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(71) Applicant *(for all designated States except US)*: **COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH** [IN/IN]; Rafi Marg, NewDelhi 110 001 (IN).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **MUKHERJEE, Ashish** [IN/IN]; Central Fuel Research Institute, P.O.F.R.I., Dhanbad 828 108, Jharkhand (IN). **BISWAS, Subhasis** [IN/IN]; Central Fuel Research Institute, P.O.F.R.I., Dhanbad 828 108, Jharkhand (IN). **KUMAR, Manish** [IN/IN]; Central Fuel Research Institute, P.O.F.R.I., Dhanbad 828 108, Jharkhand (IN). **SAHU, Santi, Gopal** [IN/IN]; Central Fuel Research Institute, P.O.F.R.I., Dhanbad 828 108, Jharkhand (IN). **CHOUDHURY, Ashim** [IN/IN]; Central Fuel Research Institute, P.O.F.R.I., Dhanbad 828 108, Jharkhand (IN). **SEN, Kalyan** [IN/IN]; Central Fuel Research Institute, P.O.F.R.I., Dhanbad 828 108, Jharkhand (IN).

(74) Agents: **NATARAJ, Guruswamy** et al.; Subramaniam, Nataraj & Associates, E-556 Greater Kailash II, New Delhi 110 048 (IN).

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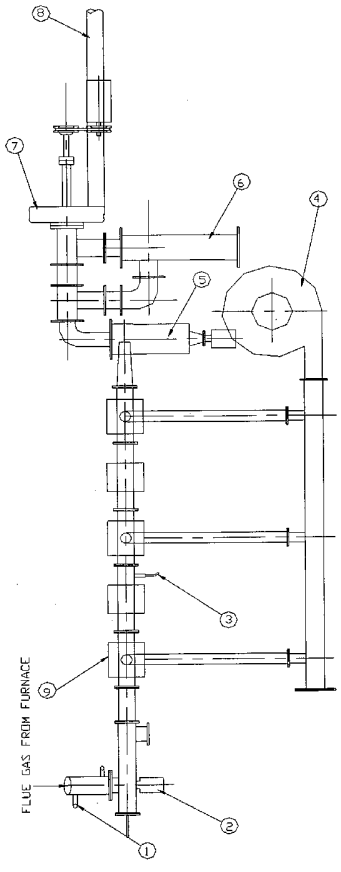
(54) Title: COOLING SYSTEM



(57) Abstract: The present invention relates to a cooling system for cooling flue gas coming out of a pulverised coal fired fornace and finds its usage in studying combustion behaviour and constituents of flue gas resulting from combustion of pulverised fuel and reducing its temperature while coming out of a fornace.

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COOLING SYSTEM

Field of the invention

The present invention relates to a cooling system. This invention particularly relates to a system for cooling flue gas coming out of a pulverised coal fired furnace. The invention finds its usage in studying combustion behaviour and constituents of flue gas resulting from combustion of pulverised fuel and reducing its temperature while coming out of a furnace.

Background of the invention

Experimental furnaces are generally used to simulate combustion and deposition conditions in pulverised fuel boilers. The essential characteristics of such reactors are heating rate, high temperature, dynamic particle phase and atmosphere simulating conditions; for example, essential components of a vertical drop tube furnace system include a fuel feeder, a reactor and equipment for sampling and analysis. The drop tube furnace is a valuable tool when attempting to simulate coal combustion on a small scale. In this furnace pulverised coal is carried down through a water-cooled feeder into a heated ceramic tube containing preheated air. After passing through the tube the particles are collected in water-cooled probe in different zones where the reactions are effectively quenched. The flue gas generated from the combustion of coal is passed through the cooling system having water and air jackets for cooling. The flue gas is sucked from the furnace using ID fan to dispose it off to atmosphere. The cooling system reduces the temperature of the flue gas from about 1000 degree Celsius to approximately 50 degree Celsius. The flow of these gases is kept sufficiently low to ensure that laminar flow conditions are met. Turbulent flow would cause the reduction of collection efficiently and the lowering of the sample integrity. The degree of decomposition experienced by the particles depends on conditions within the furnace. The residence time inside the furnace, oxygen content and the temperature can be altered as per the requirements.

Prior art search for a system for cooling flue gas coming out of a pulverised coal fired furnace was done based on literature survey and patent databases and did not yield any relevant references.

Objects of the invention

The main object of the invention is to provide a cooling system for the flue gas of furnaces like Drop Tube Furnace, which obviates the above mentioned drawbacks.

Another object of the invention is to provide a cooling system for flue gas of a furnace wherein temperature of flue gas is reduced to a temperature where an online gas analyser can be attached before ID fan.

Brief description of the accompany drawing

Figure 1 is a schematic diagram of the cooling system of the invention.

Summary of the invention

Accordingly the present invention provides a cooling system for a furnace flue gas, the system comprising a tubular means with a furnace connecting end and an outlet end, and provided connected to the furnace, a water jacket (1) being connected at the furnace end and concentric with the tubular means to cool bottom ash falling in a bottom ash collector (2) connected to the tubular means, an air supply means (4) to supply air to one or more air jackets (9) positioned concentrically with the tubular means downstream of the water jacket, a gas analyser line (3) for oxygen and CO being provided downstream of the ash collector and connected to the tubular means, an induced draft fan (7) connected to the outlet end of the tubular means and operatively associated with a bag filter (6) and a cyclone (5) to remove flue gas and pass it through a chimney (8) connected to the outlet end of the tubular means into the atmosphere, fly ash being collected in the filter bag and cyclone.

In one embodiment of the invention the cooling system is used in conjunction with a Drop Tube Furnace for cooling of flue gas.

In yet another embodiment of the invention, the air supply means is a blower.

The present invention also provides a method for cooling of flue gas from a furnace using a cooling system comprising a tubular means with a furnace connecting end and an outlet end, and provided connected to the furnace, a water jacket (1) being connected at the furnace end and concentric with the tubular means to cool bottom ash falling in a bottom ash collector (2) connected to the tubular means, an air supply means (4) to supply air to one or more air jackets (9) positioned concentrically with the tubular means downstream of the water jacket, a gas analyser line (3) for oxygen and CO being provided downstream of the ash collector and connected to the tubular means, an induced draft fan (7) connected to the outlet end of the tubular means and operatively associated with a bag filter (6) and a cyclone (5) to remove flue gas and pass it through a chimney (8) connected to the outlet end of the tubular means, the method comprising passing high temperature flue gas from a furnace through the tubular means surrounded by a water jacket (1) to cool down the flue gas and the ash contained therein and to cool the temperature of the bottom ash, passing the flue gas through the tubular means to dissipate heat therefrom into air being input into the tubular system from one or more air jackets (9) provided with an air supply means (4), the flue gas being monitored for O_2, CO gas content through a gas analyser (3) connected downstream of the ash collector (2), fly ash being carried by the flue gas being collected in a cyclone (5) and

bag filter (6) provided downstream of the air jacket(s), the cooled flue gas being then sucked by an induced draft fan (7) connected at the outlet end of the tubular means and passed through to a chimney (8) to dissipate into the atmosphere.

In one embodiment of the invention the flue gas temperature is reduced from about 1000^0C to 50^0C.

In another embodiment of the invention the cooling system is used in conjunction with a Drop Tube Furnace for cooling of flue gas.

Detailed description of the invention

The present invention will now be described in detail with reference to the accompanying drawing. In Figure 1 the components are referenced by:

1. Water Jacket
2. Bottom Ash Collector
3. Line for O_2, CO analyser
4. Air Blower for Cooling
5. Cyclone
6. Bag Filter
7. ID Fan
8. Chimney
9. Air Jacket

The cooling system of the invention essentially comprises a tube provided connected to the flue gas line of a furnace. The tube is provided at this furnace connecting end with a water jacket (1) concentric with the tube so that the bottom ash which is falling in the bottom ash collector (2) is cooled. An air blower (4) is connected downstream of the ash collector (2) to supply air to one or more air jacket (9) which are provided concentric with the tube through which the flue gas is passing. In the flue gas line, a gas analyser line for O_2, CO gas is provided to monitor the content of the flue gas. An induced draft fan (7) is positioned for the cooling system after bag filter (6) and cyclone (5) to suck the flue gas and successively the flue gas passes through the chimney (8) and goes to the open atmosphere and fly ash which is flowing with the flue gas gets collected in the cyclone and bag filter.

By the system of the invention, the flue gas temperature can be reduced from about 1000^0C to 50^0C. The cooling system is useful for furnaces, like Drop Tube Furnace, for cooling of flue gas.

The high temperature flue gas from the furnace passes through the tube surrounded with the water jacket (1) it cools down the flue gas and the ash containing with it so that the

temperature of he bottom ash also drops. While passing through the cooling system the flue gas release its heat to the air passing through air jacket (9). The air jacket is getting air by the air blower (4). The cooling system is provided with a line for O_2, CO gas analyser (3). While passing through the cooling system the ash being carried by the flue gas get collected in the cyclone (5) and bag filter (6) as fly ash. The flue gas in the cooling system is being sucked by the ID fan (7). ID fan throws the flue gas to the chimney (8) through which the flue gas disposes to the atmosphere.

The novelty of the invention lies providing a cooling system for the flue gas of the furnaces, like Drop Tube Furnace in which the temperature of the flue gas is reduced to a temperature at which online gas analyser can be attached before ID fan and the inventive step lies in the non-obvious steps of the process.

The following examples are given by way of illustration of the present invention and should not be construed to limit the scope of the present invention.

Example 1

High temperature flue gas from a Drop Tube furnace is passed through a tube surrounded with a water jacket to cool down the flue gas and the ash contained therein resulting in the temperature of the bottom ash also dropping. While passing through the cooling system the flue gas releases its heat to air passing through an air jacket. The air jacket is provided with air by an air blower connected thereto. The oxygen and CO content of the flue gas is monitored by a line for O_2, CO gas analyser provided downstream of the ash collector and air jacket. While passing through the cooling system the ash being carried by the flue gas is collected in the cyclone and bag filter as fly ash. The flue gas in the cooling system is sucked by the ID fan, which then throws the flue gas to the chimney (8) through which the flue gas disposes to the atmosphere. The following were the parameters of this example:

Rate of flue gas 138 lpm

Cooling system input temperature 1120^0C

Cooling system output temperature 60^0C

Example 2

High temperature flue gas from a Drop Tube furnace is passed through a tube surrounded with a water jacket to cool down the flue gas and the ash contained therein resulting in the temperature of the bottom ash also dropping. While passing through the cooling system the flue gas releases its heat to air passing through an air jacket. The air jacket is provided with air by an air blower connected thereto. The oxygen and CO content of the

flue gas is monitored by a line for O_2, CO gas analyser provided downstream of the ash collector and air jacket. While passing through the cooling system the ash being carried by the flue gas is collected in the cyclone and bag filter as fly ash. The flue gas in the cooling system is sucked by the ID fan, which then throws the flue gas to the chimney (8) through which the flue gas disposes to the atmosphere. The following were the parameters of this example:

Rate of flue gas 184 lpm

Cooling system input temperature 1190^0C

Cooling system output temperature 75^0C

The main advantages of the present invention are

1. The system involves high temperature reduction.
2. It consists of facility for collection of both bottom ash and fly ash.
3. It contains less wear and tear of system components due to laminar flow of flue gas.
4. Maintenance is very easy and cost effective.

We claim:

1. A cooling system for a furnace flue gas, the system comprising a tubular means with a furnace connecting end and an outlet end, and provided connected to the furnace, a water jacket (1) being connected at the furnace end and concentric with the tubular means to cool bottom ash falling in a bottom ash collector (2) connected to the tubular means, an air supply means (4) to supply air to one or more air jackets (9) positioned concentrically with the tubular means downstream of the water jacket, a gas analyser line (3) for oxygen and CO being provided downstream of the ash collector and connected to the tubular means, an induced draft fan (7) connected to the outlet end of the tubular means and operatively associated with a bag filter (6) and a cyclone (5) to remove flue gas and pass it through a chimney (8) connected to the outlet end of the tubular means into the atmosphere, fly ash being collected in the filter bag and cyclone.
2. A system as claimed in claim 1 wherein the cooling system is used in conjunction with a Drop Tube Furnace for cooling of flue gas.
3. A system as claimed in claim 1 wherein the air supply means is a blower.
4. A method for cooling of flue gas from a furnace using a cooling system comprising a tubular means with a furnace connecting end and an outlet end, and provided connected to the furnace, a water jacket (1) being connected at the furnace end and concentric with the tubular means to cool bottom ash falling in a bottom ash collector (2) connected to the tubular means, an air supply means (4) to supply air to one or more air jackets (9) positioned concentrically with the tubular means downstream of the water jacket, a gas analyser line (3) for oxygen and CO being provided downstream of the ash collector and connected to the tubular means, an induced draft fan (7) connected to the outlet end of the tubular means and operatively associated with a bag filter (6) and a cyclone (5) to remove flue gas and pass it through a chimney (8) connected to the outlet end of the tubular means, the method comprising passing high temperature flue gas from a furnace through the tubular means surrounded by a water jacket (1) to cool down the flue gas and the ash contained therein and to cool the temperature of the bottom ash, passing the flue gas through the tubular means to dissipate heat therefrom into air being input into the tubular system from one or more air jackets (9) provided with an air supply means (4), the flue gas being monitored for O_2, CO gas content through a gas analyser (3) connected downstream of the ash collector (2), fly ash being carried by the flue gas being collected in a cyclone (5) and bag filter (6) provided downstream of the air jacket(s), the cooled

flue gas being then sucked by an induced draft fan (7) connected at the outlet end of the tubular means and passed through to a chimney (8) to dissipate into the atmosphere.

5. A method as claimed in claim 4 wherein the flue gas temperature is reduced from about 1000^0C to 50^0C.
6. A method as claimed in claim 4 wherein the cooling system is used in conjunction with a Drop Tube Furnace for cooling of flue gas.
7. A method as claimed in claim 4 wherein the system reduces the temperature of flue gas up to 20 times the temperature observed at the time of entering the system.

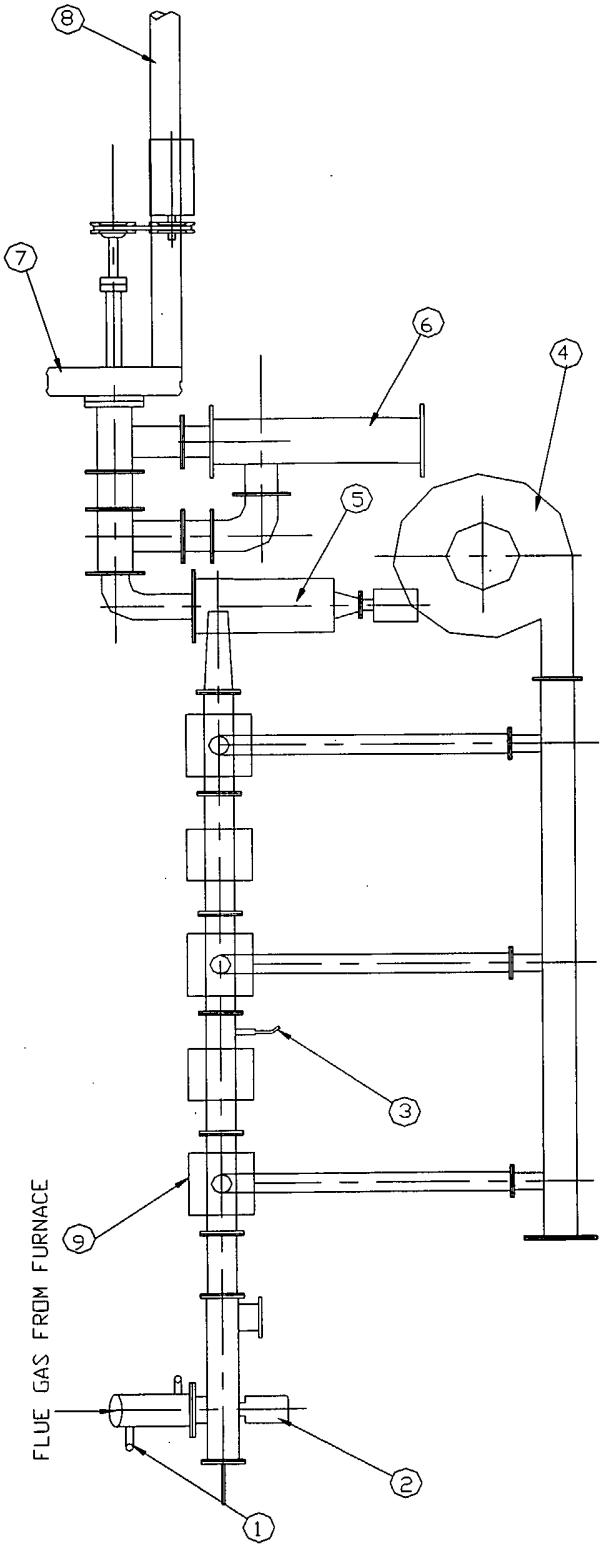

FIG. 1

CORRECTED VERSION

INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F23J15/06 F23N5/00 F23L17/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F23J F23N F23L F27B F27D B01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2003/223071 A1 (SCHULTZ PAUL CLARENCE) 4 December 2003 (2003-12-04) paragraphs [0020], [0033], [0036]; figure 1	1-7
Y	US 5 108 461 A (RUTHNER ET AL) 28 April 1992 (1992-04-28) column 3, line 36 - line 60; figure 1	1-7
Y	DE 199 18 927 A1 (STEINBRECHT, DIETER; GEIER, HELRATH; WOLFF, HANS-JOACHIM) 2 November 2000 (2000-11-02) column 3, line 60 - column 4, line 4; figure 1	1-7
A	US 5 086 715 A (BUERGIN ET AL) 11 February 1992 (1992-02-11) abstract; figure 1	5,7

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
31 August 2005	18. 10. 2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Mougey, M

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/IN2004/000425

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 421 820 A (ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIES CO., LTD) 10 April 1991 (1991-04-10) figure 1 column 5, line 15 - line 23 column 5, line 34 - line 44 -----	1,4
A	US 4 099 019 A (HORIBE ET AL) 4 July 1978 (1978-07-04) column 2, line 33 - line 63; figure 1 -----	1,4

CORRECTED VERSION

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IN2004/000425

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003223071 A1	04-12-2003	NONE	
US 5108461 A	28-04-1992	AT 382142 A	12-01-1987
		AT 399084 A	15-06-1986
		DE 3582132 D1	18-04-1991
		EP 0186042 A2	02-07-1986
		JP 1870826 C	06-09-1994
		JP 5075685 B	21-10-1993
		JP 61146338 A	04-07-1986
		YU 48987 A1	31-08-1988
		YU 195885 A1	31-12-1987
DE 19918927 A1	02-11-2000	NONE	
US 5086715 A	11-02-1992	DE 59004285 D1	03-03-1994
		DK 405375 T3	28-02-1994
		EP 0405375 A1	02-01-1991
		ES 2048899 T3	01-04-1994
		JP 2904873 B2	14-06-1999
		JP 3065211 A	20-03-1991
		NO 902898 A	02-01-1991
EP 0421820 A	10-04-1991	CA 2026927 A1	06-04-1991
		US 5020451 A	04-06-1991
US 4099019 A	04-07-1978	CA 1076180 A1	22-04-1980
		DE 2711918 A1	02-03-1978
		SE 7703722 A	25-02-1978