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[54] **PROTECTING THE CASING OF A HOT FLUID
 INJECTION WELL WITH VAPORIZABLE LIQUID**
 10 Claims, 1 Drawing Fig.

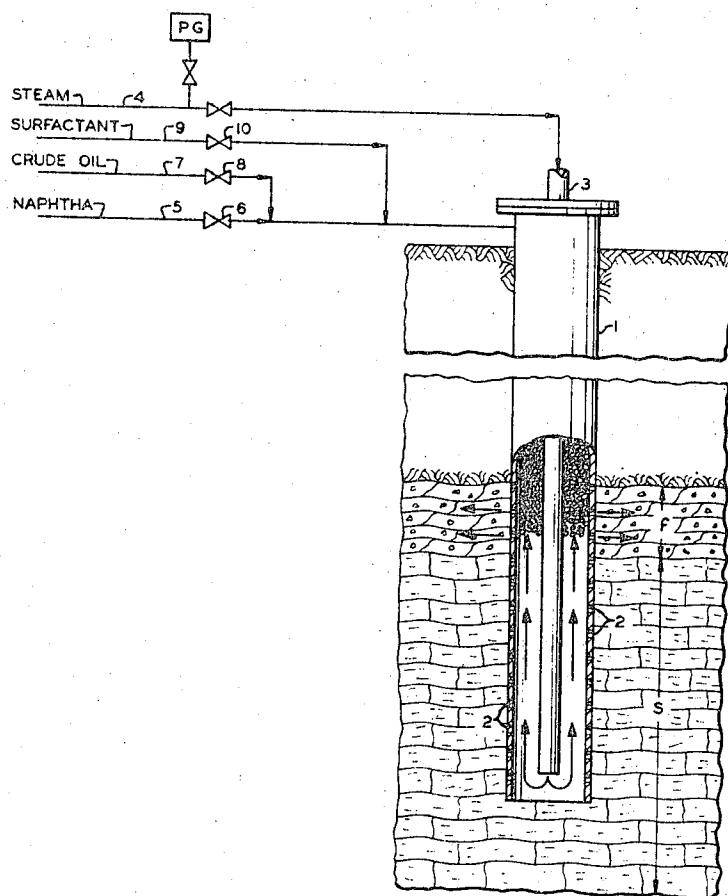
[52] U.S. Cl..... 166/303
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 [50] Field of Search..... 166/21, 29,
 30, 39, 40, 57, 272; 302, 303

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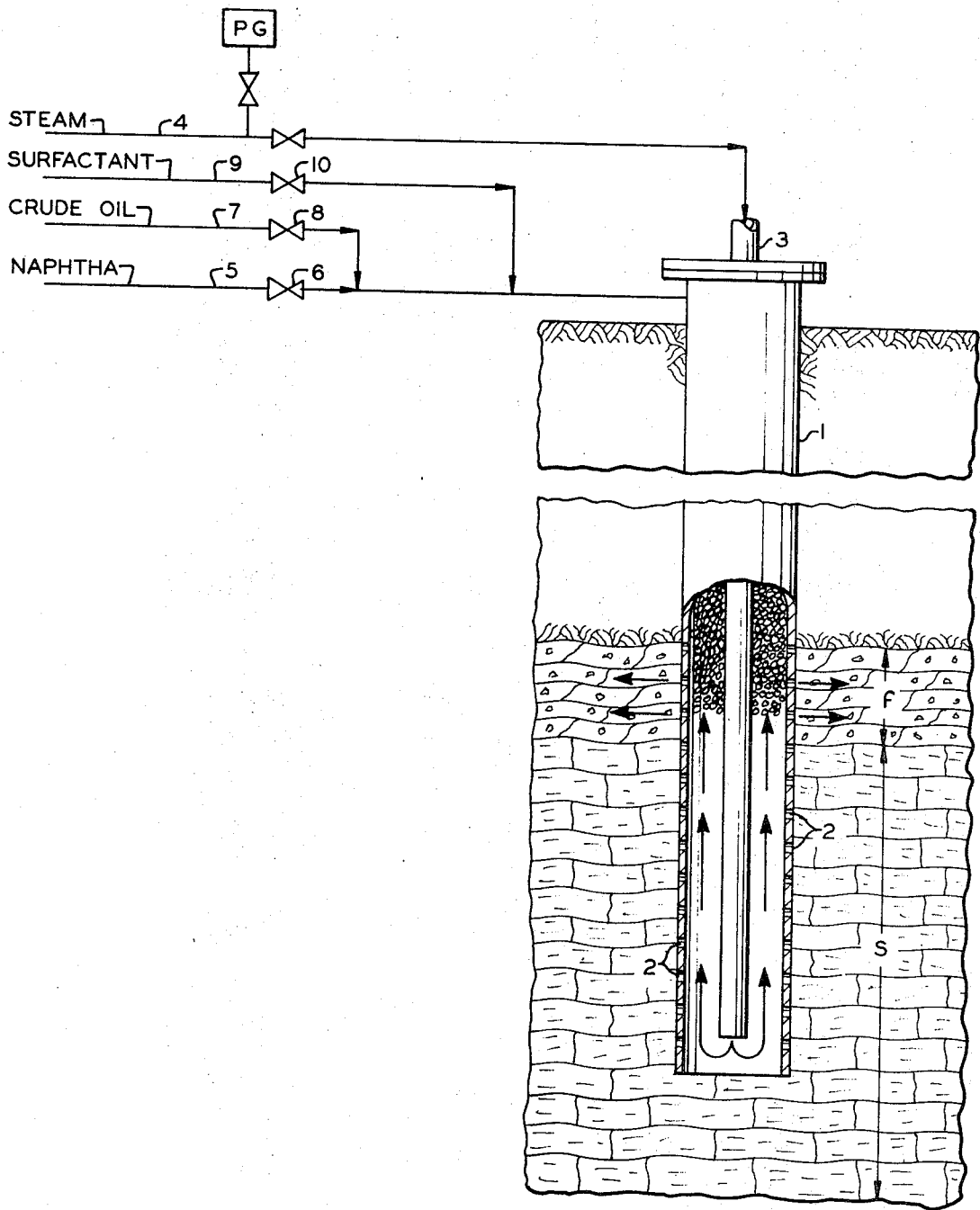
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ABSTRACT: To protect a casing against failure during injection of a heated fluid, such as steam through a conduit within said casing there is passed into the annulus between the conduit and casing a liquid, such as ammonia, whose boiling point is less than the annulus temperature at reservoir injection pressure thus causing formation of a gas or vapor to protect the casing against the heat of the hot fluid in the injection conduit. The liquid to be injected into the annulus is chosen so that its boiling point falls below the upper limit of about 400° F. at reservoir injection pressure. In a further embodiment, surfactant and a nonboiling fluid are injected with the vaporizable liquid to form a foam filled annulus.



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PROTECTING THE CASING OF A HOT FLUID INJECTION WELL WITH VAPORIZABLE LIQUID

This invention relates to an improved packerless injection of hot fluid into a formation. In one of its aspects the invention relates to a method for the injection of a hot fluid, *e.g.*, steam, into a formation from which ultimately it is desired to produce a valuable material. In another of its aspects the invention relates to a method for the injection of steam into a formation in which heat and/or steam are beneficial for the recovery of a valuable material, *e.g.*, hydrocarbon oil therefrom.

In one of its concepts the invention provides a method for injecting steam or other hot fluid into a formation below the earth's surface which comprises injecting to a portion of a formation into which a hot fluid is to be injected a liquid which is vaporizable under the conditions prevailing adjacent the hot fluid injection and injecting said hot fluid to cause, thereby, vaporization of said vaporizable liquid and yielding by said vaporization a protective shield around said hot fluid being injected. In another concept of the invention it provides a method for injecting a hot fluid into a formation below the surface of the ground comprises injecting said hot fluid through a tubing within a well bore and injecting into the annulus between said tubing and well bore, which may contain a casing, a liquid, which is vaporizable at the temperature of the annulus when said hot fluid is being injected. In a further concept of the invention it provides a method as herein described wherein together with said liquid which is injected into the annulus, there is injected a surfactant or foaming agent and another liquid which does not readily vaporize within said annulus thus to build together with the vaporizable liquid, which does vaporize, a foam-filled annulus.

In many deep heavy oil reservoirs subjected to thermal recovery techniques, the injection of steam results in casing failures. One effective though expensive method of controlling casing failure is to pull the tubing, and run a thermal packer to isolate the casing from the high tubing temperature. In this case the casing-tubing annulus is filled with low pressure gas. Other methods, involve injecting gas or foam down the casing-tubing annulus. The injection of foam is more fully disclosed and claimed in Ser. No. 567,470, filed by me July 25, 1966, now U.S. Pat. No. 3,410,344. In these methods, the casing-tubing annulus is filled with high pressure gas or foam. Balancing the gas or foam injection rate against the steam injection rate permits control of the level at which steam enters the formation. A source of high pressure gas, or a gas compressor, is required for these methods, resulting in an expense which the present invention avoids. It has now occurred to me that I can considerably improve the method of injecting steam and the use of a gas and/or foam to protect the well bore or casing against failure by injecting into the bore or casing annulus between the steam injecting tubing and the bore or casing a liquid which will vaporize in the annulus during the injection of the hot fluid, *e.g.*, steam. Such a liquid as ammonia, or any other liquid whose boiling point is lower than the annulus temperature (about 225°—400°F.) at reservoir injection pressure may be injected down the casing-tubing annulus during steam injection. The upper limit of 400°F. is set by the fact that it is desirable to not heat casing or tubing above this temperature as such high temperatures tend to cause casing damage. The vaporizable liquid is injected as a liquid with a simple feed pump, eliminating the need for a gas compressor or high pressure gas source. As the liquid flows through the annulus, it vaporizes and fills the annulus with high pressure gas. This high pressure gas lowers the temperature to which the casing is subjected. Controlling the rate of injection will control the level at which steam enters the formation if the steam injection tubing extends to the bottom of the reservoir.

The vaporizable liquid now is preferably injected together with a surfactant or foaming agent and a heavy crude oil, such as that the annulus is filled with foamed crude. The surfactant is chosen so that the foam is fairly stable at the annulus temperature. Foaming surfactants which may be used are Triton X-100; Igepal CO-990; Arquad C-50. Other surfactants are

commercially available. The foam is a better insulator than high pressure gas alone and will result in lower casing temperatures and less heat loss. In addition, the high apparent viscosity of the foam will minimize the injection requirements when the method is used to control the steam injection interval at the bottom of the well.

Use of my invention permits steam to be injected down tubing, with the annulus filled with high pressure gas or foam for casing temperature control and injection interval control purposes, without requiring a high pressure compressor or gas source because the injected liquid and foam become vaporized by the heat escaping from the tubing into the annulus.

The vaporizable liquid is pumpable by means of a small pump into the annulus of the steam injection well.

The invention is applicable to the beneficiation of valuable materials from below the surface of the ground in cases other than production of hydrocarbons or hydrocarbonaceous materials. For example, the invention can be applied to the beneficiation of sulfur from sulfur strata.

Thus, it is an object of this invention to provide an improved packerless injection of a hot fluid into a formation below the surface of the ground. It is another object of this invention to provide an improved method for the injection of steam or other hot fluid in the recovery of hydrocarbons or hydrocarbonaceous materials from below the surface of the ground. It is a further object of this invention to recover a valuable material from a formation of it or containing it below the surface of the ground. It is a still further object of this invention to improve the method of injecting a hot fluid into a formation below the ground wherein there is used a protective shield or blanket of gas or foam to protect the formation or casing which may contain the injection tube to which the hot fluid is injected from adverse effects caused by the heat of the hot fluid being injected.

Other aspects, concepts and objects of the invention are apparent from a study of this disclosure, the drawing and the appended claims.

According to the invention, there is injected surrounding an injection conduit through which hot fluid is to be injected or is being injected a liquid which will vaporize at the temperature ambient the hot fluid injection tube. Further according to the invention there is injected together with said liquid which will vaporize a liquid which will not substantially vaporize at said temperature thus to create like unto a foam to surround the hot fluid injection tube. Preferably, there is injected together with the liquids a surfactant or foaming agent to aid in the building of the protective shield or blanket which is produced in situ.

These and other surfactants which can be used include those mentioned in the table of U.S. Pat. No. 3,357,487 which is incorporated herein by reference.

Respecting the relatively nonvaporizable liquid which can be added where with to form a foam there can be used a heavy crude such as Morichal crude having a gravity of from about 10 to about 12 API. Crudes in the range of from about 10 to about 30° API are entirely suitable.

Surfactants which can be used and which are stable at injection temperatures can be determined by mere routine test and can be commercially purchased and include additionally to those earlier mentioned Tween 20, Tween 40, which are respectively polyoxyethylene sorbitan monolaurate and polyoxyethylene sorbitan monopalmitate and other like surfactants.

Referring now to the drawing, steam is injected by pipe 4 into steam injection tube 3. It travels down into the formation and out into the formation following the direction of the arrows. The steam emerges into the formation through ports 2. These ports are provided in casing 1 of which only portion are shown, that is to say, a portion at the surface and the bottom portion in the formation desired to be treated, for example, heated prior to producing the same.

To cause the steam to push into the formation and to protect the casing 1 against undue heat, naphtha, crude oil and surfactant are respectively pumped through 5, 7, and 9 and valves 6, 8, and 10 into the annulus between tubing 3 and casing 1 and there a foam, as shown, is formed. This foam prevents the steam from rising into the annulus and protects the casing from the heat emanating from tube 3 toward the casing 1.

EXAMPLE

In a typical application steam at 556°F. and 1100 p.s.i.a. is injected into a 3200 ft. deep well through a tubing string. To insulate the tubing string from the casing, a mixture of crude oil, anhydrous ammonia, and surfactant is injected into the tubing-casing annulus with a chemical feed pump so that the annulus is filled with foam, reducing convection and radiation heat transfer across the annulus. The foam is generated by the agitation of boiling ammonia or the hydrocarbon surfactant mixture. One volume of crude oil is mixed with about 2 volumes of ammonia and about 0.0015 volumes of a suitable surfactant. Some crudes may exhibit sufficient foaming tendencies so as to minimize ammonia and surfactant requirements. The rate of injection of the mixture is controlled to make up possible casing leaks and surfactant decomposition to maintain the annulus full of foam. The mixture injection rate is controlled to balance casing and tubing pressure at the formation and to minimize thermal expansion of the casing during the operation. If desired, higher mixture injection rates will result in foam entering the top of the formation and causing the steam to enter the bottom of the formation, thus controlling the part of the formation treated with the steam, as described in more detail in the aforementioned Ser. No. 567,470, filed by me July 25, 1966.

The amounts of ammonia and/or surfactant in the foregoing example can be varied. Usually about up to two or more volumes of ammonia and about up to 0—0.020 or more of the surfactant will be used. The desirable amounts can be determined by mere routine testing. It is not always necessary to use both ammonia and surfactant although use of both together is now preferred.

Reasonable variation and modification are possible within the scope of the disclosure, the drawing and the appended claims to the invention the essence of which is that a liquid which is vaporizable at the temperature attained within the injection well used for injecting hot fluids is injected to surround the injection pipe to clothe it with a protective or insulated blanket thereby to protect the well bore or casing and that in a preferred form of the invention a relatively nonvaporizable liquid and/or a surfactant are also introduced to produce a foam or foamlike protectant or shield.

I claim:

1. A method for protecting during injection the annulus surrounding a hot fluid injection tube through which a hot fluid is injected into a formation below the surface of the ground which comprises also injecting from the surface into the annulus surrounding said tube a liquid which will vaporize at the

temperature ambient said tube, vaporizing said liquid to form a vapor and retaining said vapor in said annulus for insulation and regulation of hot fluid injection level in the formation during injection of said hot fluid into said injection tube thus forming a gas protective shield or blanket around said injection tube.

2. A method according to claim 1 wherein there is injected together with the liquid which will vaporize a relatively nonvaporizable liquid which will create a foamlike mass surrounding said injection tube when the vaporizable liquid is vaporized.

3. A method according to claim 2 wherein a surfactant to help build a foamlike material or mass is also injected together with said liquid which will vaporize.

4. A method according to claim 1 wherein a surfactant to help build a foamlike material or mass is also injected together with said liquid which will vaporize.

5. A method for injecting steam into a hydrocarbonaceous or other formation below the surface of the ground which comprises injecting into an injection well, having an injection tube for steam injection and a casing, steam through said injection tube and also injecting from the surface, during said steam injection, into the annulus, formed between the tube and the casing, a liquid which will vaporize at the temperature in the annulus during the steam injection, vaporizing said liquid in said annulus and retaining the vapor formed therein in said annulus during continued injection of said steam for insulation and for regulation of steam injection level in the formation.

6. A method according to claim 5 wherein there is also injected with the liquid into the annulus a relatively nonvaporizable liquid which will build a foamlike mass with the vaporizable liquid when it vaporizes.

7. A method according to claim 6 wherein there is also introduced into the annulus a surfactant to assist in building a said foamlike mass.

8. A method for injecting steam into an oil bearing or hydrocarbonaceous formation below the surface of the ground which comprises establishing an injection well having an injection tube and a casing surrounding said tube and forming an annulus therewith, injecting steam through said injection tube, from the surface introducing into the annulus a vaporizable liquid comprising anhydrous ammonia, said liquid having a boiling temperature such that it will vaporize during steam injection to produce a vapor blanket protective shield in said annulus, vaporizing said liquid in said annulus and retaining the vapor formed therein in said annulus during continued injection of said steam for insulation and for regulation of steam injection level in the formation.

9. A method according to claim 8 wherein there is also introduced into said annulus a relatively nonvaporizable liquid comprising a crude oil or heavy crude which with the liquid ammonia will build a foamlike mass therewith.

10. A method according to claim 9 wherein a surfactant is also introduced to aid the building of said foamlike mass.