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(54) Title: REFRIGERATED PIPE LEAKAGE DETECTION SYSTEM

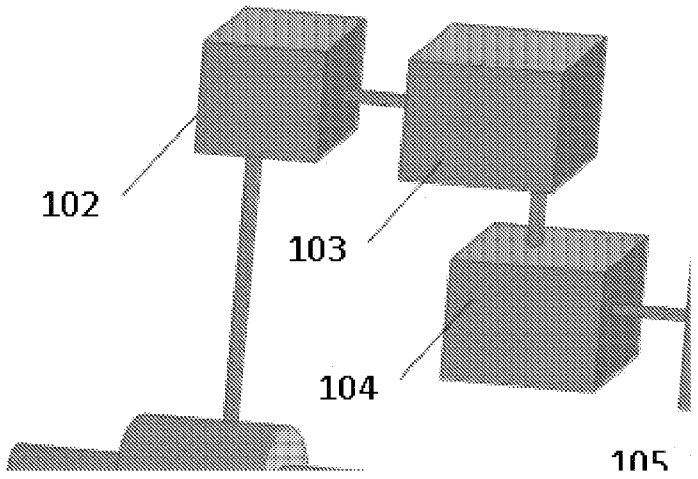


Figura1

(57) Abstract: The present invention refers to the monitoring and detection of water leaks applied in refrigerated panels, comprising piezoelectric sensors (101) installed in the refrigerated panels, where the signs generated by these sensors are sent to a data reception equipment (104) (hardware) where an installed software enables the analysis of the received data and execution of continuous monitoring and storage of all the data, even during periods of interruption and between the runs of the electric furnace.

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"REFRIGERATED PIPE LEAKAGE DETECTION SYSTEM"

The present invention refers to a system for detecting leakages in refrigerated pipes using piezoelectric sensor, specially installed in the direction of a liquid flow, which is connected to a data analysis system that enables detection of liquid leakage, but more specifically it refers to a system for detecting water leaks in refrigerated panels used in the electric arc furnace (EAF) and alike.

The present invention is intended for use in processes that have water-cooled equipments, in which leakages represent the risk of accidents, especially explosions due to the contact of water with the liquid metal. The presence of water inside the electric furnaces, for example, during steel production process leads to high-risk conditions that can be potentially dangerous to the life of operators and integrity of other equipments.

The present invention can be applied to other reactors that use refrigerated panels for different purposes.

State of the Art

The electric arc furnace was patented by in 1899 by P. L. T. Heroult in France and it became a universal equipment for steel production. The furnace has a metal enclosure, the shell, which is divided into two parts: upper shell and lower shell. The upper shell has the shape of a hollow cylinder. Refrigerated panels, in general, manufactured in metal pipes, are mounted on the walls of the upper shell to form a ring. The lower shell has the shape of a hollow cylinder with a spherical bottom. The lower shell has the hearth in its lower region and ramp and walls on its sides. The reaction chamber of the furnace is covered with a removable water-cooled roof, but in some cases it still uses roofs made of refractory material. The electric furnace has a door for slag removal, sample taking and addition of inputs, and it has a channel or spout for tapping steel. It is powered by three-phase alternating current and has three electrodes secured by contact plates connected by holders to the moving structure of the electrode. The movement of the electrodes is independent and is based on the length of the arc in relation to the charge. The current is supplied through flexible copper cables and water-cooled copper pipes. The furnace rests on two supporting sectors, which tilt on their base to incline it towards the charging door and towards the steel tapping spout, with the tilting movement executed by a hydraulic or electromechanical system.

The electric arc furnace is charged from the top through "baskets". To charge the furnace, the roof and electrode assembly are raised and displaced.

The displacement allows the positioning of the baskets that open their bottom to transfer the scrap to the bottom of the electric furnace. Then the roof and electrode assembly are positioned and lowered. The electrodes are lowered to a certain distance from the scrap when the electric arc is opened and melting process begins. The melting process can be aided by oxy-fuel burners, which are used to raise the temperature of the charge. The second stage of the process is called refining. Injectors are used in this phase to oxidize the elements of the bath and in some cases coal injectors are used to treat the slag, with the advantage of protecting the arcs through the emulsion that is formed.

Initially, the refrigerated panels were installed on the sidewalls of the electric arc furnace instead of refractory linings, with the purpose of reducing the shutdown time of the furnaces for repairs. The excellent results obtained lead to the expansion of the substitution to the entire wall and even on the roofs, outer region around the core.

The first refrigerated panels were made of a special steel plate with an internal baffle system to direct the flow of water. These refrigerated panels are also known as "box type" panels. The modern refrigerated panels can be made of steel or copper pipes, subjected to a forced flow of chilled water, with flow between 100 to 150 $l/m^2/min$ and pressures that vary from 1.5 to 3.0 bar. The cooling water, in its route, is subjected to a temperature increase of 10 to 35°C. The use of tubular panels enables a reduction in the volume of circulating water. The flow of water is adjusted to maintain output temperature control.

The increase in heat losses with the use of the panels is highly compensated by the high use of the furnace and the refractory saving. This compensation has been proven by plates that cite an average energy consumption of 545 kWh/t. The use of the panels has been particularly important in furnaces that use pre-reduced charges. In this case, not only the heat from the arc but also that coming from the slag and the superheated metal are easily absorbed.

The panels are installed about 350 mm above the liquid steel bath level and the connection with the refrigeration system is executed through the back of the panel by flexible pipes to allow movement of the furnace. The advantages of the refrigerated panels are:

a) Increased productivity;

b) Eliminates the need to reduce the power during flat bath period;

c) Cuts the time of repair with refractory material by 50%;

d) Saves time for mounting a new furnace as it reduces the refraction area;

e) Saves refractories, which is an important economic advantage;

f) Enables increase of specific power level because the furnace with forced refrigeration from the panel can resist the heat impacts of the arc more than conventional furnaces;

The use of refrigerated panels was also extended to the roofs of the EAF aim to reduce the time of repair. In this new roof concept, the center or core, region around the electrodes, is interchangeable and continues to be manufactured with refractories, while the remaining part of the roof or surrounding region also became interchangeable but made up of refrigerated panels made of metallic pipes. The refrigerated area corresponds to approximately 90% of the roof area and can consist of more than one panel to facilitate maintenance, as well as speed for eventual corrections.

The advantages of using refrigerated panels on the refrigerated roof are:

a) Weighs 30% less than refractory roofs;

b) Enables saving 60 to 90% in refractories;

c) Increases the life of the core, which can be easily changed;

d) Works at lower temperatures, of around 60°C;

e) Increases the life of the roof to 1500 to 3000 runs;

Despite the great advantages introduced by the use of refrigerated panels, considerable risks also occur with their eventual failure. The current refrigerated panel controls are normally made up of flow and pressure meters and are normally intended to control the functioning of the pumps. Temperature measurements are also taken but only at the input and output of a long network of pipes made up by the interconnection of more than one panel besides the large cold water distribution and hot water collection pipes. Lastly, from the operating safety point of view, the refrigerated panels are yet to have an effective system for leak detection. For being large volume measurements, these controls are unable to detect small water leaks that can potentially react with the metallic bath. Reports of accidents of this kind during liquid steel production are common.

The description of the occurrences generally follows the same sequence of facts. It starts with a leak of small proportions that do not cause pressure, flow and temperature loss to the control equipments. In low quantities, nothing is observed during the production of a batch of metal; however, during the preparations for the next batch, the continuous leakage is superior to the boiling

speed and a pool of boiling water is accumulated in a region of the furnace. Anything that causes the mixture of the incandescent liquid material with the pool of boiling water, normally the tilting of the furnace or charging of a new batch of liquid metal, will trigger the explosion.

This occurs because two chemical phenomena occur when the boiling pool is "covered" by an incandescent liquid material: the first is the increase in boiling speed of the water forming steam, simultaneously, dissociation of hydrogen from water occurs, both causing a volumetric expansion that is rapidly pressurized inside this cover. The rupture means an explosion without any prior warning of its occurrence, given the speed of the reactions.

Presently, in the case of suspected leaks, the operators are exposed to risk because this exposure to the furnace is necessary to try and locate the possible leaks. Normally, the leaks are detected with the naked eye due to the dark "stain" formed in contrast to the bright characteristic of the reactors.

There are regions of the Electric Furnace of easy visual inspection, especially close to the slag door and in the tapping region of the furnace, with increased potential risk due to continuous use of the equipment. In most cases, not even predictive and preventive inspections are able to detect leakages in these regions.

Summary of the Invention

The present invention refers to a **REFRIGERATED PIPE LEAKAGE DETECTION SYSTEM.** The system proposed herein consists of piezoelectric sensors installed in the refrigerated panels, where the signs generated by these sensors are sent to a data reception equipment (hardware) where an installed software enables the analysis of the received data and execution of continuous monitoring and storage of all the data, even during periods of interruption and between the runs of the electric furnace. After the necessary field checks and calibrations, the system is able to compare the signal standards of the piezoelectric sensors to accurately detect the existence of water leaks in the refrigerated panels, even tiny leaks from holes of about 5 mm in diameter.

Once the presence of leakage is detected, an alarm signal is emitted on the screen of the equipment where the data are analyzed with the use of the software developed to execute the analysis of the data. The alarm signals and their levels (attention, block, emergency, etc.) can be configured manually through the reception and data analysis equipment. The configurations of the alarm can also be performed individually and in a customized manner for each position of the refrigerated panel of the EAF.

Besides indication of the alarm on the screen of the reception and data analysis equipment, the sending of a digital signal can also be configured, for example, 3.3 Vcc, which can be used as an input in the monitoring system of the EAF, allowing this signal to be internally treated by the PLC equipment of the plant. Once the alarm signal is sent, preventive, corrective and emergency actions may be taken automatically through the PLC equipment of the plant.

The system object of the present invention can be integrated to a single refrigerated panel or also monitor a set of refrigerated panels (complete shell, for example). The system can also be used to monitor any other type of refrigerated panel that exchanges heat, such as dust removal refrigerated pipes. An application example of the present invention can be the monitoring of refrigeration water input and output systems of an assembly made up of refrigerated panel, refrigerated block and an oxy-fuel injector.

Figures

Figure 1 shows a data and information flow diagram and mounting of the proposed detection system.

Figure 2 shows a diagram of the mounting of the sensor in the refrigerated pipe of the refrigerated panel.

Description of the Invention

As observed in Figure 1, for application of a refrigerated panel, the system object of the present invention consists of a piezoelectric sensor (101) coupled to a preamplifier (102) and band filter (103), used in the monitoring of the turbulence behavior of the water that feeds the refrigerated pipe (106), where the signals are received in an equipment for data processing and storage (104), which is equipped with a specific software for analyzing the data received, and the signals that leave the equipment (104) are transferred to a logic and alarm system (105) to emit the alarm signals at the established levels.

The sound signals captured pass directly through the preamplifier (102) coupled to the piezoelectric sensor (101) and are later sent to the equipment (104) to feed the data analysis software. The amplification of the captured sound signals allows them to be treated in a more precise and reliable way by the software. Before start-up of the system, for any application, it is necessary to carry out the detailed survey of the sound behavior standard of the process along its stages. The knowledge of such behavior will be the decisive factor for the basic configurations of the software, as well as the configurations of the alarm levels of the plant.

When any change in the sound behavior standard of the process is detected, the software automatically analyzes the detected disturbance, checking if this disturbance is from a water leak in the system. Like any process, water leaks also have a sound behavior standard, a behavior that is already known by the system and therefore it can, by comparison, detect leaks with high precision rate.

Figure 2 shows the piezoelectric sensor (101) mounted inside the refrigerated pipe (106), which is part of the refrigerated panel. The purpose of this construction method is to reduce external noise interferences in order to avoid the occurrences of false alarms.

CLAIMS

1. REFRIGERATED PIPE LEAKAGE DETECTION SYSTEM characterized by comprising the use of a piezoelectric sensor (101) equipped with a preamplifier (102) and band filter (103), to monitor the turbulence behavior of water that feeds the refrigerated pipe, and equipment for data processing and storage (104), where the signs and data received are analyzed by a specific software, and after the signs are analyzed in the equipment (104) they are transferred to the logic and alarm system.

2. System according to claim 1, characterized by the fact that it is integrated to the refrigerated panel and installed in the appropriate section of the refrigerated pipe.

3. System according to claim 1, characterized by the fact that it works continuously, monitoring variations of signals detected in the piezoelectric sensor (101).

4. System according to claim 1, characterized by the fact that the meters are integrated to a data processor (104) at a distance from the source of emission of the signals.

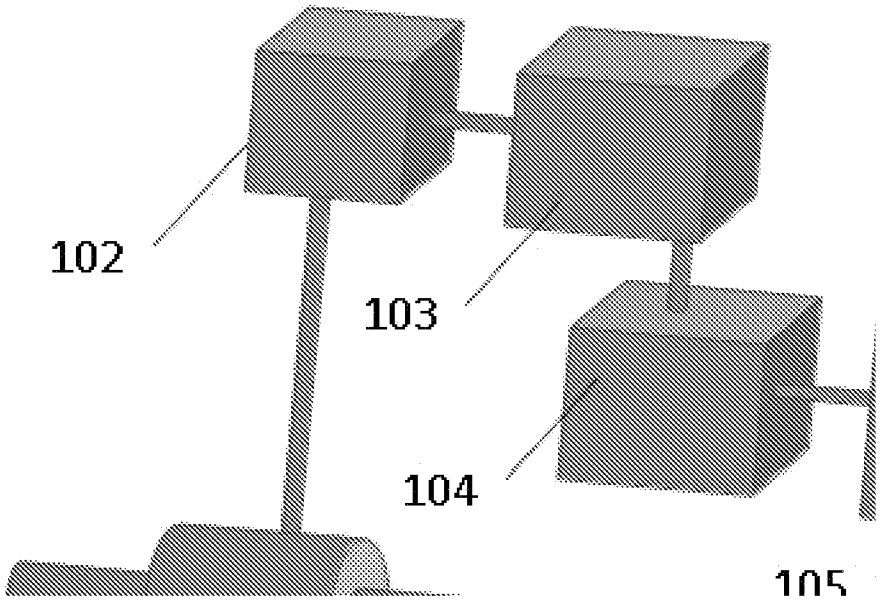


Figura1

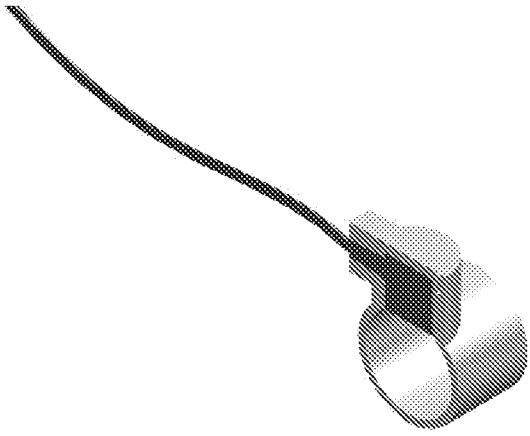


Figura 2

INTERNATIONAL SEARCH REPORT

International application N°
PCT/IB2013/055242

A. CLASSIFICATION OF SUBJECT MATTER

G01H 11/08 (2006.01)

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)

G

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 practicable, search terms used)

EPODOC, ESPACENET

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claims N°
Y	US 4953144 A (SHELL OIL CO [US]) 28 August 1990 (1990-08-28) The whole document	1 - 4
Y	US 4309576 A (HEATH CONSULTANTS INC) 05 January 1982 (1982-01-05)	1 - 4

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to stablish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority claimed

"T" later document published after the internationa filing. date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvius to a person skilled in the art

"&" document member ot the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21/10/2013	**11 11 213**

Name and mailing address of the ISA/**BR**	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application N°
PCT/IB2013/055242

Patent documents cited in search report	Publication date	Patent family members	Publication date
US 4953144 A	1990-08-28	None	
US 4309576 A	1982-01-05	None	