-slag materials.

12. The method of claim 1, wherein the filler component comprises lime-containing components or reactive silicic acid in the form of amorphous silica or silicate glass, whose hardening is caused by the interaction of lime with active silica or glass with the formation of calcium hydroxysilicates.

13. The method of claim 1, wherein the filler component comprises slag-alkali binders comprising a constituent that includes a caustic alkali and slag, in a vitreous state, and whose hardening proceeds with the formation of alcaline aluminum silicates.

14. The method of claim 1, wherein the filler component comprises cement based on high-basic calcium silicates.

15. The method of claim 1 wherein the filler component comprises at least cement based on calcium aluminate (CaA, CA₂, C₁₂A₁₇), calcium sulfaloaminates, calcium fluorolaminates (calcium aluminate cement, high-alumina cement, sulfaloaminite cement) or iron & sulfur-iron cements.

16. The method of claim 1, wherein the filler component comprises calcium ferrites or calcium sulfur ferrite cements, portland cement, roman cement, calcareous lime or mixtures thereof.

17. The method of claim 1, wherein the particulate binding component comprises phosphates.

18. The method of claim 1, wherein the filler component comprises watersoluble silicates.

19. The method of claim 1, wherein the filler component comprises polymer-cement or polymer-silicate compositions comprising organic compounds as modifying agents and inorganic compounds as the base.

20. The method of claim 1, wherein the filler component comprises at least one compound selected from the group consisting of hydroxy salts of alumina, chrome, zirconium, colloidal silica solutions, partly dehydrated crystalline hydrates of aluminum sulfates and calcium aluminates.

21. The method of claim 1, wherein at least one of the treatment fluid or the filler component further comprises at least one as additive selected from the group consisting of polymers, barite particles, red iron ore, glass beads, porous particles, sand with polymeric coating, ceramic particles, sand, cured or curable proppants and sands, swollen expanded clay, vermiculite, agloporite, deformable particles, adhesive materials and fibrous materials.

22. The method of claim 1 wherein said filler component comprises at least one particulate filler having an average particle size of from 0.5 to 500 μm.

23. The method of claim 1, in which the density of the particulate binder varies from 0.5 to approximately 5 g/cm³.

24. A method of fracturing a subterranean formation, the method comprising the steps of:
   a) providing a treatment fluid,
   b) mixing the treatment fluid with a filler component comprising at least one propping agent and at least one particulate binder having an average particle length-to-width ratio of no more than about 10 and
   c) injecting the fluid into the formation, and
   d) fracturing the formation,
   wherein the fluid solidifies under subterranean formation conditions.

25. A gravel-packed filter obtained by application of a method according to claim 1.

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