United States Patent [19]
Culter

[11] **3,899,026**
[45] **Aug. 12, 1975**

[54] **USE OF THERMAL INSULATING FLUIDS IN WELLS**

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[22] Filed: **Mar. 27, 1974**

[21] Appl. No.: **455,446**

[52] **U.S. Cl.** **166/302**; 166/303; 166/DIG. 1
[51] **Int. Cl.**^{2} **E21B 43/00**; E21B 43/24
[58] **Field of Search** .... 166/302, 303, DIG. 1, 57; 252/62

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[57] **ABSTRACT**

A process of thermally insulating the borehole of a well by providing in the annular space of the well between the wall of the borehole and a well conduit a suspension of an ultra finely divided silica in a low thermal conductivity oil.

3 Claims, No Drawings

USE OF THERMAL INSULATING FLUIDS IN WELLS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method of thermally insulating the annular space in a well surrounding a well conduit to cut down heat transfer between the conduit and the casing or borehole wall from fluids passing through the conduit. High heat transfer can result in damage to casing, the bond between the casing and the cement behind it or to the surrounding formation itself.

2. Description of the Prior Art

In various well operations heat may be transferred from relatively hot fluids flowing through well conduits such as tubing outwardly to the relatively cold casing or borehole wall of an uncased well. Similarly, heat transfer may be from a relatively hot casing or borehole wall to a relatively cool fluid flowing through a well conduit.

In thermal stimulation operations steam or hot water is injected down the tubing of a cased well and into a subterranean formation containing high viscosity oil. The hot fluids raise the temperature of and decrease the viscosity of the oil which is then produced via the same or a different well. The temperature of the injected steam or hot water is quite high. Considerable heat is conducted outwardly through the tubing, the annular space between the tubing and the casing and through the casing which is generally cemented to the borehole wall. This often causes stresses in the casing due to thermal expansion which may result in failure of the casing such as by buckling or rupture of the casingcement bond.

In wells drilled in arctic environments, drilling fluids or fluids produced from the well following completion are at a higher temperature than the permafrost region through which the well is drilled. It is desirable to cut down heat transfer from the fluids flowing through the tubing or drill string to the permafrost formation to minimize melting of the permafrost which can result in loss of stability of the casing.

In wells producing fluids from relatively hot formations, it may be desirable to maintain such fluids at a relatively high temperature during their passage up a well conduit to the surface, as when cooling of these fluids may cause the paraffin constituents therein to come out of solution, deposit on the conduit wall and possibly plug the same.

A wide variety of materials have been suggested as insulating fluids for the annulus between a well conduit and the surrounding casing or borehole wall to cut down heat transfer between the conduit to its surrounding environment. Such materials include oil thickened with various thickening agents such as soaps, vermiculate, asbestos, magnesium silicate and the like. However, there still exists a need for such an insulating fluid which possesses the desired insulating properties and is able to withstand the high temperature of steam or similar fluids without deterioration.

OBJECTS OF THE INVENTION

It is an object of this invention to provide a process for thermally insulating the annular space between a well conduit and the surrounding environment which may be a casing or a borehole wall.

It is a further object to provide such a process which provides improved insulation under conditions where either the well conduit or its surrounding environment are at a high temperature.

It is a still further object to provide such a process wherein the insulating medium is stable at high temperatures.

Other objects, advantages and features of this invention will become apparent from the following description and claims.

BRIEF SUMMARY OF THE INVENTION

This invention involves a process of thermally insulating the casing or borehole of a well and its environment from a fluid passing through a well conduit such as tubing or drill string by providing in the annular space between the casing or borehole and the well conduit a thermal insulating fluid comprising an oil having low thermal conductivity containing an ultra finely divided silica suspended therein

DESCRIPTION OF THE PREFERRED EMBODIMENT

The thermal insulating fluid used in the process of this invention is a suspension of an ultra finely divided silica in an oil having a low thermal conductivity. By ultra finely divided silica is meant silica having a particle size of less than about **0.1** micron. Such pyrogenic silicas can be prepared at high temperatures of about **1100°C** by the vapor phase hydrolysis of silicon tetrachloride. The silica is collected from the gaseous phase. Larger particle size silicas also form a thermal insulating fluid when mixed with the oils of this invention, but the resulting suspensions tends to settle with time especially in environments of elevated temperature resulting in unsatisfactory thermal insulating properties in the upper regions of the fluid column.

The oil having a low thermal activity can be selected from such oils as pale oils, fuel oils and bright stocks. Specific examples include furfural extracted pale oil, No. **6** fuel oil, **95** viscosity index bright stock (a paraffinic mineral oil) and **170** pale oil.

The concentration of ultra finely divided silica in the low thermal conductivity oil can range from **0.15** pounds per gallon to **1.0** pounds per gallon. At concentrations of less than **0.15** pounds per gallon the composition has insufficient gel strength, i.e., is too fluid to provide sufficient insulation properties. At concentrations above about **1.0** pounds per gallon the composition is a gel which is so viscous that it becomes difficult to pump and handle. The mixing may be carried out by any convenient stirring device such as a bladed stirrer or the like. The composition may be used as an insulating fluid over a wide temperature range from protecting permafrost formations to steam injection wells where the temperature of the steam approaches **700°F.**

A suspension was prepared of ultra finely divided silica having a particle size range of from **0.015** to **0.02** micron in furfural extracted pale oil. A concentration of **0.32** pound silica per gallon pale oil was used. The gel strength of the resulting mixture was **2.5** pounds per **100** square feet at room temperature and **2.0** pounds per **100** square feet at **175°F.** Thus the gel strength did not change appreciably with temperature.

An annular test cell was prepared by welding together at each and with annular discs, concentric **32** inch long sections of a **2⅞** inch diameter tubing and a

7 inch diameter casing. Access ports to the annular space between the tubing and the casing were provided in the casing near each end thereof. Thermocouples were located at selected positions along the tubing and casing axis and were used to monitor the temperature of each. A heating element with guard heaters at either end was centered inside the tubing to provide a uniform source of heat from the surface of the tubing. Two rows of copper tubing with holes drilled at uniform intervals were located at both ends of the casing to help end effects. Air was used as the coolant. The annular space of the test cell was filled with a thermal insulating fluid prepared by mixing an ultra finely divided silica into 95 viscosity index bright stock with a laboratory stirrer. The pyrogenic silica used had a particle size range of 0.015 to 0.020 micron, a surface area of 175 to 200 square meters per gram and a specific gravity of 2.1. The silica was used at a concentration of 0.24 pounds per gallon of bright stock. Heat was applied to the tubing at the rate of 277 BTU/hr-ft °F. After 68 hours of heating the average tubing temperature was 521°F. and the average casing temperature was 160°F. The apparent thermal conductivity of the thermal insulating fluid was 0.095 BTU/hr-ft °F. Heating was continued. After 74 hours the heat input rate was increased to obtain an average tubing temperature of 650°F. and an average casing temperature of 170°F. The apparent thermal conductivity of the thermal insulating fluid was 0.106 BTU/hr-ft °F. The test was terminated after 164 hours of heating. Samples of the thermal insulating fluid were withdrawn from the top, middle and bottom portions of the annulus, an ash determination was made to determine the amount of silica in each sample. The top sample contained 3.46 weight percent ash. The middle sample contained 3.34 weight percent silica. The bottom sample contained 3.24 weight percent ash. These results indicate that little segregation of the silica had occurred in the fluid during the heating period. The above temperature results showed that the fluid provided excellent protection to the test casing.

The thermal insulating fluid can be used in a well by mixing together at the surface the ultra finely divided silica and the low thermal conductivity oil. The resulting suspension is then pumped into the annular space between the tubing and the borehole wall or casing following well known placement techniques. The annulus is generally closed off near the bottom of the tubing by a packer positioned between the tubing and the borehole wall or casing.

It is to be understood that the above description is only illustrative of the various ways in which the process of this invention may be carried out. Other modifications within the scope of the invention will occur to those skilled in the art.

What is claimed is:

1. A method of thermally insulating an annular space between the borehole of a well and a conduit therein comprising providing in said annular space a suspension comprised of ultra finely divided silica having a particle size of less than 0.1 micron in an oil having low thermal conductivity, said silica being present in an amount of from 0.15 to 1.0 pounds per gallon.

2. The method of claim 1 wherein the ultra finely divided silica has a particle size range of from 0.015 to 0.02 microns.

3. The method of claim 1 wherein the oil having low thermal conductivity is selected from a group consisting of pale oil, fuel oil and bright stock.

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