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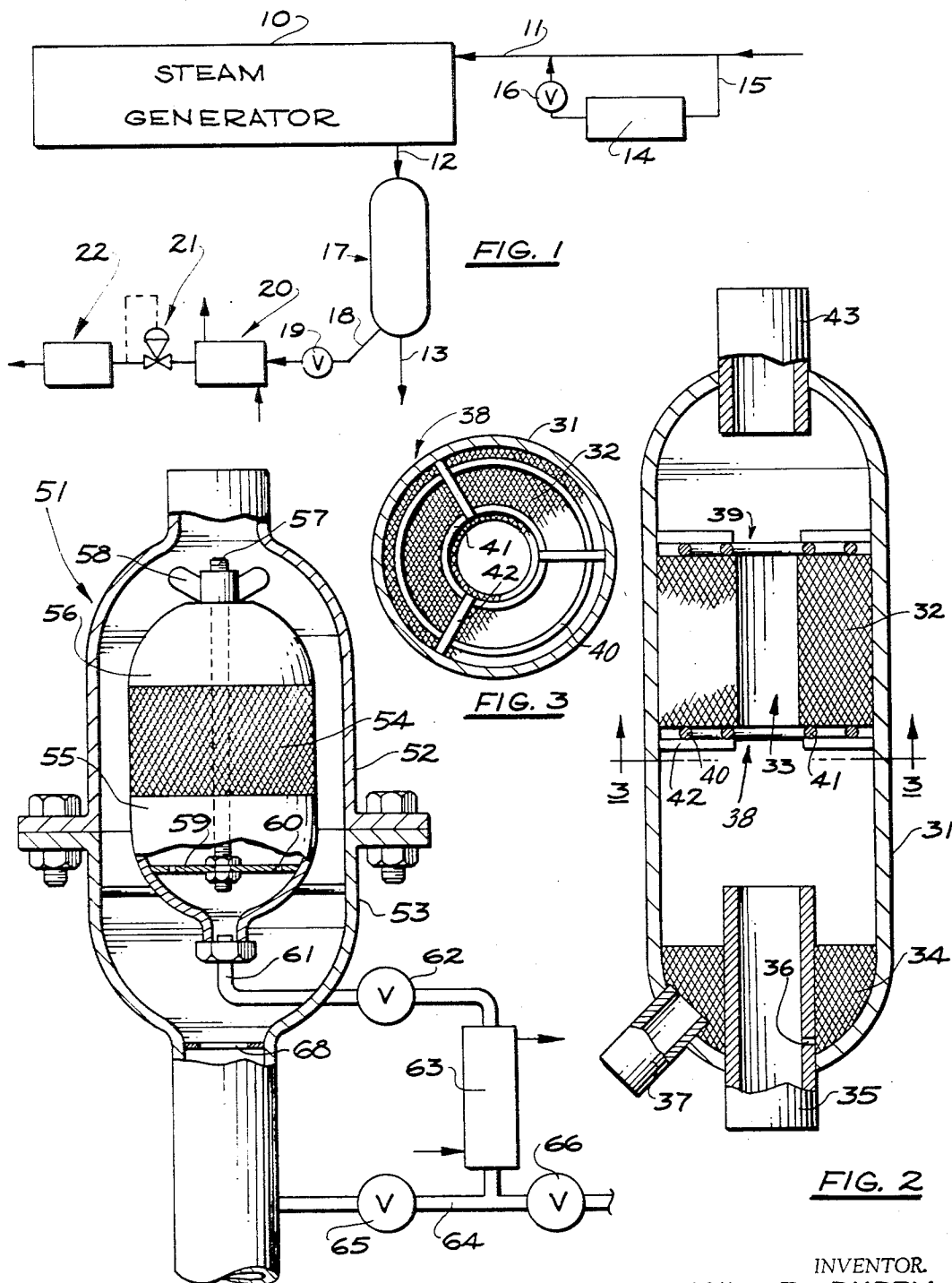


FIG. 4

FIG. 1

FIG. 3

FIG. 2

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STEAM QUALITY DETERMINATION

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ABSTRACT OF THE DISCLOSURE

A process for measuring the percent conversion of a liquid to a vapor in a vaporizer designed to vaporize a portion only of a multi-component liquid stream at elevated temperatures and pressures which process comprises monitoring the content of a non-vaporizable component of said liquid prior to vaporization, vaporizing a portion of said liquid to form a combined liquid-vapor stream wherein the liquid phase of said stream is rich in said non-vaporizable components, collecting a sample of liquid from said combined liquid-vapor stream without condensing any vapor in said combined stream and measuring the content of the non-vaporizable component in said sample.

This invention relates to a process and apparatus for measuring the amount of vapor produced when a liquid is partially vaporized in an apparatus designed to produce a vapor with substantial amounts of entrained liquid. More particularly, this invention relates to the measurement of steam quality effluent from a steam generator which produces steam containing relatively large quantities of water.

In recent years a technique for the so-called secondary recovery of oil from depleted wells or wells containing highly viscous crude oils has been developed in which low quality wet steam is injected into the well to lower the viscosity of the crude oil and facilitate its removal. The steam employed can vary greatly in quality (that is, liquid water content) depending on the particular steam generator employed and the amount and type of impurity dissolved in the water employed.

The steam is conveniently produced in a direct fired heater in which water flowing through coils is heated directly by a gas or oil flame. Such a device is, for example, disclosed in patent application Ser. No. 425,432 filed Jan. 14, 1965, now U.S. Patent No. 3,357,407, by J. P. Fanaritis.

One limitation which must be imposed on the generator is that the percent conversion of water into steam must be controlled so that no salts or scale will deposit on the interior surfaces of the tubes through which the steam and water travel.

To accomplish this limitation, it is desirable to monitor the amount of water in the wet steam.

It is therefore an object of this invention to provide a method of determining the amount of vapor in a liquid-vapor mixture.

Another object of this invention is to provide a novel and simple method for the determination of steam quality in a relatively low quality steam.

A further object is to provide a device for separating a sample of liquid from a vapor in which the liquid is entrained.

The above and other objects of this invention are in part accomplished by a process for measuring the percent conversion of a liquid to a vapor in a vaporizer designed to vaporize a portion only of a multi-component liquid stream at elevated temperatures and pressures which process comprises monitoring (measuring) the content of a non-vaporizable component of the liquid prior to vaporization,

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vaporizing a portion of the liquid to form a combined liquid-vapor stream, collecting a sample of the liquid from the combined liquid-vapor stream without condensing any vapor in the stream and measuring the content of the non-vaporizable component in the sample.

Another aspect of this invention comprises a sample collecting cylinder for separating a representative sample of a liquid from a liquid-vapor mixture, which cylinder comprises a tubular vessel having a downflow vapor-liquid inlet means, means for separating a portion of the liquid in the liquid-vapor mixture, collection means for collecting the separated liquid, discharge means for withdrawing a sample of the collected liquid, means for purging and returning excess liquid to the liquid-vapor mixture and downflow outlet means for the main portion of the liquid-vapor mixture.

In the drawings accompanying this application, FIGURE I is a schematic diagram of a steam generator which produces wet steam for subsequent ground injection and the associated liquid-vapor measuring equipment according to this invention;

FIGURE II represents one embodiment of the sample collection device of this invention;

FIGURE III is a cross-sectional view of the device shown in FIGURE II along the line 3—3;

FIGURE IV represents a diagrammatic view of another embodiment of the sample collection device of this invention.

Referring now to FIGURE I of the drawings, a direct fired steam generator is represented generally at 10. The generator is fed through the line 11 with feed water to be vaporized and a mixture of steam and water produced from the heater leaves through line 12 for ultimate injection into an oil well through line 13. In order to monitor the steam quality in the line 12, a conductivity bridge or salinity meter 14 monitors the dissolved solids content of the feed water in line 11. The salinity meter or conductivity bridge can be of the continuous recording type or may simply be a direct returning meter. In either case, it may monitor the dissolved solids content of the water from a side stream 15 of the feed line 11. When not in use, the valve 16 can be used to discontinue the side stream feed through the meter 14. The wet steam in line 12 is fed into a sample separator 17, to be described in detail later, wherein a portion of the water contained in the low quality steam is separated and conducted via line 18 through valve 19 to sample cooler 20. As the steam-water mixture in the line 12 and separator 17 are usually at high pressure, a pressure reducing valve 21 is provided to lower the sample pressure after it is cooled and conducted to a second salinity meter 22 for determination of the total dissolved solids content of the residual water in the steam.

From the two salinity or solids determinations, the percent water in the steam in lines 12 and 13 can be calculated. For example, if the feed water in line 11 has a total dissolved solids content of 200 parts per million while the sample analyzed in the salinity meter 22 has a dissolved solids content of 400 parts per million then 50 percent of the feed water has been converted to steam in the generator 10. Similarly, if the feed water contains 100 parts per million total dissolved solids as indicated by the indicator 14, and the sample effluent from separator 17 through line 18 has a dissolved solids content of 400 parts per million, then 75 percent of the feed water has been converted to steam in the generator. Thus, this invention provides a simple and efficient process for continuously or intermittently monitoring the quality of low quality steam and enables rapid adjustments to be made to the generator to insure that the solids content of the residual unvaporized water in the low quality steam does not exceed

the solubility of deleterious inorganic materials which may precipitate on the interior surfaces of the tubes and other associated generator equipment.

The simplicity of the process depends on the ability to continuously and inexpensively separate a small sample of the water in the low quality steam without condensing the steam. According to this invention, the sample separation is conducted in a vertical downflow sample collector such as illustrated in FIGURES II and III. FIGURE II illustrates a preferred embodiment of the sample collection device of this invention. It comprises a tubular vessel 31, preferably fabricated from steel capable of withstanding elevated temperatures and pressures. To the upper end of the tubular vessel is attached an inlet pipe 43 beneath which is located a knitted wire mesh pad 32 having a center open area 33. Wet steam enters the device through the inlet pipe 43 and flows through the open area 33 and the wire mesh pad 32. On the demister pad the small particles of water contained in the steam tend to collect and drop into the sample reservoir 34 which is formed by a tubular member extending upwards into the body of the tubular member 31 to form an annulus. In order that the sample collected in the annulus be representative of the water in the wet steam produced at any given point in time, the tubular member 35 is provided with a weep hole 36 which continuously returns a portion of the separated sample to the main stream of the liquid-vapor mixture flowing through the tube 35.

In order to filter the collected sample, the annulus 34 may be filled with knitted wire mesh pad as illustrated. In the event that the rate of sample accumulation is more rapid than the rate of sample withdrawal, separated water will be returned to the main stream by overflowing the sample collecting area into the tube 35. Sample to be analyzed is withdrawn through the pipe 37. The sample pipe 37 is conveniently fitted with a valve (not shown) so that the separated sample will be returned to the vapor-liquid mixture through weep hole 36 and by overflowing annulus 34 when the sample collecting device is not in use.

The wire mesh pad 32 is held in the tubular member 31 by brackets 38 and 39 which may be attached to the tube wall by welding or any other convenient means. As the sample device is ordinarily operational in the vertical position, the bracket 39 is optional.

The mesh pad in the annulus 34 is primarily for the purpose of filtering collection sample to protect the salinity meter 22. Optionally, the pad in the annulus 34 may be omitted and replaced by a filter between the pressure reduction valve 21 and the salinity meter 22 in FIGURE I so that any deleterious particles developed in the sample will not interfere with the operation of the salinity meter.

The mesh pad 32 has been illustrated with a central hole 33 so that in case the pad becomes plugged by tube scale the main stream of wet steam can still pass through the sample device without causing a shutdown of the steam generator.

In FIGURE III the bracket 38 detail and the location of the wire mesh pad 32 is shown. Although any convenient method of securing the wire mesh pad may be employed, it is shown in FIGURE III as a spider comprising two concentric circular metal pieces 40 and 41 in which are attached struts 42. The struts extend past the outer circular members 40 and are welded to the tubular member 31, as illustrated.

FIGURE IV represents another embodiment of the sample collection device of this invention. It comprises, generally, a tubular vessel 51 having a top section 52 and a bottom section 53 which are assembled by means of a body flange. In the internal interior section is a wire mesh pad 54 which is held in place by means of a bottom pipe cap 55 attached for example, by struts to the body of vessel 51, and a top pipe cap 56 which has a retaining rod 57 held in place by the top nut 58. The bottom of the retaining rod 57 is attached to a bottom plate 59

having a series of holes 60. In operation, wet steam enters through the top opening and passes through the vessel 51. A portion of the wet steam diffuses into the wire mesh pad 54 where some of the water in the steam collects and falls to the bottom plate 59, through the holes 60 into the sample tube 61. The main stream of wet steam passes through the bottom outlet for ground injection. Communicating with the sample tube 61 is an external valve 62 through which the water sample is drained into the cooler 63 which, as shown by the arrows, cools the sample by indirect exchange with cooling water. After passing through the cooler 63, the water sample can be returned to the effluent side of the collecting device through the return line 64 and return valve 65. When a sample is to be taken for determination, it is withdrawn through the outlet valve 66 and the sample analyzed as described above.

Although the device has been illustrated showing the retaining rod 57 attached to a bottom plate 59 having holes 60 for the passage of sample, it is to be understood that any convenient means of fastening the retaining rod 57 may be employed. For example, a spider device such as shown in FIGURE III having a central hole small enough to accommodate the rod 57 may be employed. In fact, the use of such a spider constitutes a preferred embodiment of this invention inasmuch as it allows for a freer flow of collected sample than does the retaining plate 59 shown in FIGURE IV.

In order to allow return of collected sample through the return line 64 and return valve 65, the bottom portion of the vessel 51 is fitted with an orifice plate 68 so that the pressure below the orifice plate will be slightly below the pressure in the line 64. Otherwise, because the sample is cooled in the heat exchanger 63, it would be below the pressure of the vessel 51 and opening of the valve 65 would cause backflow through the return line 64 and the sample tube 61.

The knitted wire mesh pads 32, 54 and 34 are preferably fabricated from stainless steel knitted or woven mesh by rolling the mesh in concentric cylindrical form. However, the mesh parts 32, 34 and 54 may be fabricated in any manner which will allow the passage of steam and water therethrough and which will cause coalescence and accumulation of the water sample. Any fine mesh material which is inert to water and steam at the temperatures and pressures encountered may be employed. However, stainless steel mesh is preferred.

The vessels 31 and 51 are preferably insulated on their exterior surfaces so that heat leak therefrom will be minimized. In this way steam condensation will be kept to a minimum and the water sample collected will be representative of the water in the wet steam.

As used throughout the specification, the term multi-component liquid means any liquid having more than one component which is separately measurable. For example, in the embodiment of the invention illustrated, the multi-component liquid is water containing dissolved mineral solids. In general, for use in wet steam generating equipment, the water employed can have an initial salinity of from fractional parts per million of dissolved solids up to as much as 20,000 parts per million so long as the dissolved solids will remain in solution in the residual water after steam generation.

The device and method of this invention are applicable to steam quality determination wherein from 40 to 95 percent of the water initially treated is converted to steam. In general, from 70 to 90 percent steam is found to be most useful in secondary oil recovery.

I claim:

1. A process for measuring the percent conversion of a liquid to a vapor in a vaporizer designed to vaporize a portion only of a multi-component liquid stream at elevated temperatures and pressures which process comprises monitoring the content of a non-vaporizable component of said liquid prior to vaporization, vaporizing a portion of said liquid to form a combined liquid-vapor

stream wherein the liquid phase of said stream is rich in said non-vaporizable components, collecting a sample of liquid from said combined liquid-vapor stream without condensing any vapor in said combined stream and measuring the content of the non-vaporizable component in said sample.

2. A process for measuring the percent conversion of water to steam in a steam generator which produces wet steam from water containing dissolved mineral solids, said process comprising monitoring the dissolved solids content of said water prior to steam generation, vaporizing a portion of said water to form a combined stream of steam and residual water of increased dissolved solids content, collecting a sample of said residual water with-

out substantial condensation of said steam, and measuring the dissolved solids content of said sample.

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