(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
2 July 2015 (02.07.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/097715 A2

(51) International Patent Classification:
G01N 25/14 (2006.01)

(21) International Application Number:
PCT/IN2014/000723

(22) International Filing Date:
18 November 2014 (18.11.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
3620/MUM/2013 19 November 2013 (19.11.2013) IN

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) Title: AN APPARATUS AND PROCESS TO ANALYZE AND CHARACTERIZE SPALLING DUE TO THERIRIO-MECHANICAL FAILURE OF COAL DURING UNDERGROUND COAL GASIFICATION

(57) Abstract: The present invention relates to an apparatus for analyzing and characterizing spalling behavior of coal during underground coal gasification. The apparatus comprises a furnace (1) having a lid (2) with an opening (3). A heat source (4) is located at the bottom surface of the furnace (1). A coal block holder (5) with a coal block (6) is suspended within the furnace (1). The coal block holder (5) has an open bottom (7) facing the heat source (4). The apparatus comprises a device (10), for monitoring weight of the coal block (6), placed outside the furnace (1) and comprising a suspension means (1 1) for suspending the coal block (6) with the coal block holder (5), wherein the suspension means (1 1) passes through the opening (3) of the furnace lid (2). The present invention further relates to a process for analyzing and characterizing spalling behavior of coal during underground coal gasification.

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TITLE OF THE INVENTION

An apparatus and process to analyze and characterize spalling thermo-mechanical failure of coal during underground coal gas

FIELD OF THE INVENTION

The present invention, in general, is directed to an apparatus and a proc analyzing and characterizing the physical and chemical processes occu underground coal seams during UCG process. More specifically, the pr invention relates to the spalling behavior of coal during underground c gasification.

BACKGROUND

Underground coal gasification (UCG), is an in-situ conversion proc which is present in deep underground seams, to combustible product the process of UCG, a cavity is formed inside the coal seam d consumption by chemical reactions. The temperature inside the around700-1000°C and at this temperature, the coal present at the cavity develops cracks in it, due to its drying and pyrolysis. These c with time until a piece of coal breaks from its parent material and falls of the cavity. This phenomenon is called spalling. The extent of sp particular type of coal is an important input to UCG process model t the product gas calorific value. Till date, there is no equipment or m available for the analysis, characterization and/or quantification

Spalling is conceptualized as something which occurs in regul
However, as yet no apparatus or process is known for the charact
spalling behavior of coal. There has been a long-felt need to study
process in detail in order to predict and/or estimate the product gas
UCG process.

The present inventors have solved this long-felt need by developing a
for studying and quantifying the spalling behavior of coal and a proce
the apparatus.

DESCRIPTION OF THE INVENTION

The invention relates to an apparatus for analyzing and characterizi
behavior of coal during underground coal gasification comprising a
having a lid (2) with an opening (3); a heat source(4) located at the bot
of the furnace (1); a coal block holder (5) for holding a coal block (6
furnace (1),wherein the coal block holder (5) has an open bottom (7
heat source (4);at least one inlet tube (8), for supplying gas to the
placed between the heat source (4) and open bottom (7) of the coal b
(5);at least one outlet tube (9), for removing gas from the furnace
between the heat source (4) and open bottom (7) of the coal block
device (10), for monitoring weight of the coal block (6), placed
furnace (1) and comprising a suspension means(11) for suspending the

(6) with the coal block holder(5) in the furnace (1); wherein the means(11) passes through the opening (3) of the furnace lid (2).

Another aspect of the invention relates to a process for ana characterizing the spalling behavior of coal during underground coal g wherein the process comprises the steps of

a) Placing a coal block (6) within a coal block holder (5);

b) suspending the coal block holder (5) with the coal block device(10) for monitoring weight of the coal block (6) a point of time; wherein the device (10) comprises a suspen (11) for suspending the coal block holder (5) with the coal b

c) placing the device(10) for monitoring weight of the coa outside a furnace (1) such that the suspension means through an opening (3) in lid (2) of the furnace(1) with the (6) within the coal block holder (5) suspended from the de monitoring weight of the coal block (6) and being placed furnace (1);

d) passing a mixture of gases into the furnace (1) through a (8);

e) raising the temperature in the furnace to 700 to 900°C b heat source(4) placed in the furnace (1); and

f) recording weight profile of the coal block (6) with respect tc

BRIEF DESCRIPTION OF DRAWING

Fig. 1 illustrates a schematic diagram of the apparatus.

Fig. 2 illustrates the weight profile of coal block versus time on he coal block under air atmosphere and at a temperature of 700°C.

DETAILED DESCRIPTION OF THE INVENTION

The description of the specific embodiments will so fully reveal the ge of the embodiments herein that others can, by applying current knowle modify and/or adapt for various applications such specific embodim departing from the generic concept, and, therefore, such adap modifications should and are intended to be comprehended within 1 and range of equivalents of the disclosed embodiments. It is to be unc the phraseology or terminology employed herein is for the purpose o and not of limitation. Therefore, while the embodiments herein described in terms of preferred embodiments, those skilled in 1 recognize that the embodiments herein can be practiced with modific the spirit and scope of the embodiments as described herein.

An embodiment of the present invention relates to an apparatus for ar

apparatus comprises a furnace (1) having a lid (2) with an opening (3)
source (4) located at the bottom surface ofthe furnace(1). The conditio
furnace (1) is maintained analogous to the condition in underground
during UCG process. The furnace (1) can be made up of any material
withstand high temperatures of upto 1300°C and withstand highl
and/or reducing atmosphere. The material can be selected from stai
super alloys etc.

The walls of the furnace (1) is thermally insulated in order to ensu
temperature within the furnace (1) is maintained and to minimize the he

The furnace (1) comprises a heat source (4) placed preferably on
surface thereof. This set-up mimics the underground coal gasificatio
The heat source (4) is in the form of a plate or a disc. The heati
electrical heating or heating can be carried out using any fuel. The heat
is specifically a disc type heating coil with an Inconnel plate at the
source (4).

The apparatus comprises a coal block holder (5) for holding a coal blo
coal block holder (5) has an open bottom (7) with the coal block (6)
heat source (4). The open bottom (7) of the coal block holder (5) faci
source (4) ensures that the coal block (6) gets directly heated from t

process. The open bottom (7) of the coal block holder (5) has a projections (14) to help in retaining/holding the coal block (6) with block holder(5). The projections (14) can be flanges or metal strips strip may be a slidable/rotatable metal strip such that the coal block (within the coal block holder (5) and the metal strip is slid/rotated inwa each other so that the coal block (6) is held/retained within the coal b (5).

The apparatus further has at least one inlet tube (8) for supplying furnace (1).The inlet tube (8) is preferably placed between the heat so open bottom (7) of coal block holder(5). The gas supplied to the fu selected from air, oxygen, nitrogen, carbon dioxide and/or steam deper reaction in the furnace. For e.g. for an analytical study of the spall during the UCG process, air, steam and/or oxygen is passed throu tubes (8) into the furnace (1). Alternatively, in a study of the pyroly nitrogen can be passed through the inlet tubes (8).

The apparatus further has at least one outlet tube (9) for removing g furnace (1).The outlet tube (9) is placed between the heat source (4 bottom (7) of the coal block holder(5). The outlet tube (9) is used to gas from the furnace (1). The gas removed is generally the product g after the reactions in the furnace including, but not limited to, combu

varying compositions and inert gases like carbon dioxide and ni analysis of the product gas enables the study of the reactions occu underground coal seams during UCG process.

The general reactions or processes taking place or occurring in the furn drying, pyrolysis and other chemical reactions. Drying is the eva moisture present in the coal at high temperature. Pyrolysis is the bre higher hydrocarbon components present in coal at higher temperature char or carbon in solid form and lighter components in gaseous form chemical reactions are combustion, gasification and water gas shift r given below:

$C + O_2 \longrightarrow CO_2$, combustion

$C + H_2O \leftrightarrow CO + H_2$, gasification

$C + CO_2 \longleftrightarrow 2CO$, Boudouard reaction

$CO + H_2O \longleftrightarrow CO_2 + H_2$, water gas shift reaction

The apparatus also comprises a device (10) for monitoring weight block (6) at any given point of time. The device (10) is placed outside (1) and comprises a suspension means (11) for suspending the coal blo the coal block holder (5) in the furnace (1); wherein the suspension passes through the opening (3) of the furnace lid (2). The opening (3) ir is packed around the suspension means (11) to ensure complete insulati to minimizing heat loss and gas leakage. The suspension means (

block (6) can be a load cell. The load cell may be attached to a data lc record the weights at different time intervals.

Another embodiment of the invention relates to a process for an characterizing the spalling behavior of coal during underground coal comprising the steps of

a) Placing a coal block (6) within a coal block holder (5);

b) suspending the coal block holder (5) with the coal block device (10) for monitoring weight of the coal block (6) a point of time; wherein the device (10) comprises a suspei (11) for suspending the coal block holder (5) with the coal l

c) placing the device (10) for monitoring weight of the co: outside a furnace (1) such that the suspension means through an opening (3) in lid (2) of the furnace (1) with th (6) within the coal block holder (5) suspended from the de monitoring weight of the coal block (6) and being placec furnace (1);

d) passing a mixture of gases into the furnace (1) through a (8);

e) raising the temperature in the furnace to 700 to 900°C b heat source (4) placed in the furnace (1); and

f) recording weight profile of the coal block (6) with respect t

The gases passed through the inlet tube (8) are selected from a nitrogen, carbon dioxide and/or steam. The process is continued till change of the coal block is negligible with respect to time. The produ furnace (1) is continuously removed from the furnace through an out A graph is plotted for the data obtained with regards to the weight of the time. The sudden drops in weight of coal block (6) observed in th time data are identified as spalling events. Thus, the occurrence of spal block can be identified from the sudden drops in weight. One such figu infigure2. On accumulating all these sudden weights, the rate of spal calculated.

The product gas is collected from the outlet tube and can be analyz Chromatograph (GC) for studying its components and thereby cal calorific value or understanding the reactions occurring in the under seams. Other equipments like GC-MS, engine or downstream reactors the product gas into other fuels) can also be integrated with our appar analysis or processing of product gas.

The apparatus and the process as defined hereinabove relate to st spalling behavior of coal in the underground coal gasification proces the present apparatus can be modified for the study of other processe the UCG. like kinetics. heat and mass transfer phenomena and/or any r

The apparatus enables the study of feasibility of a particular coa process. Further, it is also possible to characterize and analyze the l thermo-mechanical processes for other carbonaceous solid fuel bi slight modifications to the apparatus and the process for use thereof within the scope of the person skilled in the art.

Examples

The following experimental examples are illustrative of the invent limitative of the scope thereof.

A furnace was selected having a plate type heater at the bottom su heating chamber. The dimension of the heating chamber was 380 x mm. The internal openings of the inlet and outlet tubes were made in chamber just above the heating plate. A box type coal block holder m temperature withstanding stainless steel, with its bottom face opened inside the heating chamber. The dimension of the coal block holder wa x 140 mm. The holder was thermally insulated on all its internal fa thickness of 15mm. The coal block was cut into a dimension suitable to holder. The thermal insulation between the coal block and holder surf the heating of the coal block to happen from the bottom exposed face block. This scenario is analogous to the condition in underground during UCG process. After placing the coal block within the holder,

surface 15 mm inward from all its sides. This prevented the coal falling down through the bottom open face of the holder. Then this coal block assembly was suspended from a load cell which was placed furnace, using a stainless steel rod, to monitor the weight of coal suspending rod was passed through the opening in the lid of the furnac taken to prevent the load getting in contact with any solid object to ha results.

This apparatus generated the weight profile of coal block with time, the UCG like conditions inside the heating chamber, as shown in figur

We claim:

1. An apparatus for analyzing and characterizing spalling beha during underground coal gasification comprising

a furnace (1) having a lid (2) with an opening (3);

a heat source(4) located at the bottom surface of said furnace (1

a coal block holder(5) for holding a coal block (6) within said

wherein the coal block holder (5) has an open bottom (7) fac source (4);

at least one inlet tube (8), for supplying gas to said furn between the heat source and open bottom of coal block holder;

at least one outlet tube, for removing gas from said furnace between the heat source(4) and open bottom (7) of coal block h

a device (10), for monitoring weight of the coal block (6), pla the furnace (1) and comprising a suspension means (11) for sus coal block (6) with the coal block holder (5) in the furnace (1), suspension means (11) passes through the opening (3) of the (2).

2. The apparatus as claimed in claim 1, wherein the furnace insulated furnace.

3. The apparatus as claimed in claim 1, wherein the furnace (1 material selected from stainless steel, inconnel. superal tantalum based compounds or alloys.

4. The apparatus as claimed in claim 1, wherein the heat source form of a plate or a disc.

5. The apparatus as claimed in claim 1, wherein the open botto coal block holder (5) comprises at least two projections (14 prevent the coal block (6) from falling down from the coal (5).

6. The apparatus as claimed in claim 7, wherein the proj comprise a slidable metal strip.

7. The apparatus as claimed in claim 1, wherein the gas passed inlet tube (8) into the furnace (1) is selected from air, oxyg carbon dioxide and/or steam.

8. The apparatus as claimed in claim 1, wherein the devi monitoring weight of the coal block (6) is a load cell.

9. The apparatus as claimed in claim 11, wherein the load cell is data logger (12).

10. The apparatus as claimed in claim 1, wherein the suspension m selected from a rod and/or a spring.

11. The apparatus as claimed in claim 1, wherein the rod for susp weighing the coal block is made up of stainless steel, inconnel, and/or tantalum based compounds or alloys.

12. A process for analyzing and characterizing the spalling beha during underground coal gasification, wherein the process co steps of

a) Placing a coal block (6) within a coal block holder (5);

b) suspending the coal block holder (5) with the coal block device (10) for monitoring weight of the coal block (6) a point of time; wherein the device (10) comprises a suspen (11) for suspending the coal block holder (5) with the coal b

c) placing the device (10) for monitoring weight of the coa outside a furnace (1) such that the suspension means through an opening (3) in lid (2) of the furnace (1) with the (6) within the coal block holder (5) suspended from the dev monitoring weight of the coal block (6) and being placed furnace (1);

d) passing a mixture of gases into the furnace (1) through a

e) raising the temperature in the furnace to 700 to 900°C heat source (4) placed in the furnace (1); and

f) recording weight profile of the coal block (6) with respe and time.

13. The process for analyzing and characterizing the spalling beh during underground coal gasification as claimed in claim 12, gases passed through the inlet tube (8) is selected from nitrogen, carbon dioxide and/or steam.

14. The process for analyzing and characterizing the spalling beh during underground coal gasification as claimed in claim 12, heating and passing of gases is continued till the weigh negligible with respect to time.

15. The process for analyzing and characterizing the spalling beh during underground coal gasification as claimed in claim 12, product gas is continuously removed from the furnace (1) outlet tube (9).

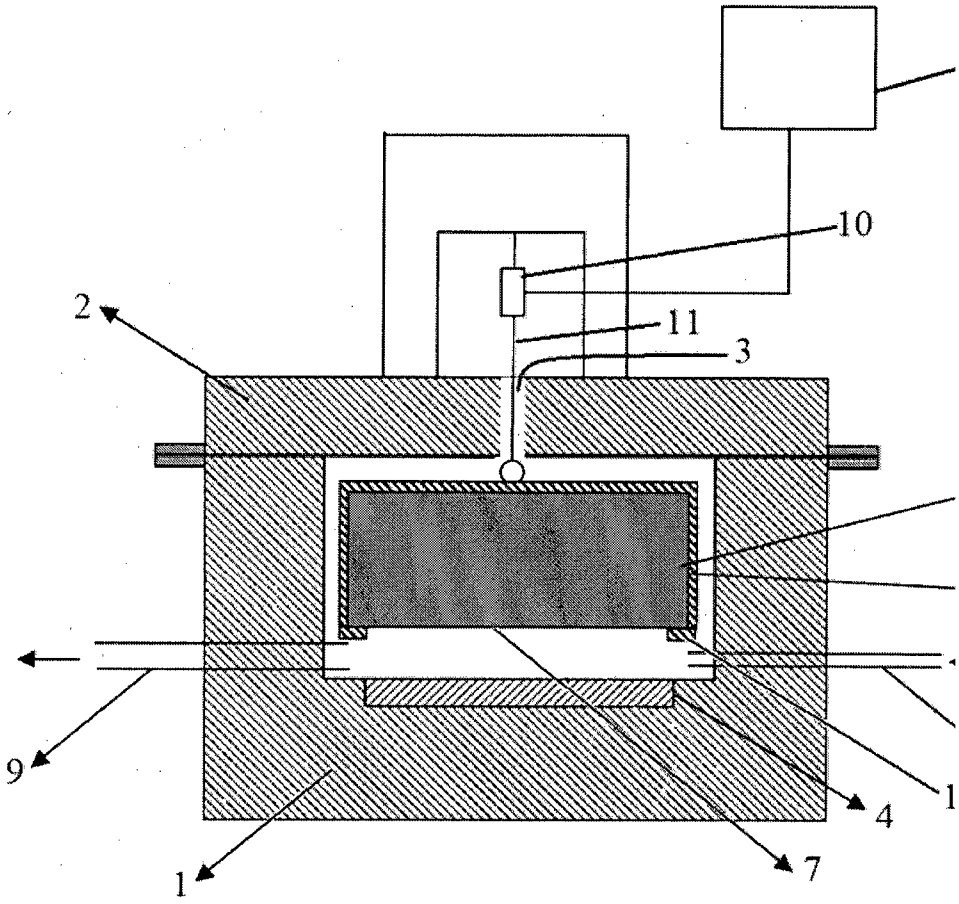

Fig. 1

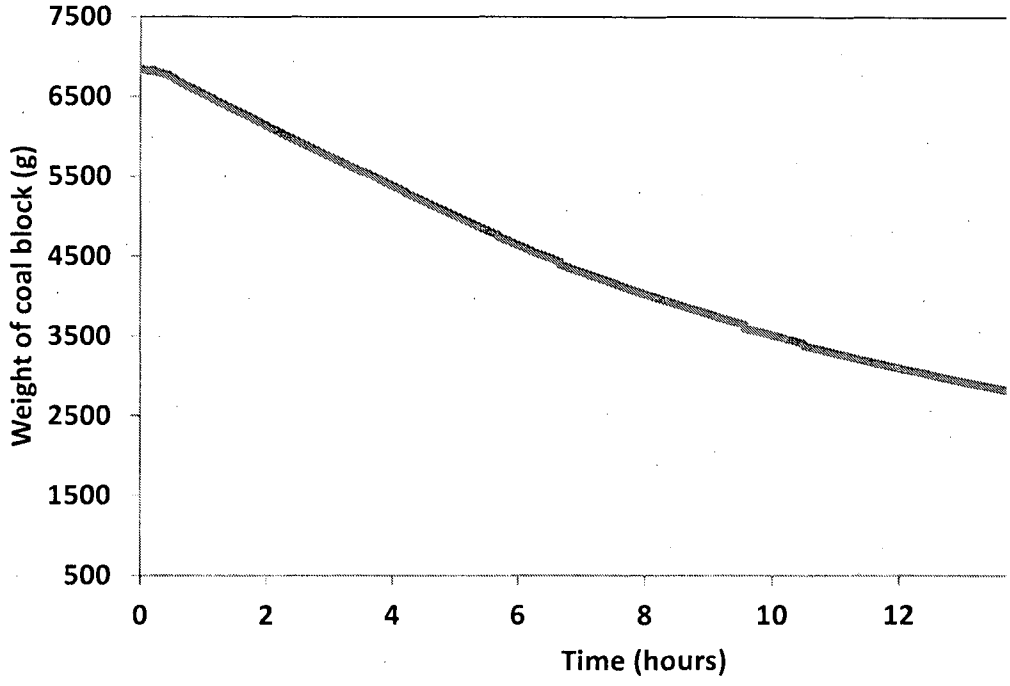
7500
6500
5500
4500
3500
2500
1500
500
Weight of coal block (g)
0
2
4
6
8
10
12
Time (hours)

Fig.2