ABSTRACT: The heat absorption surface in the furnace section of a vapor generator is cleaned of slag deposits by injecting water under pressure. This creates thermal shock together with a mechanical force which causes the slag deposits to be separated from the heat absorption surfaces.
FIG. 1

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APPARATUS AND PROCESS FOR SLAG DEPOSIT REMOVAL

BACKGROUND OF THE INVENTION

In the generation of power from fossil fuels, there has been a great deal of interest in building the vapor generators close to source of fuel. This type of installation has resulted in the availability of many types of fossil fuels which heretofore have not been practical. Thus, the use of fuels such as various types of lignite is now feasible from an economic standpoint, with the advent of vapor generator installations which are proximate to the fuel source.

There is a major problem attendant in the firing of fuels such as lignite, which have a high alkali metal content, and this relates to the severe slag deposits that are formed on the heat absorption surface in the furnace section during the operation of the vapor generator. Thus, severe slagging of the furnace wall heat transfer surface has been found to occur when the combined content of sodium and potassium in the fuel exceeds 2 percent of the ash. The presence of calcium in the fuel can also further aggravate the problem.

In the past, the fouling of boiler surfaces by heavy slag deposits has been avoided primarily by restricting the lignite fuel which has been used to fuels having an alkali metal content of less than 2 percent of the ash, and this has generally been achieved by blending the lignite fuel. Also, additives have been used with the lignite such as kaolin. Even with this restricted use of lignite, to fuels having a relatively low alkali metal content and also with the use of additives, the problem of fouling furnace heat transfer surfaces has still persisted to a great degree, and it has been necessary to use a large number of steam stop blowers.

Through the present invention, means have been provided for exerting a combined thermal shock and mechanical force on the heat absorption surface in the furnace section in order to continuously clean the deposits formed thereon. It is important to be able to continuously operate vapor generators which are fired with fuels containing in excess of 2 percent sodium and potassium in the ash without fouling the heat absorption surface in the furnace. Heretofore, without utilizing the slag removal apparatus of the present invention, it has been impossible to continuously operate at anywhere near rated capacity with lignite-type fuels containing in excess of 2 percent alkali metals in the ash. Accordingly, the present invention affords the first effective means for operating large vapor generators at full rated capacity when fired with a fuel such as lignite having a high alkali metal content.

SUMMARY OF THE INVENTION

In accordance with an illustrative embodiment demonstrating features and advantages of the apparatus aspects of the present invention, there is provided an apparatus for removal of slag from the heat absorption surfaces in the furnace section of a vapor generator. Accordingly, means are provided in the furnace section for injecting water under pressure against the heat absorption surface along at least 75 percent of the lower furnace height. Thus, the water creates a combined thermal shock and mechanical force which causes the deposits of slag to be separated from the heat absorption surface. In accordance with an illustrative embodiment demonstrating features and advantages of the process aspects of the present invention, there is provided a process for the removal of deposits of slag from the heat absorption surface in the furnace section of a vapor generator. The process comprises the step of injecting water under pressure against the heat absorption surface on which the slag deposits are formed from a material selected from the class consisting of sodium and potassium. The water is sprayed against the heat absorption surface included within at least 75 percent of furnace height.

BRIEF DESCRIPTION OF THE DRAWINGS

The above brief description as well as further objects, features, and advantages of the present invention will be more fully appreciated by reference to the following detailed description of presently preferred but nonetheless illustrative embodiments in accordance with the present invention when taken in connection with the accompanying drawings wherein:

FIG. 1 is a schematic view of burners and an injection system of the present invention, removed from the furnace section of a vapor generator, together with a block diagram showing means for controlling and supplying water to the injection system;

FIG. 2 is a sectional view taken through the front and rear walls of a typical vapor generator, to more clearly show the location of the injection system in the furnace section;

FIG. 3 is a sectional view through line 3-3 of FIG. 2 of an enlarged portion of the heat absorption surface on the front furnace wall, with the concentric circles showing the spray patterns achieved during slag removal;

FIG. 4 is an enlarged sectional view showing a portion of the wall of a vapor generator with the water injection device in a retracted position outside of the furnace section; and

FIG. 5 is a sectional view through line 5-5 of FIG. 4 with the broken line views showing the injection device in two different extended positions within the furnace section during the slag removal operation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now specifically to the drawings, there is shown schematically in FIG. 2 a vapor generator 10 provided with a water injection system embodying features of the present invention and generally designated by the reference numeral 12. The vapor generator 10 includes a furnace section 14 capable of being fired with high alkali metal content fossil fuels and forming combustion gases which are passed through an upward vertical gas pass 16, to a horizontal gas pass 18 and through a downward vertical gas pass 20 to the stack, as indicated by the directional arrows shown.

The vapor generator 10 is formed from fin-tube walls 22 which are schematically shown in FIG. 2. By referring to FIG. 3, it can be seen that the fin-tube walls 22 in furnace section 14 are formed with a heat absorption surface designated 24. The furnace section 14 includes a front wall 26, rear wall 28 and side walls 30.

The furnace section 14 includes a heavy slagging zone 32 which extends from the bottom portion of furnace section 14 up to 75 percent of the height of the furnace section 14. It has been found that, when firing furnace section 14 with high alkali metal content fuels, the slagging problem is concentrated in zone 32.

In accordance with the present invention, the injection system 12 is provided for cleaning the heat absorption surface 24 in furnace section 14 of slag deposits generally designated by the letter S. It should be understood that reference herein made to the slag deposits S, is contemplated to mean the buildup of material on the heat absorption surface 24 when firing furnace section 14 with high alkali metal content fuels such as lignite, which have a content of sodium and/or potassium in excess of 2 percent of the ash. The slag deposits S form a coating on the heat absorption surface 24 which results from the ash fusing at relatively high thermal conditions.

Turning to the schematic diagram of the injection system 12 shown in FIG. 1, a continuous circuit 40 is shown in flow communication with spray nozzles 42. By referring to the arrows in FIG. 1, which denote the direction of spray, it can be appreciated that the nozzles 42 train the spray rearwardly toward the wall on which the nozzles 42 are mounted. This back-raking spray from spray nozzle 42 is provided from a source of water 44 which is maintained under pressure by means of a pump 46.

A regulator 50 is connected in circuit 40 in flow communication with spray nozzles 42, and the pressure is generally maintained within a range of from 150 to 400 p.s.i.g., with the preferred operating pressure being substantially 300 p.s.i.g. In the FIG. 1 schematic view of the injection system 12, there is also shown the location of burners 52 in furnace section 14.
Accordingly, in a front fired unit such as vapor generator 10, it is preferable to mount the majority of the spray nozzles 42 in an opposing and slightly staggered relation with respect to the burners 52. Thus, the FIG. 1 embodiment of the injection system 12 includes nine of the spray nozzles 42 which would be located on front wall 26, as there are 12 burners which would be located on rear wall 28. Moreover, the rear wall 28 and each of the sidewalls 30 would respectively be provided with two spray nozzles 42. The nozzles 42 direct their spray in a rearward direction and the greatest number of the nozzles 42 are trained on rear wall 28 where the largest amount of slag deposits 5 are formed. It should be noted that the slag deposits 5 are continuously formed on heat absorption surface 24, and in order to maintain full capacity performance of vapor generator 10, it is necessary to periodically and sequentially actuate the injection system 12. The actuation of injection system 12 is achieved by means of a control system 54, which is schematically shown in FIG. 1, as being operatively connected in continuous circuit 40. Thus, at given time intervals depending upon the slag buildup, the injection system 12 is periodically actuated during which time the nozzles 42 are actuated in sequence dependent upon the spray pattern required. Any variety of control devices well known in the art may be utilized in control system 54, such as combined electric relay and timer control, or solid state controls.

By progressively inspecting FIGS. 4 and 5, it can be seen that the injection system 12 includes a carriage 58 which is adapted to travel on rails 60 in a direction which is lateral with respect to the longitudinal axis of furnace section 14. Mounted on the carriage 58, is a carriage drive 62 for imparting lateral directional movement to carriage 58 and a spray nozzle drive 64 is also mounted on carriage 58 for imparting rotational movement to spray nozzle 42. The drive 64 is operatively connected to spray nozzle 42 by means of a spray pipe lance 66. Thus, the spray nozzle 42 is secured to the outer end of pipe lance 66, and the other end thereof is mounted for rotation on drive 64. The water source 60 is placed in flow communication with the spray nozzles 42 by means of a flexible hose connection in continuous circuit 40, which is connected to spray pipe lance 66. The spray nozzle 42 is formed with a frustoconical body 68 on which an orifice jet 70 is mounted to direct a spray of water against the heat absorption surface 24, which is coextensive with the wall of furnace section 14 on which the spray nozzle 42 is mounted. The pipe lances 66 travel into furnace section 14 by means of through openings 72 which are formed in walls 26, 28 and 30.

The control system 54 is operatively connected to carriage drive 64 in order to periodically actuate lateral and rotational movement of spray pipe lance 66. By referring to FIGS. 4 and 5, there can be seen schematic connections 74 between control system 54 and the water source 44, carriage drive 62, and nozzle drive 64.

In accordance with the operation of the injection system 12 of FIGS. 4 and 5, it is possible to achieve a continuous spray pattern. Thus the control system 54 is programmed to periodically and sequentially actuate carriage drive 62, nozzle drive 64, and continuous flow circuit 40. In this manner the carriage 58 is moved in a forward and rearward direction with respect to through opening 72. As shown in FIG. 5, the pipe lance 66 is moved from a solid line retracted position to a series of broken-line extended positions, with the nozzle body 68 continuously rotating, whereby the water spray creates a combined thermal shock and mechanical force against the slag deposits 5 which causes separation from heat absorption surface 24. The actual pattern of the spray from orifice jets 70 is shown by the concentric circles of FIG. 3, which when compared with FIG. 5, graphically demonstrates the removal of slag deposits 5 from heat absorption surface 24 by the combined thermal shock and mechanical force exerted by spray nozzle 42. It should be understood that the embodiment of injection system 12 shown in FIGS. 4 and 5 is only one mode of advancing the spray nozzles 42 into and out of the furnace section 14.

Accordingly, it would be possible to apply a variety of mechanical means to advance and retract the spray nozzles 42, such as a combined motor and solenoid. Also, the rotation of pipe lance 66 is only one mode of achieving a uniform spray against the heat absorption surface 24. Thus, the rotating pipe lance 66 could be replaced by a spray nozzle 42 having a series of orifice jets 70 along the cross-sectional periphery of the body portions 68 of spray nozzles 42, such that a continuous circular or spiral spray pattern can be obtained. Thus, in accordance with the foregoing alternative modes of operation, the direction of the arrows of FIG. 2 which are associated with injection system 12 indicate the lateral and rotational movement functions of the spray nozzles 42.

From the foregoing it can be appreciated that an apparatus and process has been provided, in accordance with the present invention, for removing slag deposits 5 from the heat absorption surface 24 along up to 75 percent of the lower height of furnace section 14. Accordingly, by utilizing the injection system 12 it is possible to fire the furnace 14 with fuels having a combined content of sodium and potassium in excess of 2 percent of the ash obtained from burning the fuels.

A latitude of modification, change and substitution is intended in the foregoing disclosure and in some instances some features of the invention will be employed without a corresponding use of other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the spirit and scope of the invention herein.

We claim:

1. A slag deposit removal apparatus for cleaning the heat absorption surface in a furnace zone of a vapor generator in which said slag deposit is formed from material selected from the class consisting of sodium and potassium, comprising:

- a source means for supplying water which is capable of being applied to said heat absorption surface;
- pump means in flow communication with said source means for introducing said water under a pressure to said furnace section;
- regulator means operatively connected to said pump means for maintaining a predetermined pressure;
- spray nozzles mounted on said heat absorption surface in said furnace section in flow communication with said pump means for supplying water under pressure against said heat absorption surfaces of said furnace section; and
- whereby said water creates a combined thermal shock and mechanical force which causes said deposit of slag to be separated from said absorption surface.

2. A slag deposit removal apparatus as recited in claim 1, in which control means are operatively connected to the means for injecting water, such that the injection of water is periodically and sequentially actuated in accordance with the buildup of slag on said heat absorption surface.

3. A process for the removal of slag from the heat absorption surface in the furnace section of a vapor generator comprising the steps of:

- supplying water for application to said heat absorption surface;
- pumping said water under pressure to said furnace section; maintaining said water at a predetermined pressure; and
- spraying said water on said heat absorption surface of said furnace section such that a combined thermal shock and mechanical force is created to cause said deposit of slag to be separated from said heat absorption surface.

4. A process for the removal of slag deposits from the heat absorption surface in the furnace section of a vapor generator capable of being fired with fuels having a combined content of sodium and potassium in excess of 2 percent comprising the steps of:

- supplying water for application to said heat absorption surface on which said slag deposits are formed from material selected from the class consisting of sodium and potassium;
- pumping said water under pressure to said furnace section; maintaining said water at a predetermined pressure; and
spraying said water on said heat absorption surface of said furnace section such that a combined thermal shock and mechanical force is created to cause said deposit of slag to be separated from said heat absorption surface.

5. A process according to claim 4, in which the spraying of said water is controlled such that spraying is periodically and sequentially actuated in accordance with the buildup of slag.

6. A slag deposit removal apparatus according to claim 1 in which said spray nozzles are mounted on said heat absorption surface for spraying said water under pressure against said heat absorption surface along up to 75 percent of the lower height of said furnace section.

7. A process according to claim 3 in which the spraying of said water on said heat absorption surface is along up to 75 percent of the lower height of said furnace section.

8. A process according to claim 4 in which the spraying of said water on said heat absorption surface is along up to 75 percent of the lower height of said furnace section.