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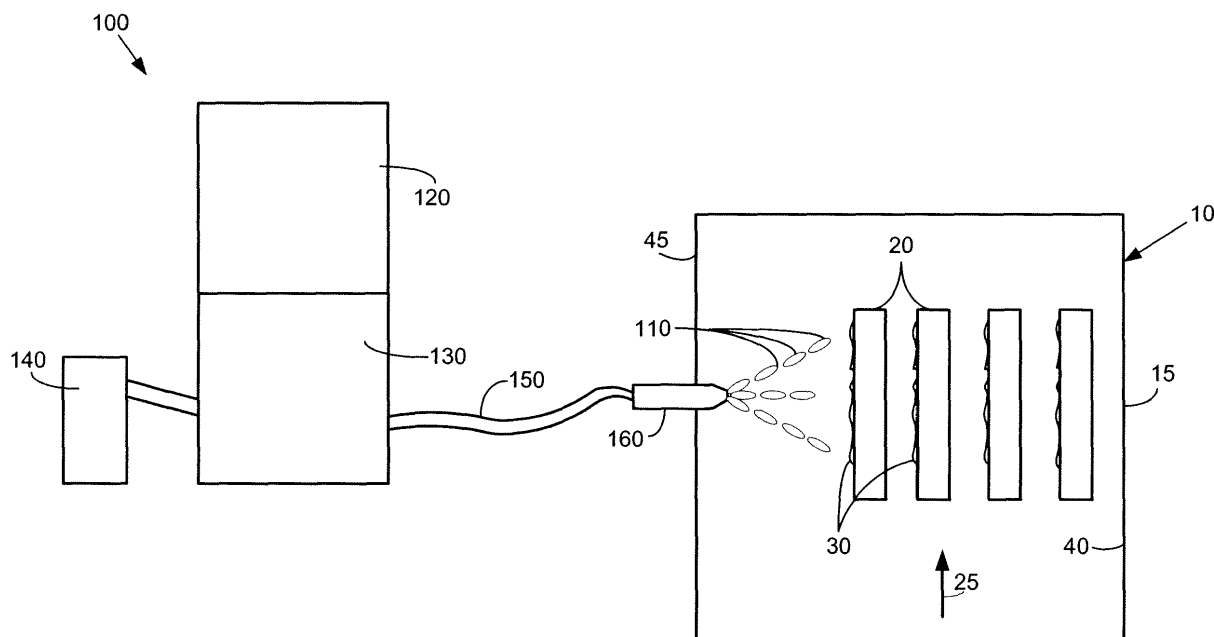
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(54) **Ice blast cleaning systems and methods**

(57) The present application provides an ice blast cleaning method for a layer of slag (30) on a surface (40). The ice blast cleaning method may include the steps of maintaining the surface (40) with the layer of slag (30) thereon at an elevated temperature, shooting a number

of ice pellets (110) at the layer of slag (30) on the surface (40), and loosening the layer of slag (30) on the surface (40) via a mechanical impact of the ice pellets (110) on the layer of slag (30) and a thermal shock caused by a temperature differential between the ice pellets (110) and the layer of slag (30).



Description

[0001] The present application relates generally to ice blast cleaning systems and methods and more particularly relates to high pressure ice blast cleaning systems and methods to clean slag and the like from industrial boiler tubes via mechanical impact and thermal stress.

[0002] Generally described, industrial boilers operate by using a heat source to create steam from water or another type of a working fluid. The steam may be used to drive a turbine or another type of load. The heat source may be a combustor that burns a fuel-air mixture therein. Heat may be transferred to the working fluid from the combustor via a heat exchanger. Burning the fuel-air mixture, however, may generate residue on the surface of the combustor, the heat exchanger, and the like. Such deposits of soot, ash, slag, dust, and/or other types of residues on the heat exchanger surfaces may inhibit the efficient transfer of heat to the working fluid. This reduction in efficiency may be reflected by an increase in exhaust gas temperatures from the backend of the process as well as an increase in the fuel burn rate required to maintain steady steam production and energy output.

[0003] Periodic removal of these deposits thus may help maintain the efficiency of such a boiler system. Typically, the complete removal of the deposits generally requires the boiler to be shutdown while the cleaning process is performed. Such cleaning processes thus may be relatively time consuming and costly at least in terms of boiler downtime.

[0004] Pressurized steam, water jets, acoustic waves, abrasive ash, mechanical hammering, detonative combustion devices, and other types of cleaning processes have been used to remove these internal deposits. The use of pressurized steam and/or water may blow the accumulated ash off of the tube banks but generally will not eliminate a hard layer of slag. Moreover, the abrasive particle methods may add more hard particles of materials into the boiler, which also may cause a blockage. Other types of cleaning processes may be known.

[0005] There is thus a desire for improved boiler cleaning system and methods that are able to operate quickly to remove internal slag deposits and the like so as to minimize overall downtime of the boiler and similar types of devices. Moreover, such cleaning systems and methods should not interfere with the overall operation and use of the boiler.

[0006] The present application thus provides an ice blast cleaning method for a layer of slag on a surface. The ice blast cleaning method may include the steps of maintaining the surface with the layer of slag thereon at an elevated temperature, shooting a number of ice pellets at the layer of slag on the surface, and loosening the layer of slag on the surface via a mechanical impact of the ice pellets on the layer of slag and a thermal shock caused by a temperature differential between the ice pellets and the layer of slag.

[0007] The present application further provides a heat

exchanger system. The heat exchanger system may include a heat exchanger positioned within a combustion stream such that the combustion stream creates a layer of slag on the heat exchanger. The heat exchanger system further includes an ice blast system positioned about the heat exchanger. The ice blast system shoots a stream of ice pellets at the layer of slag so as to loosen the layer of slag via a mechanical impact of the stream of ice pellets on the layer of slag and a thermal shock caused by a temperature differential between the stream of ice pellets and the layer of slag.

[0008] The present application further provides a boiler system. The boiler system may include a boiler with a number of boiler tubes therein. The boiler tubes may include a layer of slag thereon. The boiler system also may include an ice blast system positioned about the boiler. The ice blast system shoots a stream of ice pellets at the layer of slag so as to loosen the layer of slag via a mechanical impact of the stream of ice pellets on the layer of slag and a thermal shock caused by a temperature differential between the stream of ice pellets and the layer of slag.

[0009] Various features and improvements of the present application will become apparent to one of ordinary skill in the art upon review of the following detailed description when taken in conjunction with the drawings, in which:

Fig. 1 is a schematic view of an ice blast cleaning system as may be described herein for use with a boiler system or other type of heat exchanger system and the like.

[0010] Referring now to the drawing, in which like numbers refer to like elements throughout the view, Fig. 1 shows a heat exchanger system 10 such as a boiler 15 as may be known in the art. The boiler 15 may include a number of boiler tubes 20 or other types of heat exchanger surfaces positioned therein. Heat is transferred to a medium flowing within the boiler tubes 20 via a combustion stream 25 or other types of heat sources. As described above, the combustion stream 25 tends to build a layer of slag 30 onto the boiler tubes 20 or other types of internal surfaces 40 such as boiler chamber water walls 45. By the term "slag", we refer to slag, soot, ash, slug, dust, and/or any type of unwanted residue thereon. This layer of slag 30 may interfere with the efficiency of the overall boiler 15. Other types of heat exchangers 10 or boiler 15 configurations also may be used herein. Generally described, any surface 40 with a buildup of the layer of slag 30 or the like may be used herein.

[0011] Fig. 1 further shows an ice blast cleaning system 100 as may be described herein that may be used with the heat exchanger 10 or the boiler 15. Generally described, the ice blast cleaning system 100 may shoot a stream of ice pellets 110 at the layer of slag 30 of the boiler tubes 20 or other type of surface 40. The ice pellets 110 may be made out of any type of fluid such as water

and the like. The ice pellets 110 also may be dry ice pellets. The ice pellets 110 may have any desired size, shape, temperature, velocity, and/or other characteristics and combinations thereof. Any number of the ice pellets 110 may be used herein.

[0012] The ice blast cleaning system 100 may include an ice hopper 120 for making and/or storing the ice pellets 110. In turn, the ice hopper 120 may be in communication with a mixer 130 or other type of staging device. The mixer 130 also may be in communication with a compressed air source 140. Any type of compressed air source 140 or other type of pressurized medium may be used herein. Likewise, any type of drive force may be used as a drive mechanism herein. The mixer 130 may forward a stream of the ice pellets 110 with the aid of the compressed air source 140 or other type of drive mechanism.

[0013] The ice blast cleaning system also may use a tube 150 with a lance or a nozzle 160. The tube 150 and the nozzle 160 may deliver the ice pellets 110 to the surface 40 of the desired target. The tube 150 may be of conventional design and may be flexible or stiff. The tube 150 and the nozzle 160 may be retractable and may be positioned in any desired location. The nozzle 160 may have one or multiple apertures thereon. Other types of delivery systems may be used herein.

[0014] The ice blast cleaning system 100 as a whole may have any desired size, shape, or configuration. Specifically, any device for shooting ice pellets 110 at a sufficient rate, velocity, and/or other characteristics with respect to the boiler tubes 20 or other surface 40 may be used herein.

[0015] In use, the ice blast cleaning system 100 may be used while the boiler 15 is still in operation or at least still heated. The nozzle 160 or other type of delivery device of the ice blast cleaning system 100 may be positioned about the boiler tubes 20 or other surface 40 and blast the ice pellets 110 under pressure towards the layer of slag 30. The combination of the impact of the ice pellets 110 and the thermal shock of the high temperature layer of the slag 30 combines to loosen and remove the layer of slag 30 thereon. Specifically, the mechanical impact of the ice pellets 110 on the layer of slag 30 combines with the thermal shock caused by the temperature differential between the cold ice pellets 110 and the hot layer of slag 30.

[0016] Modifications may be made as to the size of the ice pellets 110, the initial temperature of the ice pellets 110, and other variables. Moreover, the initial velocity of the ice pellets 110 also may vary. Calculations based upon the size, temperature, and velocity of the ice pellets 110 may ensure the desired mechanical and thermal impact of the ice pellets 110 on the layer of slag 30 or otherwise. As described above, dry ice also may be used herein and has the advantage of a colder initial temperature. Other types of frozen mediums also may be used herein. Likewise, combinations of different types of ice pellets 110 also may be used herein.

[0017] The ice blast cleaning system 100 thus provides the advantage of the steam, water, or abrasive cleaning systems and methods described above but without the associated detriments of each, i.e., thicker layers of slag 30 may be removed as compared to steam or water system but without the potential for blockage that may be caused by the use of abrasive particles. The combination of the high pressure impact of the ice pellets 110 along with the associated thermal shock to the high temperature layer of the slag 30 thus provide the improved cleaning methods and benefits herein without the downtime normally associated with such cleaning methods.

[0018] It should be apparent that the foregoing relates only to certain embodiments of the present application and that numerous changes and modifications may be made herein by one of ordinary skill in the art without departing from the general spirit and scope of the invention as defined by the following claims and the equivalents thereof.

[0019] Various aspects and embodiments of the present invention are defined by the following numbered clauses:

1. An ice blast cleaning method for a layer of slag on a surface, comprising:

maintaining the surface with the layer of slag thereon at an elevated temperature;

shooting a plurality of ice pellets at the layer of slag on the surface; and

loosening the layer of slag on the surface via a mechanical impact of the plurality of ice pellets on the layer of slag and a thermal shock caused by a temperature differential between the plurality of ice pellets and the layer of slag.

2. The method of clause 1, wherein the surface comprises a boiler tube and wherein the step of maintaining the surface at an elevated temperature comprises a combustion stream within a boiler.

3. The method of any preceding clause, wherein the step of shooting a plurality of ice pellets comprises shooting a plurality of water ice pellets.

4. The method of any preceding clause, wherein the step of shooting a plurality of ice pellets comprises shooting a plurality of dry ice pellets.

5. The method of any preceding clause, further comprising the step of removing the layer of slag from the surface.

6. A heat exchanger system, comprising:

a heat exchanger positioned within a combus-

tion stream;

wherein the combustion stream creates a layer of slag on the heat exchanger; and

an ice blast system positioned about the heat exchanger;

wherein the ice blast system shoots a stream of ice pellets at the layer of slag so as to loosen the layer of slag via a mechanical impact of the stream of ice pellets on the layer of slag and a thermal shock caused by a temperature differential between the stream of ice pellets and the layer of slag.

7. The heat exchanger system of any preceding clause, wherein the heat exchanger comprises a plurality of boiler tubes.

8. The heat exchanger system of any preceding clause, wherein the ice blast system comprises a hopper and a mixer.

9. The heat exchanger system of any preceding clause, wherein the ice blast system comprises a tube and a nozzle.

10. The heat exchanger system of any preceding clause, wherein the stream of ice pellets comprises a plurality of water ice pellets.

11. The heat exchanger system of any preceding clause, wherein the stream of ice pellets comprises a plurality of dry ice pellets.

12. The heat exchanger system of any preceding clause, wherein the ice blast system comprises a compressed air source.

13. The heat exchanger system of any preceding clause, wherein the heat exchanger comprises an elevated temperature.

14. A boiler system, comprising:

a boiler with a plurality of boiler tubes therein;

wherein the plurality of boiler tubes comprises a layer of slag thereon; and

an ice blast system positioned about the boiler;

wherein the ice blast system shoots a stream of ice pellets at the layer of slag so as to loosen the layer of slag via a mechanical impact of the stream of ice pellets on the layer of slag and a thermal shock caused by a temperature differ-

ential between the stream of ice pellets and the layer of slag.

15. The boiler system of any preceding clause, wherein the ice blast system comprises a hopper and a mixer.

16. The boiler system of any preceding clause, wherein the ice blast system comprises a tube and a nozzle.

17. The boiler system of any preceding clause, wherein the stream of ice pellets comprises a plurality of water ice pellets.

18. The boiler system of any preceding clause, wherein the stream of ice pellets comprises a plurality of dry ice pellets.

19. The boiler system of any preceding clause, wherein the ice blast system comprises a compressed air source.

20. The boiler system of any preceding clause, wherein the boiler comprises an elevated temperature.

Claims

1. An ice blast cleaning method for a layer of slag (30) on a surface (40), comprising:

maintaining the surface (40) with the layer of slag (30) thereon at an elevated temperature; shooting a plurality of ice pellets (110) at the layer of slag (30) on the surface (40); and loosening the layer of slag (30) on the surface (40) via a mechanical impact of the plurality of ice pellets (110) on the layer of slag (30) and a thermal shock caused by a temperature differential between the plurality of ice pellets (110) and the layer of slag (30).

2. The method of claim 1, wherein the surface (40) comprises a boiler tube (20) and wherein the step of maintaining the surface (40) at an elevated temperature comprises a combustion stream (25) within a boiler (10).

3. The method of any preceding claim, wherein the step of shooting a plurality of ice pellets (110) comprises shooting a plurality of water ice pellets (110).

4. The method of any preceding claim, wherein the step of shooting a plurality of ice pellets (110) comprises shooting a plurality of dry ice pellets (110).

5. The method of any preceding claim, further comprising the step of removing the layer of slag (30) from the surface (40).

6. A heat exchanger system (10), comprising: 5
 - a heat exchanger (15) positioned within a combustion stream (25);
 - wherein the combustion stream (25) creates a layer of slag (30) on the heat exchanger (15); 10
 - and
 - an ice blast system (100) positioned about the heat exchanger (15);
 - wherein the ice blast system (100) shoots a stream of ice pellets (110) at the layer of slag (30) so as to loosen the layer of slag (30) via a mechanical impact of the stream of ice pellets (110) on the layer of slag (30) and a thermal shock caused by a temperature differential between the stream of ice pellets (110) and the layer of slag (30). 15
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7. The heat exchanger system (10) of claim 6, wherein the heat exchanger (15) comprises a plurality of boiler tubes (20) 25

8. The heat exchanger system (10) of claim 6 or claim 7, wherein the ice blast system (100) comprises a hopper (120) and a mixer (130). 30

9. The heat exchanger system (10) of any of claims 6 to 8, wherein the ice blast system (100) comprises a tube (150) and a nozzle (160).

10. The heat exchanger system (10) of any of claims 6 to 9, wherein the stream of ice pellets (110) comprises a plurality of water ice pellets (110). 35

11. The heat exchanger system (10) of any of claims 6 to 10, wherein the stream of ice pellets (110) comprises a plurality of dry ice pellets (110). 40

12. The heat exchanger system (10) of any of claims 6 to 11, wherein the ice blast system (100) comprises a compressed air source (140). 45

13. The heat exchanger system (10) of claims 6 to 12, wherein the heat exchanger (15) comprises an elevated temperature. 50

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