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(54) Device for detecting the thickness of scale on resistive elements of electric resistor-based steam generators

(57) A device for detecting the thickness of scale on resistive elements of electric resistor-based steam generators, comprising a temperature probe (19) which is arranged inside a sheath (15) that contains the resistive element (14) that is used to generate the steam. The probe is connected to means which at least indicate to the user the temperature in comparison with a preset threshold.

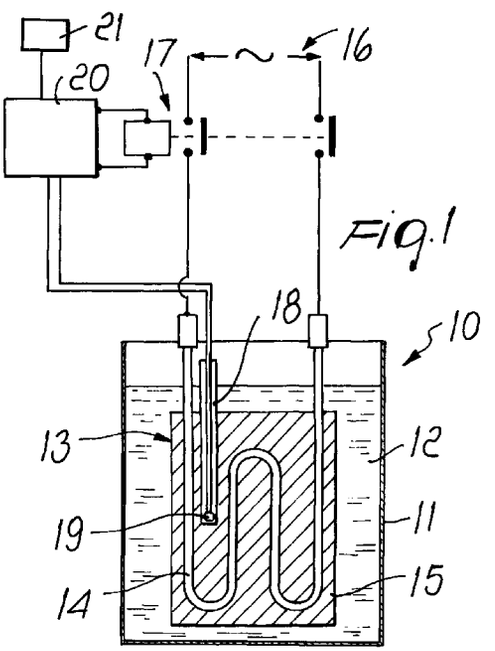

Fig.1

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Description

[0001] The present invention relates to a device for detecting the thickness of scale on resistive elements of electric resistor-based steam generators.

[0002] Conventional steam generators based on electric resistors are substantially constituted by a water tank in which one or more electric resistors are immersed; when suitably supplied with power, said resistors supply heat energy to the water to bring it to the boiling temperature and therefore convert it into steam.

[0003] One of the known drawbacks of steam generators supplied with commonly available water (the production of demineralized water requires complicated and expensive systems) which contains dissolved calcium and magnesium salts is constituted by the fact that during boiling the salts concentrate and precipitate, adhering to the hottest surfaces.

[0004] This precipitation is substantially unavoidable, although it is also possible to control the concentration of the dissolved salts with adapted dilution and flushing systems.

[0005] Accordingly, in steam generators that use electric resistors, scale gradually and incrementally deposits during operation on the walls of the hottest surfaces, constituted in practice by the sheaths that contain the resistive filaments through which electric current flows.

[0006] The resistive filaments are in fact embedded in these sheaths, which have the dual function of providing mechanical protection and of electrically insulating the filaments from the boiling water.

[0007] The sheaths can be constituted by a metal plate or pipe or by a suitably shaped cast element generally made of aluminum.

[0008] The presence of the layer of scale has negative effects on the heat exchange between the heating element and the boiling water, leading to an increase in the temperature of the heating element.

[0009] The scale crust is fragile and tends to crack and break off in flakes, consequently subjecting the surface of the resistive element to thermal shocks which can instantaneously increase the local heat flow, producing a consequent "film" boiling, to the point of producing burns therein.

[0010] The aim of the present invention is to provide a low-cost device which is capable of monitoring the thickness of the layer of scale on the heating element of the steam generator.

[0011] Within the scope of this aim, an object of the present invention is to provide a device which can issue a prealarm signal if an excessive increase of the thickness of the layer of scale occurs or can block the operation of the steam generator until scale removal is performed.

[0012] Another object of the present invention is to be able to estimate, with good approximation, the appropriate time for cleaning and scale removal operations.

[0013] Another object of the present invention is to provide a device which avoids excessive temperatures of the sheath in which the resistive elements are placed.

[0014] This aim, these objects and others which will become apparent hereinafter are achieved by a device for detecting the thickness of scale on resistive elements of electric resistor-based steam generators, characterized in that it comprises a temperature probe which is arranged inside a sheath that contains the resistive element that is used to generate the steam, said probe being connected to means which at least indicate to the user the temperature in comparison with a preset threshold.

[0015] Advantageously, said probe is connected to an electronic control device which drives the power supply of said resistive element as a function of said preset temperature threshold.

[0016] Further characteristics and advantages of the device according to the present invention will become apparent from the following detailed description of an embodiment thereof, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

Figure 1 is a schematic view of a steam generator provided with the device according to the invention;
Figure 2 is a chart which plots the thermal resistance coefficient of the layer of scale as a function of its thickness;
Figure 3 is a chart which plots the temperature of the heating element as a function of the thickness of the layer of scale.

[0017] With reference to the above figures, a steam generator with electric resistors is generally designated by the reference numeral 10.

[0018] The generator 10 is substantially constituted by a vessel 11 which contains water to be evaporated; designated by the reference numeral 12, in which at least one heating element 13 is immersed; in practice, the heating element is constituted by a resistive element 14 which is embedded in a sheath 15 generally made of cast aluminum.

[0019] Conveniently, the terminals of the resistive element 14 that protrude from the vessel 11 are connected to an electric power source 16 and a contactor 17 is present which is capable of opening and closing the power supply circuit.

[0020] According to the invention, in the sheath 15 a measurement pocket 18 is provided which constitutes, in practice, a seat which is separated from the water in which the sheath 15 is immersed and in which a probe 19 is present for measuring the temperature of said sheath 15.

[0021] The probe 19 is in turn connected to an electronic control device, represented by the block 20, which drives the contactor 17.

[0022] The control device 20 is designed to continuously compare the temperature measured by the probe

19 with a preset threshold considered as a maximum acceptable value.

[0023] The physical law that governs heat exchange between the heating element 13 and the water 12 is represented by the formula

$$W = (S/R).(T_g - T_a)$$

where

W = thermal power to be dissipated
S = exchange surface of the sheath
R = thermal resistance coefficient of the exchange
T_g = temperature of the sheath
T_a = temperature of boiling water (100°C at sea level)

[0024] The thermal resistance coefficient R of the exchange is the sum of the elementary series resistances, the most important of which are the resistance R_f of the convective exchange and the resistance R_c offered by the layer of scale, i.e., approximately

$$R = R_f + R_c$$

[0025] As shown in the diagram of Figure 2, the coefficient R_c increases as the thickness S of the layer of scale increases, in addition to depending on its composition.

[0026] The temperature assumed by the sheath 15 to perform the required heat exchange can be calculated from the above formulae:

$$T_g = T_a + (W/S) \cdot (R_f + R_c)$$

[0027] This temperature has a general trend which is shown in the chart of Figure 3, which shows that the temperature (which is of course always higher than 100°C at sea level) increases as the thickness of the layer of scale increases as a consequence of the increase in the thermal resistance of said layer.

[0028] Therefore, with the above-described device the probe 19 is used to measure the temperature of the sheath 15 while the control device 20 is used to compare said temperature with a preset threshold T_{lim} (see Figure 3) which is considered as the maximum acceptable value.

[0029] In practice, the growth of the layer of scale that deposits on the immersed heating element 13 is monitored and the appropriate time for cleaning and scale removal operations is estimated with good approximation.

[0030] If required, the operation of the steam generator 10 can be interrupted by disconnecting the power supply by means of the contactor 17 if the sheath 15 of the resistive elements reaches an excessive temperature which can depend not only on scaling but also on lack of water or on a short-circuit within the resistive filament 14.

[0031] The device can also simply provide for an alarm which is activated when the limit temperature T_{lim} is reached, or it is simply possible to provide a continuous visualization, for example by means of a display 21, of the temperature to be compared with a limit value indicated by the manufacturer.

[0032] The device is very economical to produce, since it is simply necessary to provide a pocket 18 into which the probe 19 is to be placed and couple it to the control device 20.

[0033] Due to the excellent thermal conductivity of the sheath 15, the temperature can in fact be considered uniform thereon and therefore the temperature inside the pocket 18 is approximately equivalent to the temperature of the surface exposed to the water.

[0034] In practice it has been observed that the intended aim and objects of the present invention have been achieved.

[0035] The invention thus conceived is susceptible of numerous modifications and variations, all of which are within the scope of the inventive concept.

[0036] All the details may also be replaced with other technically equivalent elements.

[0037] In practice, the materials used, so long as they are compatible with the contingent use, and the dimensions may be any according to requirements.

[0038] The disclosures in Italian Patent Application No. PD98A000079 from which this application claims priority are incorporated herein by reference.

[0039] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the Interpretation of each element identified by way of example by such reference signs.

Claims

1. A device for detecting the thickness of scale on resistive elements of electric resistor-based steam generators, characterized in that it comprises a temperature probe which is arranged inside a sheath that contains the resistive element that is used to generate the steam, said probe being connected to means which at least indicate to the user the temperature in comparison with a preset threshold.

2. The device according to claim 1, characterized in that said probe is connected to an electronic control device which compares the detected temperature with the threshold temperature.

3. The device according to claim 1, characterized in that said probe is arranged in a pocket which lies inside said sheath.

4. The device according to claim 3, characterized in that said pocket keeps said probe separated from the water in which said sheath is to be immersed.

5. The device according to claim 1, characterized in that said means which at least indicate the temperature are constituted by a display.

6. The device according to claim 2, characterized in that said electronic control device is connected to an alarm.

7. The device according to claim 2, characterized in that said electronic device drives a contactor on a power supply of said resistive element.

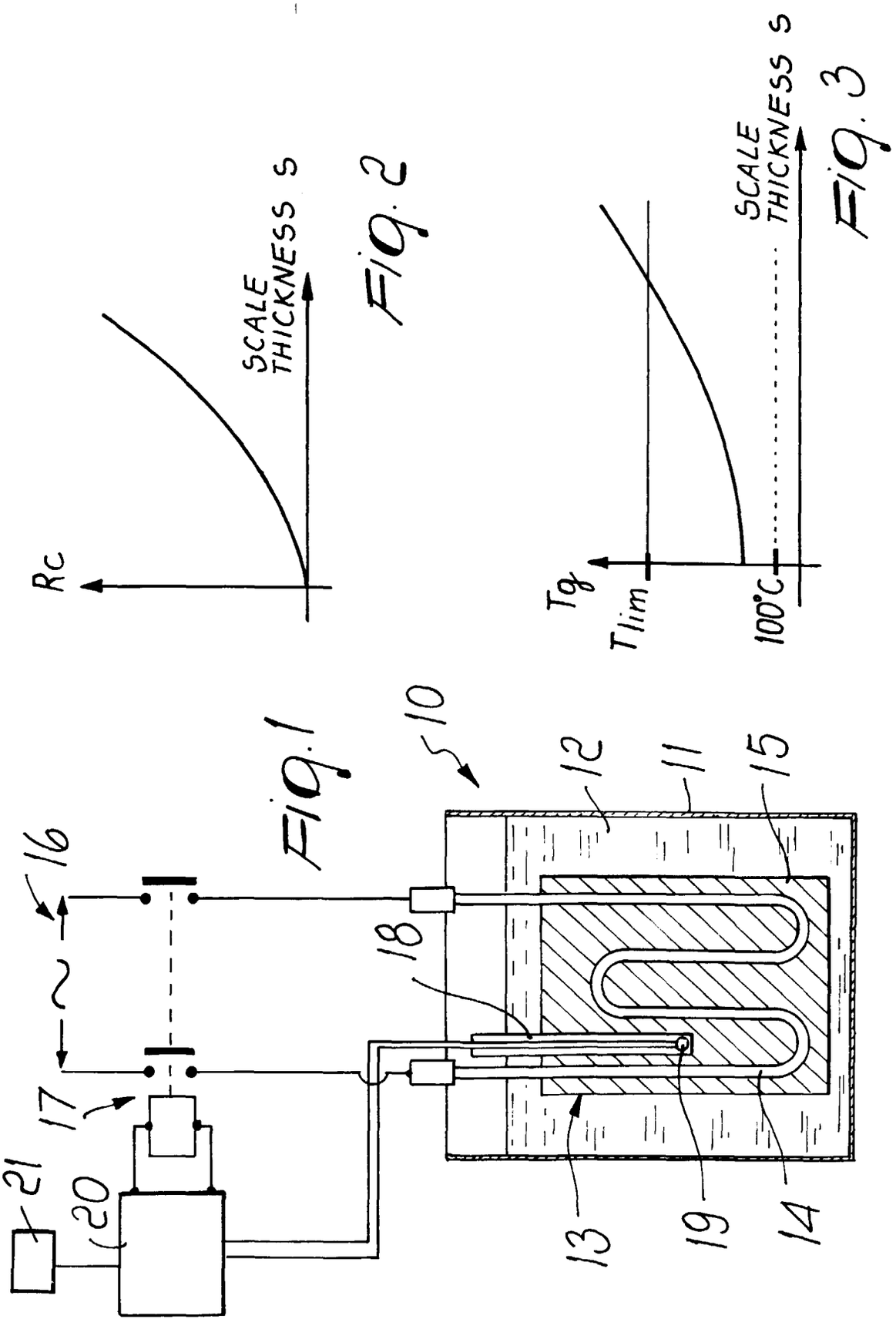

Fig. 2

Fig. 3

Fig. 1