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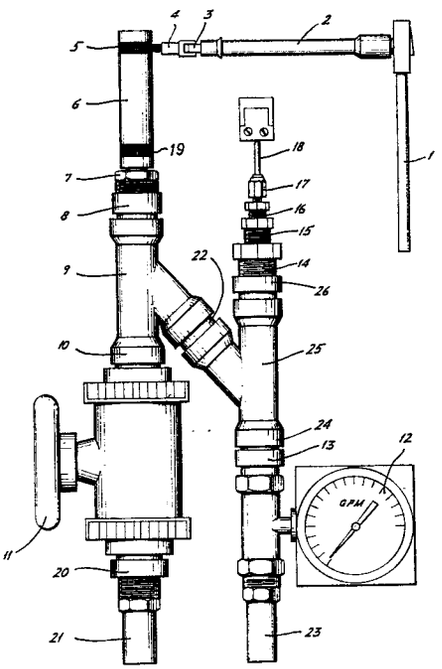
(54) Apparatus and method for detecting fouled cooling circuits in a blast furnace or the like.

(57) Apparatus and method for detecting fouled cooling circuits in a blast furnace or the like are disclosed. The apparatus comprises a first (6, 22, 23) and second (9, 20, 21) flow passage. Operatively associated with the first flow passage are a temperature sensing member (18) and a flow meter member (12). A valve (11) or the like, positioned within the first flow passage, is capable of diverting fluid flow from the first flow passage through the second flow passage so as to minimize instrumentation damage which may otherwise occur upon installation of the device. Data generated from the device is utilized to calculate heat flux for individual cooling circuit lines. These heat flux values are then compared to predetermined optimal values to ascertain if fouling or pluggage of the particular cooling circuit line has occurred.



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DESCRIPTION

APPARATUS AND METHOD FOR DETECTING FOULED COOLING CIRCUITS IN A BLAST FURNACE OR THE LIKE

The present invention pertains to an apparatus and method for determining which, if any, cooling circuits in a blast furnace or similar device have become fouled or plugged.

The ultimate life and total performance of an iron making blast furnace are dependent on the ability of the furnace refractory to withstand the extreme operating conditions of high gas temperature and abrasive charge materials. Unfortunately, furnace refractories have a limited life. Aside from mechanical abrasive effects, degradation or solution rate of most refractories is dependent on the refractory temperature itself. Generally, as refractory temperature increases, so does the solution rate.

In order to decrease high temperature effects on the blast furnace refractory and to provide structural integrity, cooling water stack systems have been incorporated into most blast furnace designs. It is typical for these furnaces to have a matrix of copper stack plates embedded in the refractory stack walls to supply

the necessary cooling. Each individual cooling circuit normally has an upstream end and a downstream end and includes about 10 or less of these stack plates. Most blast furnace cooling circuits utilize once-through water systems and are diagonally or horizontally disposed about the furnace. Commonly, about 80 - 150 of such circuits are provided about the furnace. Water supply is usually off a common header with each circuit having its own discharge into an open trough surrounding the furnace.

Various cooling system monitoring means have been designed to monitor varying operating parameters of the cooling circuits. For instance, in U.S. Patent 3,652,070 (Sagara), there is disclosed an apparatus wherein a temperature sensing means extends within the refractory itself, and is associated with control means to regulate the passage of cooling fluid through the refractory medium to thereby control the adhesion of fused slag to the refractory.

In U.S. Patent 4,188,021 (Patuzzi, et al) entitled "Metallurgical Vessel Cooling and Safety System" an emergency drainage system is disclosed, the intent of which is to provide for the dumping of cooling fluid during an upset to prevent equipment and/or personal damages. Of similar import is U.S. Patent 4,133,373 (Slagley et al) which discloses a leak detecting apparatus for a blast furnace cooling system.

Althouth the above-noted cooling system monitoring means are known in the art, to our knowledge, no one has yet devised a portable, hand-held assembly that provides an easy and convenient means for ascertaining if certain circuits in the blast furnace have become clogged or fouled. As is well-known, clogging or fouling of

these cooling circuits impedes the desired heat transfer function of the cooling system, leading to decreased refractory life. Moreover, although various chemical additives may be added to these systems, to minimize deposition and fouling of the cooling circuits, it is highly desirable to provide a means which is capable of gauging the efficacy of these chemical additives.

These and other objects are achieved by the apparatus and methods disclosed herein.

The present invention provides a convenient hand-held portable device which can be used to measure the flow rate and temperature on the open-ended discharge pipes of a blast furnace cooling circuit line or lines. By the use of the above two parameters, in addition to measurement of the influent cooling fluid temperature, the heat flux for each cooling line may be calculated, with the data allowing the observer to render certain judgments regarding the cooling circuit performance of individual circuits or the entire furnace in general.

A measured decrease in flow, temperature, or heat flux from a predetermined value will generally indicate a problem such as circuit pluggage or fouling. An increase in these parameters, over the predetermined value, is generally indicative of reduced pluggage or scale removal. It is thus apparent that this data is useful in monitoring the efficacy of any chemical additives that may have been admitted to the cooling system for the purpose of controlling deposits.

Briefly, the apparatus comprises a first conduit that defines a first flow passage for the cooling liquid when the device is connected to the discharge end of a particular cooling circuit. A thermocouple or the like is disposed in this first flow passage to measure the temperature of the cooling fluid flowing therethrough. This thermocouple, or similar temperature sensing device, may be associated with a digital LED readout display so that the user may immediately read and record the discharge temperature of the particular cooling circuit line.

A flow meter is also operatively connected to the first flow passage to measure the cooling fluid flow at the discharge end of the cooling circuit. Preferably, a by-pass conduit means is also part of the integral, hand portable equipment, so that, when the device is initially connected to the cooling circuit, back pressure may be relieved thereby. Also, use of the by-pass conduit means at initial hook-up time prevents damage to the temperature sensing device and flow meter that may otherwise occur.

The invention shall now be illustrated in further detail in the following detailed description and the appended drawing in which:

Figure 1 is a schematic drawing illustrating the preferred embodiment of the blast furnace cooling circuit fouling detection device of the present invention.

With respect to the drawing, therein shown is the fouling detection device of the present invention. Rachet handle 1 connected to clamp means 5 through linkage members 2, 3, and 4, serves to provide a convenient means of attaching the device to the discharge end of the desired blast furnace cooling circuit line.

Hose member 6 is provided with another clamp 19 to aid in securing the device to the cooling circuit line. Adaptors 7, 8 connect hose 6 to "Y" pipe 9. The downstream end of "Y" pipe 9 is threadably engaged to piping 10, which, in turn, is secured to manually operable on-off socket valve member 11. At the downstream end of valve 11, adaptor 20 and hose member 21 are serially connected.

At one Juncture of "Y" pipe 9 is provided pipe 22, threadably secured to member 9. Pipe 22 is secured in fluid tight relation with one Juncture of "Y" pipe 25. The upstream end of "Y" pipe 25 is connected to reducer bushings 14, 15 through female adaptor 26. The upstream end of bushing 15 is, in turn, connected to compression fittings 16, 17. Extending within the flow passage from atop fitting 17, is thermocouple member 18. This member is designed to measure the temperature of the cooling fluid as it flows through the device. We have found that a "K" type thermocouple best serves the intended function of the device, although it is noted that other equivalent temperature sensing means may suitably be employed.

For convenience of the user, the thermocouple may be connected to any one of a number of digital readout devices (not shown). One such LED readout device is manufactured by Omega Engineering, Stamford, Connecticut.

Threadably engaged to the downstream end of "Y" pipe 25 is pipe member 24, which, in turn, is connected to male adaptor 13.

Flow meter 12 is secured to the downstream edge of adaptor 13. Preferably, the flow meter 12 is of the type, known in the art, which operates by a mechanical differential pressure method. In this method, differential pressure, produced by fluid flow through a calibrated flow nozzle, is sensed by an arrangement of opposed bellows. Displacement of the bellows is transferred by a low-friction cam and lever to a rotary geared movement to indicate flow rate directly on the dial shown in the drawing. Operation of the depicted flow meter 12 is completely mechanical, with no electrical connections being required for operation. One such flow meter, presently preferred, is made by RCM Industries of Orinda, California. It is, of course, to be noted that those skilled in the art will be capable of utilizing other types of flow meters in conjunction with the inventive ideas herein disclosed and claimed. All such equivalent flow measuring devices are deemed to be within the spirit and scope of the present invention.

A first flow passage is defined by members 6, 9, 22, 25, 24, 13, 12, and 23. During passage through this first flow passage, temperature and flow rate of the cooling fluid may be measured. When, valve 11 is in the "open" position, fluid flow is diverted from the first flow passage and instead is caused to flow through a second flow passage, defined by members 9, 20, and 21. This "di-

verting" structure has proven quite helpful, especially when the device is first connected to the discharge end of the desired cooling line circuit. In this way, back-pressure problems which may cause spraying of the cooling fluid on the user and/or flow meter and thermocouple damage are minimized.

It thus becomes apparent that the device is used to detect fouled or plugged cooling circuits of the blast furnace cooling system. In this respect, data generated from the device is recorded along with the temperature of the influent cooling fluid. Heat flux for a particular circuit or for all circuits may then be calculated according to:

$$Q = MC_P \Delta t$$

wherein Q = heat flux, btu's per hour; M = mass water flow, lbs per hour at discharge; C_P = specific heat of fluid, btu's per lb. per °F (Note: water is approximately 1 btu per lb per °F); Δt = temperature difference between influent and discharge in °F.

Predetermined optimal or normal values may be determined by recording the above parameters for a given circuit or circuits over a given period of time, or predetermined optimal values may be determined by averaging heat flux figures for all circuits, with heat flux values for particular circuits falling below this value being possibly indicative of abnormal circuit pluggage, etc.

As is now apparent, a decrease in flow, temperature or heat flux, from the predetermined value, could indicate such prob-

lems as pluggage or fouling. An increase in these parameters may indicate reduced pluggage or scale removal. This method may be thus used as a means of gauging the efficacy of certain chemical additives which are added to the system for the purpose of minimizing deposition and fouling.

Although use of the above device and method are especially well suited for monitoring once-through cooling systems, they may also be adapted to monitor open recirculating systems where there is a discharge of cooling fluid into a reservoir or the like. The invention may also be used in connection with normally closed recirculating systems, if some type of by-pass discharge plumbing is present.

The foregoing detailed description has been given for clearness of understanding only and no unnecessary limitations should be understood therefrom as modifications will be obvious to those skilled in the art.

CLAIMS

1. Apparatus for measuring fouling characteristics of a cooling circuit line of a blast furnace or the like, characterised by

a) First conduit means defining a first flow passage(6,9,22,25,24,13,12 and 23) adapted to permit cooling fluid flow therethrough;

b) Temperature sensing means (18) connected to said first flow passage (a) for measuring the temperature of said cooling fluid;

c) Fluid flow sensing means (12) connected to said first flow passage for measuring the flow rate of said cooling fluid; and

d) Coupling means (5,19) for connecting said first conduit means (a) to said cooling circuit line.

2. Apparatus as claimed in claim 1, further characterised by by-pass conduit means (e) (9,10,11, 20 and 21) connected to said first conduit means (a) and defining a second flow passage, said by-pass conduit means (e) diverting fluid flow from said first flow passage into said second flow passage.

3. Apparatus as claimed in claim 2, characterised in that said by-pass conduit means (e) comprises a manually operable on-off socket ball valve (11).

4. Apparatus as claimed in claim 1, 2 or 3, characterised in that said coupling means (d) comprises a ratchet actuated clamp means (5).

5. Apparatus as claimed in any of claims 1 to 4, characterised in that said temperature sensing means (b) comprises a thermocouple.

6. Method for determining the fouling characteristics of a cooling circuit of a blast furnace or the like, said cooling circuit being of the type having a

cooling fluid influent end and a discharge end, said method being characterised by the steps of:

a) measuring the temperature of said cooling fluid at said influent end;

b) measuring the temperature of said cooling fluid at said discharge end;

c) measuring the flow rate of said cooling fluid at said discharge end;

d) calculating the heat flux for said circuit in accordance with the formula:

$$Q = MCp \Delta t$$

wherein Q = heat flux, btu's per hour; M = mass water flow, lbs per hour at discharg; Cp = specific heat of fluid, btu's per lb. per °F; t = temperature difference between influent and discharge in °F; and

e) comparing said heat flux value derived from said calculating step (d) to a predetermined value.

7. Method as claimed in claim 6, wherein said steps (b) and (c) include connecting the apparatus of Claim 1 to said cooling circuit discharge end.

8. Method as claimed in claim 6 or 7, characterised in that said measurement and said calculation are effected in respect of each of a plurality of said cooling circuits disposed in said blast furnace or the like, wherein each said cooling circuit comprises a cooling fluid influent end and a discharge end.

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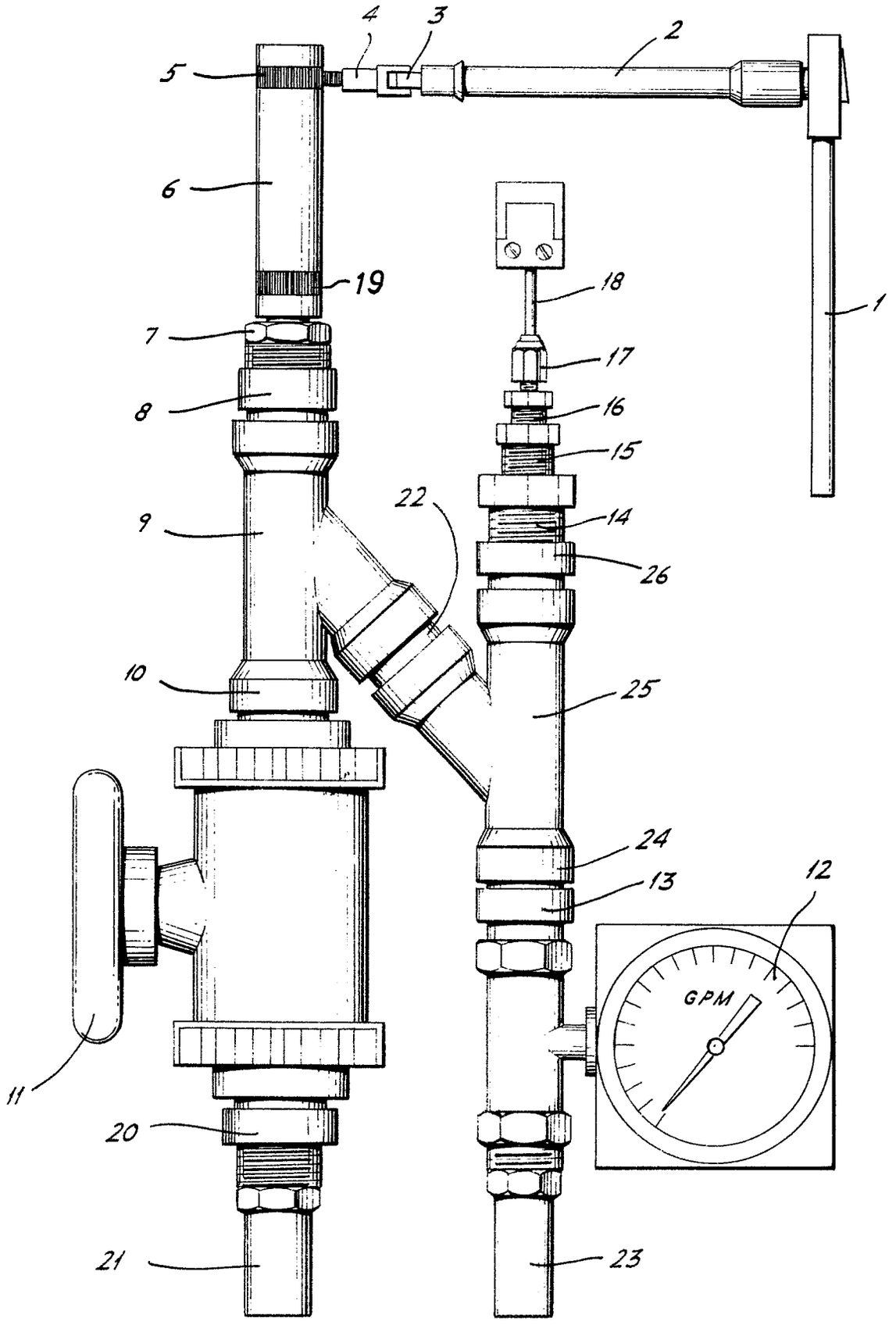

European Patent Office

EUROPEAN SEARCH REPORT

0075420
Application number

EP 82 30 4764.2

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
X	FR - A - 932 508 (M. ROSENFELDER) * page 3 *	1,6
A,D	US - A - 3 652 070 (H. SAGARA)	
A,D	US - A - 4 133 373 (W.E. SLAGLEY et al.)	
A,D	US - A - 4 188 021 (A. PATUZZI et al.)	

CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)

C 21 B 7/10

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

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CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same category
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: earlier patent document, but published on, or after the filing date
D: document cited in the application
L: document cited for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	15-12-1982	SUTOR

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