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LOW-TEMPERATURE PACKER

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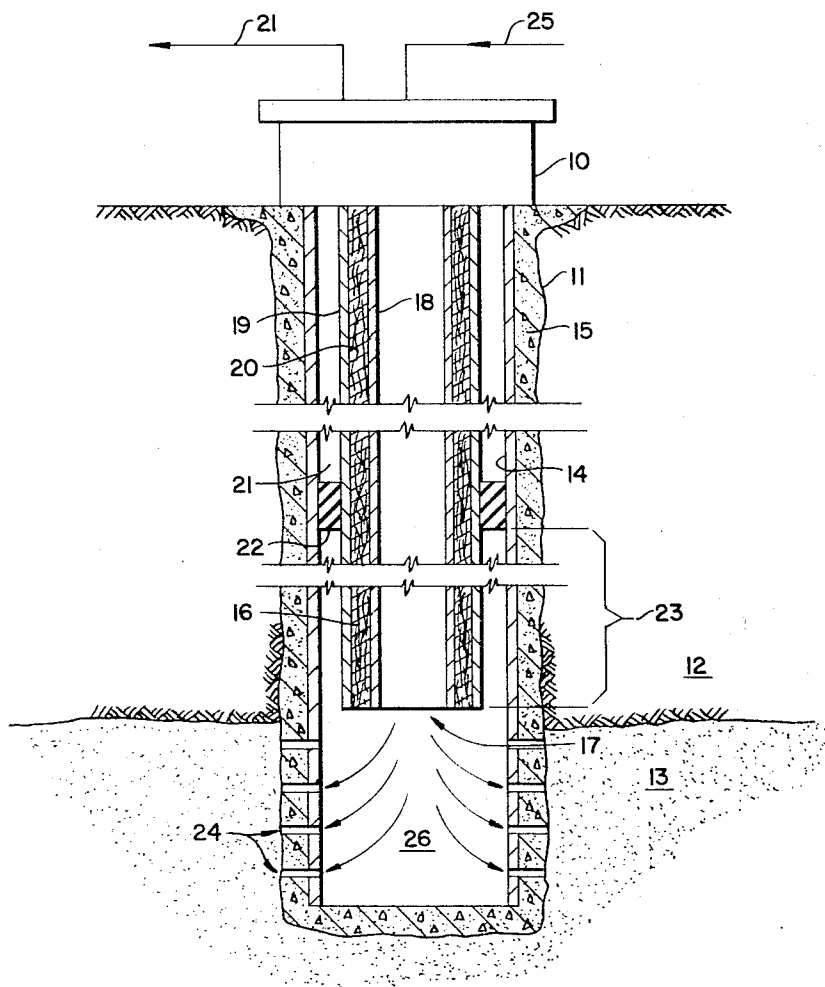


FIG. 1

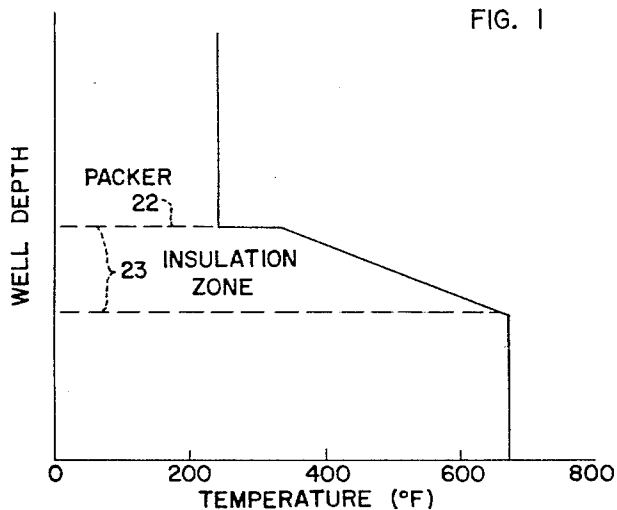


FIG. 2

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LOW-TEMPERATURE PACKER

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2 Claims

ABSTRACT OF THE DISCLOSURE

Method and apparatus for treating an oil-bearing formation with steam through an injection well wherein an insulated tubing string providing a flow path for the steam is maintained in position within casing in the vicinity of the formation by means of a low-temperature packer. The low-temperature packer seals the well annulus at a position above the outlet of the tubing string sufficient to provide an insulation zone between the packer and the high-temperature injection zone of the well.

This invention relates to the production of oil from underground formations and pertains more particularly to a method and apparatus for treating an oil-bearing formation through an injection or injection-production well to reduce the viscosity of the oil in the formation and/or drive it to a producing well in communication with the same formation.

The producing formations of many oil fields contain low-gravity oil having viscosity values that are sufficiently high so as to prevent easy flow of the oil through the formation and into a well. In some fields of this type, steam flooding of the producing formations is carried out through one or more injection wells in order to reduce the viscosity of the production fluid and/or drive the heated oil to adjacent wells, in the same field, through which it is produced to the surface.

An injection well is usually provided with a casing extending from the surface down to at least the top and generally into the producing formation to provide a liner for the wellbore. Internally of the casing there is provided a tubing string having a bore extending from the surface of the well down to a point proximate of the well bottom. The casing extends a distance below the terminal end of the tubing string and is perforated to allow the steam, which is conducted from the surface down through the tubing string, to penetrate the producing formation through the casing perforations. Between the tubing string and the casing there is an annular space generally denoted as the well annulus. This annulus is usually sealed at the bottom of the tubing string by means of a packer, well known in the prior art, so as to restrict the steam from flowing back up this annulus and require that it be forced out through the perforations into the producing formation. In many cases packers are usually used to protect poor casing from pressure and high steam temperatures.

Due to the destructive effects of the high temperatures (600°–1000° F.) in steam injection wells, packers for this purpose have become highly engineered and consequently expensive.

Summary of the invention

It is therefore a primary object of the present invention to provide a method and apparatus for treating an oil-bearing formation with steam through an injection well in which the annulus is sealed from the high-temperature zone by a packer of the conventional low-temperature type.

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It is another object of this invention to provide an insulation zone or a heat transfer barrier zone between the high-temperature injection zone of a steam-injection well and a low-temperature packer for sealing the well annulus above said zone.

Another object of the present invention is to provide apparatus for steam injection through wells wherein the packing elements used therein are insulated from the steam heat.

These objects have been attained in the present invention by providing a method and apparatus for conducting high-temperature treating fluid to a subsurface earth formation through a wellbore which is lined with a casing. An insulated tubing string having a fluid outlet near the bottom end thereof is positioned within the casing and maintained in fixed relative position with respect thereto by a packer means. The packer means is positioned in such a manner so as to provide a fluid-filled annular insulation zone between the casing and the insulated tubing string to protect the packer means from destructive thermal conditions existing with respect to the operation of conducting the high-temperature treating fluid to the subsurface earth formation.

These and other objects of this invention will be understood from the following description taken with reference to the drawings, wherein:

FIGURE 1 is a diagrammatic view taken in longitudinal cross-section of a steam-injection well installation in accordance with the present invention; and

FIGURE 2 is a graph illustrating the temperature of the well annulus versus the well depth of an installation incorporating the present invention.

Referring to FIGURE 1 of the drawing, there is shown a wellbore 11 extending from the surface through the earth or overburden 12 into a permeable and porous formation 13 containing minerals, such as hydrocarbons. A casing 14 is secured to the well wall with cement 15 to line the wellbore 11. The wellbore and casing are closed at the top by a wellhead 10. Depending from the wellhead 10 is an insulated tubing string 16 extending internally of the casing 14 down into the porous formation 13. Steam supply line 25 communicates through the wellhead 10 with the bore of the insulated tubing string 16. Between the outside diameter of the insulated tubing string 16 and the inside diameter of the casing 14 is an annular space 21 that may be vented through the wellhead 10 by vent line 21. The casing 14, if cemented as at 15, is provided with perforations 24 at the well bottom to allow steam, conducted from the supply line 25 down through the insulated tubing 16, to be injected into the porous oil-bearing formation 13. In many cases, slotted casing is employed that is not cemented in the oil zone. At a predetermined point above the steam outlet 17 or uppermost perforation 24, there is provided a packer 22 to seal the annulus 21 from the steam injection zone 26 that is proximate to the perforations 24. The packer 22 may be of the conventional low-temperature, such for example as one of the elastomer-cup type.

The insulated tubing string 16 is fabricated from a plurality of pipe sections joined in series. Each pipe section may be constructed, for example, in the manner taught by a copending patent application Ser. No. 568,899, filed July 29, 1966, and entitled "Insulated Tubing." Such construction calls for an inner tube 18 surrounded by a concentrically-spaced outer tube 19 that is sealed at its ends to the said inner tube so as to leave an annular space 20 therebetween which may be filled with any suitable insulation material, such for example as calcium silicate or aluminum silicate.

The point at which the packer 22 is placed above the injection zone 26 is determined from several factors which

include the temperature of the steam, the radial heat transfer rate across the insulated tubing 16, the radial heat transfer rate across the wellbore casing and the heat conduction rate from the injection zone 26 through the static vapor head forming the insulation zone 23. These criteria are integrated in such a manner as to locate a position at which the thermal influx from the injection zone and the insulated tubing 16 equilibrates with the heat loss to the surrounding earth formation at a temperature compatible with the continued preservation of the structural integrity of the packer.

Although an exact distance from the steam outlet 17 or the uppermost perforation 24, whichever is the uppermost of the two, may be calculated from the criteria indicated above, it has been found from experience that an insulation zone distance of 75 to 100 feet is usually adequate to protect and preserve the packer in most applications.

In operation, steam is injected through the line 26, the wellhead 10, the inner bore of the insulated tubing 16 and into the injection zone 26. The injection zone 26 is a region of high temperature and pressure and constitutes a manifold for the perforations 24 through which the steam is passed and distributed uniformly into the porous formation 13. Insulation zone 23 is in fluid communication with the injection zone 26 but, having no outlet for fluid flow therethrough, constitutes a relatively static pressurized gas head above the injection zone 26. There being no flow through the insulation zone 23 to regenerate the temperature of the gases trapped therein, a temperature gradient is formed which diminishes in temperature in direct relation to the linear distance from the injection zone 26 as measured from the steam flow channel from the outlet 17 through the uppermost perforation 24.

The insulated tubing string 16 fundamentally preserves the heat of the steam as it passes down its long course to the injection zone 26. In so doing, however, the insulation also protects the packer 22 from the destructive thermal effects of the incoming steam. Additionally, the insulated tubing 16 protects the static vapor trapped within the insulation zone 23 from temperature generation by heat conduction from the said inlet steam. Hence, the packer 22 is protected at all points from the destructive thermal effects of the injection steam, which result allows the use of simple, low-cost elastomer-cup packers.

The chart of FIGURE 2 graphically illustrates the temperature profile for 660° F. steam in a well and shows the relatively low temperature along the length of the annulus 21 of approximately 250° down to the packer 22. Across the packer there is a small but abrupt increase in temperature of approximately 100°. Below the packer the annulus temperature of the insulation zone 23 further increases at a relatively small rate until the injection temperature of the steam at zone 23 is reached.

In many cases the system of the present invention is such that the tubing is only insulated below the packer and for a relatively short distance above it to protect the outer casing mainly from pressure, with relatively less protection from temperature.

We claim as our invention:

1. An apparatus for conducting high-temperature treating fluid to an oil bearing subsurface earth formation through a wellbore, said apparatus comprising:

- a casing string in said wellbore having at least one opening adjacent said formation to be treated;
- an insulated tubing string depending within said casing

string such that an annular space is defined between said casing string and said insulated tubing string, said insulated tubing string having at least one opening near its lower end;

a fluid-filled annular insulation zone formed near the lower end of said casing string above the uppermost opening of said casing and tubing strings;

an injection zone formed below said tubing string within said casing string, said injection zone being a region of high temperature;

packer means positioned in said casing string at a selected level above the oil bearing subsurface formation sealing said annular space from said annular insulation zone and forming the upper end of said insulation zone; and

said tubing string extending downwardly below said packer means a distance sufficient to define an insulation zone below said packer means and above said uppermost openings, such insulation zone being of a length in relation to the temperature of said injection zone such that said packer means is protected by said insulation zone from destructive thermal conditions existing below said uppermost openings and with substantially the entire length of the insulation zone extending above the oil bearing subsurface formation.

2. A method for conducting high-temperature treating fluid to an oil bearing subsurface earth formation through a wellbore lined with a casing, said method comprising the steps of:

descending within the casing an insulated tubing string to conduct said high-temperature fluid into said subsurface formation, said tubing having a fluid outlet near the bottom end thereof and an annular space formed about the exterior thereof;

positioning said insulated tubing string within said casing so that said fluid outlet is spaced upwardly from the bottom of said casing so that a high-temperature injection zone is formed in said casing;

sealing the annular space between said casing and said insulated tubing with packer means positioned at a selected level above the oil bearing subsurface formation; and

providing an insulation zone of pressurized gas between said high-temperature fluid outlet of said tubing and said packer means of sufficient thermal gradient to protect said packer means from injurious effects of heat from said high-temperature treating fluids, said insulation zone being of a length in relation to the temperature of said injection zone with substantially the entire length of the insulation zone extending above the oil bearing subsurface formation.

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