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Goldbach

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[54] **FLUID BED COMBUSTOR FOR OPERATION AT ASH FUSING TEMPERATURES**

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[73] Assignee: **Government of the United States Environmental Protection Agency**, Washington, D.C.

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[52] **U.S. Cl.** ..... **110/8 F**; 110/28 J

[51] **Int. Cl.**[2] **F23G 5/00**

[58] **Field of Search** ..... 110/8 R, 8 F, 28 J; 122/4 D; 34/57 R, 57 A

[56] **References Cited**

UNITED STATES PATENTS

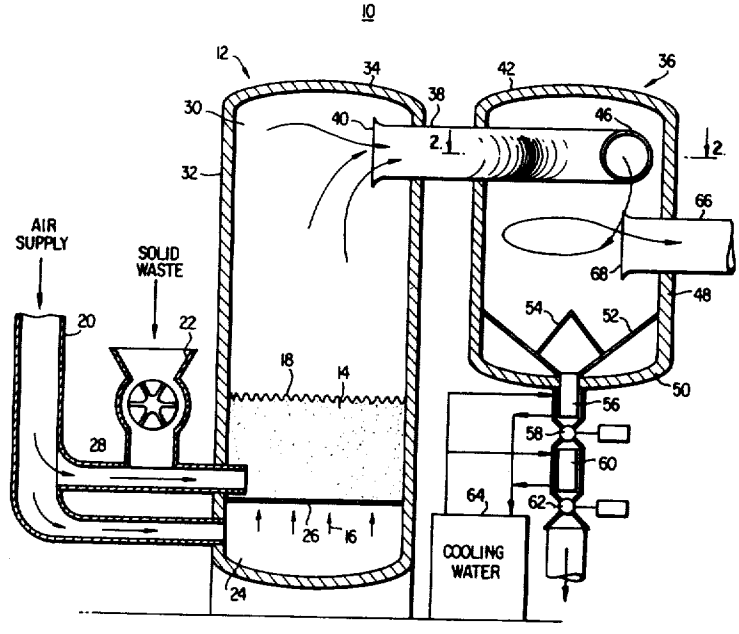
2,958,298	11/1960	Mayers	110/28
3,366,080	1/1968	Albertson	110/8
3,589,313	6/1971	Smith et al.	110/8
3,779,181	12/1973	Staffin et al.	110/8
3,818,846	6/1974	Reese	110/8

Primary Examiner—Kenneth W. Sprague

[57] **ABSTRACT**

A fluidized bed combustor is disclosed which includes means for preventing the agglomeration of sticky ashes, salts and molten metals entrained in exhaust gases on the interior surfaces of the combustion chamber and exhaust system used for venting the exhaust products from the combustion chamber. A fluidized bed is disposed within the combustion chamber which has intake and exhaust sides. A pressurized air supply is coupled to the intake side of the fluidized bed to force oxygen into the fluidized bed. A pressurized source of shredded solid waste material is also coupled to the intake side of the fluidized bed to promote waste burning. An exhaust system having an outwardly flared opening located remote from the dome and the side wall of the combustion chamber couples the exhaust gases and entrained sticky ashes, salts and molten metals to a second chamber which contains a low velocity centrifugal separator. The bottom of the second chamber contains an apparatus for collecting the sticky ashes, salts and molten metals. A valve mechanism also located in the bottom of the second chamber periodically empties the collected materials therefrom. A cooling water jacket is provided around the collecting apparatus to quench the collected materials.

6 Claims, 2 Drawing Figures



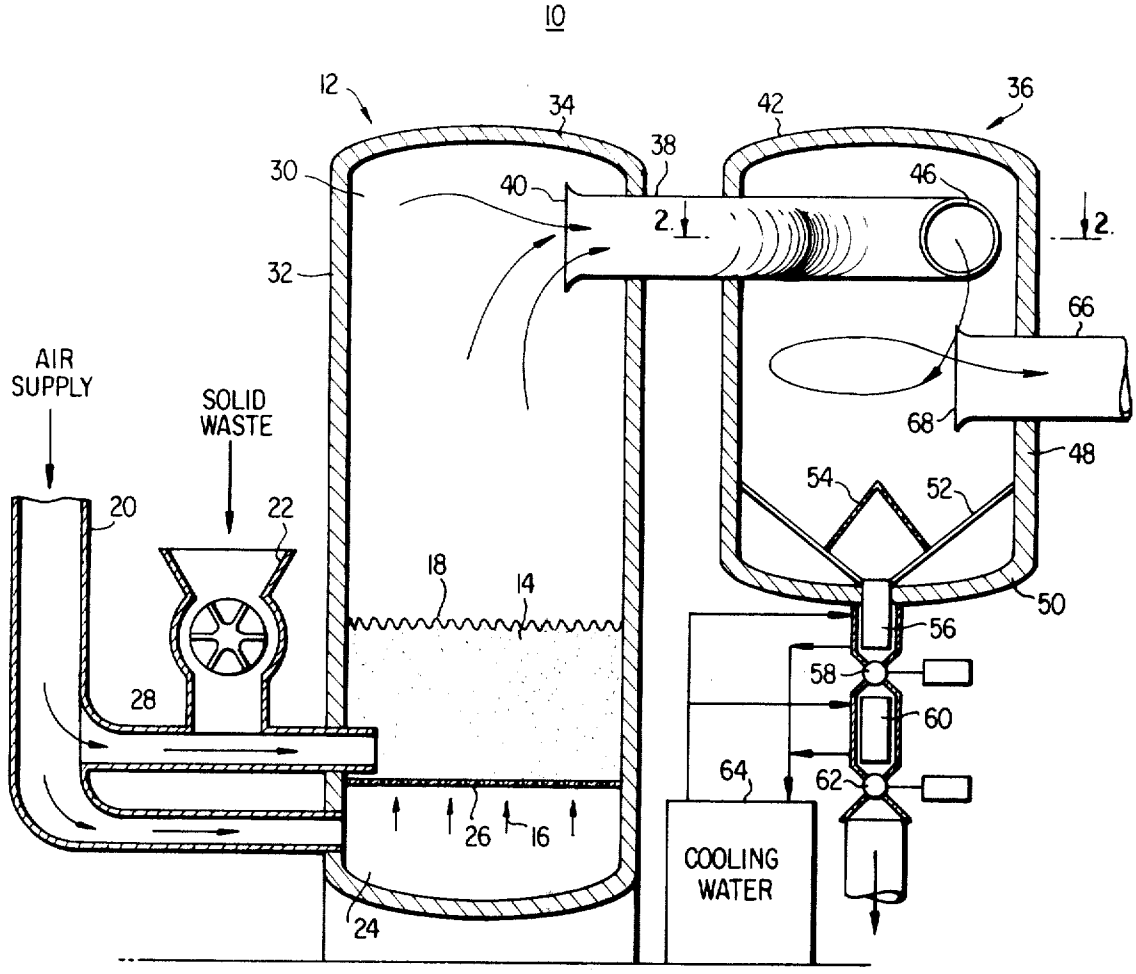

10
12
34
38
42
36
30
40
46
2
2
32
66
AIR SUPPLY
SOLID WASTE
68
48
54
52
20
22
18
14
50
56
58
60
28
64
62
26
16
COOLING WATER
24

FIG.1

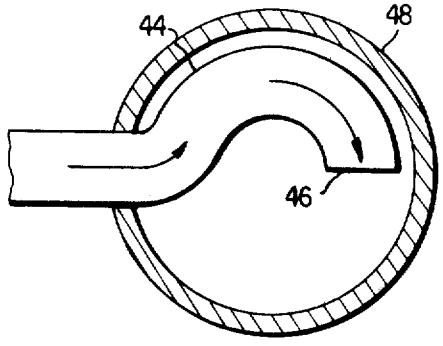

44
48
46

FIG.2

FLUID BED COMBUSTOR FOR OPERATION AT ASH FUSING TEMPERATURES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to fluid bed combustors which burn solid wastes. More particularly, the invention relates to fluid bed combustors of the type which burn shredded solid wastes that produce sticky ashes, salts and molten metals having a temperature at or above the ash fusing temperature and which contain apparatus for preventing the agglomeration of these materials on the surfaces of the combustion chamber and the exhaust system of the combustor.

2. Description of the Prior Art

Apparatus for burning solid wastes have been well known for many years. The high combustion temperatures of the prior art apparatus produced sticky ashes, salts and molten metals having a temperature at or above the ash fusing temperature. When waste burning systems were continually operated at or above the ash fusing temperature, the resultant sticky ashes, salts and molten metals contained within the exhaust gases formed slag within the combustion chamber and large clinkers which blocked the pipes of the exhaust system or which fell back into the combustion chamber. Removal of these materials involved a large amount of down time and prevented the efficient useage of the combustion apparatus to its full capacity.

Attempts have been made in the prior art apparatus to prevent the formation of sticky solid wastes on the blades of turbines by lowering the intake gas temperature below the ash fusion temperature. An exemplary apparatus is disclosed in U.S. Pat. No. **3,309,866,** issued to Kydd. That apparatus uses flameless combustion to prevent the temperature of the intake gas from rising to the ash fusing temperature.

Other attempts to solve the problem of accretion of sticky solids on turbine blades have involved the use of filters. The surface of the filter is disposed within the intake gas stream of the turbine to effect separation of sticky ashes. The filter is then plunged into water to rapidly cool the surfaces which have solids formed thereon to the point where the accretion flakes off and settles into the water. The cleaned filter is then removed from the water and is again disposed within the exhaust gas stream. U.S. Pat. No. **3,550,372,** issued to Craig is exemplary of this type of system.

U.S. Pat. No. **2,616,256,** issued to Davy, et al. discloses apparatus for removing solids from the intake gases of turbines by using centrifugal force. Solid fuel is introduced into a primary combustion chamber and is therein burned at temperatures above the ash fusing temperature. The shape of the primary combustion chamber imparts a high circumferential velocity to the combustion products contained therein. The resultant centrifugal force exerted upon the sticky ashes contained within the primary combustion chamber causes their impingement and accretion upon the side walls of the primary combustion chamber. The resultant ash film flows downwardly by gravity where it is trapped by a truncated conical wall. Gases containing the remaining sticky ash particles flow through a centrally disposed exhaust port which is located in the bottom of the primary combustion chamber into a second combustion chamber. Therein they are cooled by air tempering and moved toward the bottom of the chamber where solidified ash particles are collected. Periodically the solid ash particles are removed from the second combustion chamber by the opining of a valve mechanism.

Each of the prior art solutions for preventing the accretion of sticky ashes on the interior surfaces of combustion chambers differs substantially from the present invention. Unlike the present invention, none of the prior art exemplified by the aforementioned patents prevents the accretion of solids on interior combustion and exhaust surfaces by limiting the velocity of the exhaust gases and entrained solids below a velocity which causes them to stick to the interior surfaces of the combustion chamber and the exhaust system from impact.

SUMMARY OF THE INVENTION

The disadvantages and limitations of the prior art are obviated by the present invention which provides an apparatus for burning shredded solid wastes that prevents the accretion of sticky ashes, salts and molten metals on the interior surfaces of the combustion chamber and the associated exhaust system. Accretion of solids on the interior surfaces of the combustion chamber and the exhaust system is prevented by maintaining the velocity of the exhaust gases and entrained solids below a velocity which imparts sufficient inertia to them to cause their adhesion because of impact on these surfaces.

In this specification, the terminology "ash fusion temperature" defines the temperature at which solids resulting from combustion become adherent to surfaces.

An apparatus constructed according to the present invention includes a combustion chamber which contains a fluidized bed having intake and exhaust sides. A source of pressurized air and a source of pressurized shredded solid waste is coupled to the intake side of the fluidized bed. The exhaust side of the fluidized bed opens up into the freeboard section of the combustion chamber. The freeboard section is enclosed by the exhaust side of the fluidized bed, the side walls, and the dome of the combustion chamber. An exhaust system is mounted in the side wall of the combustion chamber. The exhaust system includes an exhaust pipe disposed within the combustion chamber which has an opening that is outwardly flared and located remote from the dome and the side wall to prevent the direct impingement of entrained solids contained within the exhaust gas thereon. The outwardly flared shape of the opening prevents the entrained solids contained within the exhaust gases which traverse the freeboard section of the combustion chamber from impringing at an angle of incidence on the interior surface of the opening which is near the perpendicular. As a result, the solids tangentially strike the interior surface of the opening.

A second chamber is provided which has part of the exhaust system disposed therein. The part of the exhaust system contained within the chamber forms a low velocity centrifugal separator which has a discharge port disposed within the second chamber. The low velocity centrifugal separator is formed from a semicircular section of pipe having a relatively large radius. In terms of the specification, the terminology "low velocity centrifugal separator" defines a centrifugal separator in which the velocity of gases and entrained solids passing therethrough is below a velocity which causes

their adherence to its interior surfaces because of centrifugal force. The discharge port of the exhaust system opens toward the bottom of the chamber. Disposed within the bottom of the chamber is a removal conduit having an intake port located within the chamber and an exhaust port coupled to a ball valve mechanism. Coupled to the ball valve mechanism is an intermediate air lock having an intake port which is coupled to the removal conduit and an exhaust port which is coupled to a second ball valve mechanism. The first and second ball valve mechanisms are periodically opened to remove solids which have collected in the bottom of the chamber that have been cooled below the ash fusing temperature. Cooling of collected solids is accomplished by a water jacket which is mechanically coupled to the removal conduit and to the intermediate air lock. Exhaust gases are removed from the chamber by an exhaust system which includes an opening disposed within the second chamber that is outwardly flared and located remote from the top, bottom and side walls. The discharge port of the exhaust network opens to the exterior of the second chamber. A collecting cone is disposed in the bottom of the second chamber for guiding solids which have been discharged from the discharge port of the exhaust system into the intake opening of the removal conduit. A large mesh conical screen is disposed in the bottom of the chamber to prevent large clinkers from entering the intake opening of the removal conduit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a section of the front view of the present invention; and

FIG. 2 is a partial section of the top view of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. 1 and 2, a fluid bed combustor for operation at ash fusing temperatures **10** constructed according to the present invention is described as follows. Combustion chamber **12** is provided with a fluidized bed **14** having an intake side **16** and an exhaust side **18.** A source of pressurized air **20** and a source of pressurized shredded solid waste **22** is coupled to the intake side **16** of fluidized bed **14.** Pressurized air coming from source **20** initially passes into plenum chamber **24** and then passes through a perforated distributor plate **26** disposed in the bottom of the fluidized bed **14.** The high pressure source of air **20** upon passing through the distributor plate **26** fluidizes the bed of sand contained within fluidized bed **14.** Part of the pressurized air supply from source **20** is bled off through pipe **28** to entrain shredded solid waste injected by source **22** into pipe **28.** The shredded solid waste and air pass into the fluidized bed where they are combusted at temperatures well above the ash fusing temperature. Contained within the solid wastes which are combusted in the fluidized bed **14** are non-ferrous metals that melt below **1,400°F.**, substances which produce sticky ashes, and salts that are sticky or molten at the combustion temperature which are maintained within the fluidized bed. The burning materials pass through the exhaust portion **18** of the fluidized bed **14** into the freeboard **30** of the combustion chamber **12.** The freeboard portion **30** of the combustion chamber **12** is enclosed by wall section **32,** dome **34** and exhaust side **18** of the fluidized bed **14.**

The exhaust system **36** of the combustion chamber **12** and chamber **42** of the present invention is described with reference to FIGS. **1** and **2.** Pipe **38** of the exhaust system **36** extends through the side wall **32** of the combustion chamber **12** to form an outwardly flared opening **40** which is located remote from the side wall **32** and dome **34** of the combustion chamber **12.** The remaining part of exhaust pipe **38** opens into chamber **42.** The position of exhaust pipe **38** contained within chamber **42** comprises a low velocity centrifugal separator **44.** The low velocity centrifugal separator **44** is constructed from a relatively large radius of curvature. The end of centrifugal separator **44** opens into chamber **42** through discharge port **46.** The portion of chamber **42** below discharge port **46** is comprised of side wall **48** and bottom section **50.** A conical collecting cone **52** is located in the bottom of chamber **42.** The base of conical large mesh screen **54** is joined to the surface of conical collecting cone **52.** Disposed in the bottom center of chamber **52** at the apex of collecting cone **52** is removal conduit **56.** The intake port of removal conduit **56** opens into the apical section of the collecting cone **52.** The exhaust port of removal conduit **56** opens into ball valve mechanism **58.** Ball valve mechanism **58** opens into the intake port of intermediate air lock **60.** The exhaust port of intermediate air lock **60** opens into ball valve mechanism **62.** A source of coolant **64** is coupled to the removal conduit **56** and to the intermediate air lock **60.** Disposed in the side wall **48** of chamber **42** is an exhaust system **66** having an outwardly flared opening **68** which opens into chamber **42** remote from the side wall **48.** The outwardly flared opening **68** of the second chamber **42** is designed to perform the same function as outwardly flared opening **40** of the combustion chamber **12.** The exhaust system **66** has a discharge port opening to the exterior of chamber **42.**

OPERATION

The operation of the present invention is as follows: A combustible mixture of air and shredded solid waste is introduced into fluidized bed **14,** where, in the course of normal combustion, sticky ashes, sticky salts and molten metals and exhaust gases are produced. The combustion products pass into the freeboard section **30** and through the outwardly flared opening **40** of exhaust system **38.** The inner contour of opening **40** prevents perpendicular or near perpendicular impingement of the solids onto the interior surface of opening **40.** The tangential or near tangential impingement of solids on the interior surface of opening **40** prevents their accretion thereon. The entrained solids and exhaust gases pass through low velocity centrifugal separator **44.** The velocity of the entrained sticky ashes within the centrifugal separator **44** is maintained below the velocity which produces a centrifugal force that causes accretion of the sticky solids on the interior surface of the centrifugal separator. The entrained solids pass through discharge port **46** and collect in removal conduit **56.** Conical large mesh screen **54** prevents large clinkers from entering the removal conduit **56.** Removal conduit **56** is cooled to quench the solids collected therein. Periodically, ball valve **58** opens to allow the ashes contained in removal conduit **56** to pass into intermediate airlock **60** and then closes. Intermediate airlock is cooled to further quench the collected solids. Ball valve **62** then opens to permit removal of

the cooled solids. The exhaust gases pass from chamber **42** through opening **68** of exhaust system **66.**

It has been discovered that the elutriation of sand from the fluidized bed **14** scours the surfaces of the freeboard **30,** exhaust system **36** and the second chamber **42** to help remove residual accretion.

While the preferred embodiment of the invention relates to fluidized bed combustors for burning shredded waste, it should be apparent to those persons skilled in the art to which the invention pertains that the teachings of the invention are applicable to all types of combustion systems wherein agglomeration of sticky ashes have been a problem.

What is claimed is:

1. In a fluidized bed combustor which burns waste materials of the type that produce sticky ashes, salts and molten metals which form slag that adheres to the interior surfaces of the combustor, the combination comprising:

a. a fluidized bed disposed within a combustion chamber having intake and exhaust sides;

b. a pressurized air supply coupled to the intake side of said fluidized bed;

c. a pressurized source of waste material coupled to the intake side of said fluidized bed;

d. means coupled to said exhaust side of said fluidized bed for removing said sticky ashes, salts and molten metals and exhaust gases from said combustion chamber while they are at or above the temperature at which the sticky ashes, salts and molten metals begin to adhere to said interior surfaces of the combustor, said means comprising an exhaust system which maintains the velocity of said sticky ashes, salts and molten metals entrained within said exhaust gas below a velocity which produces their agglomeration on interior surfaces of said combustion chamber and said exhaust system.

2. In a combustor as recited in claim **1** wherein:

a. said combustion chamber on the exhaust side of said fluidized bed comprises a sidewall and a dome and;

b. said exhaust system comprises an exhaust pipe disposed partially within the combustion chamber on the exhaust side of the fluidized bed, said part of said exhaust pipe disposed within the combustion chamber having an opening which is outwardly flared, said opening being remote from said dome and said sidewall to prevent the high velocity impingement of said sticky ashes, salts and molten metals entrained in the exhaust gas at an angle of incidence near the perpendicular onto the surface of said flared opening.

3. In a combustor as recited in claim **2** wherein said exhaust system further comprises:

a. a second chamber having part of said exhaust pipe disposed therein, said part of said exhaust pipe disposed within said second chamber being curved in a radius to form a low velocity centrifugal separator, said low velocity centrifugal separator having a discharge port disposed within said second chamber.

4. In a combustor as recited in claim **3** wherein:

a. said chamber comprises a top, bottom and sidewall; and

b. a first ball valve mechanism disposed in the bottom of said second chamber which opens periodically to empty ash collected in the bottom of said second chamber.

5. In a combustor as recited in claim **4** wherein said exhaust system further comprises:

a. a removal conduit partially disposed in the bottom of said second chamber for removing accumulated solids therefrom, said removal conduit having an intake port disposed within said second chamber and an exhaust port coupled to said first ball valve mechanism;

b. an intermediate airlock having an intake port and an exhaust port, said intake port of said airlock being coupled to said first ball valve;

c. a second ball valve mechanism, said second ball valve mechanism being coupled to said exhaust port of said airlock;

d. a cooling means coupled to said removal conduit and to said intermediate airlock to cool solids contained therein; and

e. an exhaust pipe disposed within the sidewall of said chamber, said exhaust pipe having an outwardly flared opening located within said chamber remote from said top, bottom and sidewall and a discharge port located outside said chamber.

6. In a combustor as recited in claim **5** wherein said exhaust system further comprises;

a. a collecting cone disposed within the bottom of said chamber, said cone having an apical section coupled to said intake port of said removal conduit; and

b. a conical wire mesh screen disposed in the bottom of said chamber, said wire mesh screen having a base coupled to said collecting cone and an apical section extending upward into said chamber.

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