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APPLICATION OF HOT BLAST PIPELINES MONITORING SYSTEM IN 5500M^3 BLAST FURNACE[1]

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Abstract

Using high hot blast temperature is a main trend of modern blast furnace operation, at the same time an effective and full-scale manual inspection tour of the hot blast pipelines including the hot blast main, branch pipes and bustle pipe, becomes increasingly difficult and time-consuming. Shougang Jingtang has two of China's most advanced blast furnaces with effective inner volume of 5500 m^3, and the hot blast temperature reaches 1300℃. To avoid the inadvertence during manual inspection, the hot blast pipelines monitoring system was developed based on wireless sensor networks technology. Two kinds of wireless sensors are used to measure the surface temperature and deformation of the pipelines, wireless repeaters and collectors are used for measurement data transmission to upper computer. So inspector can monitor the real-time safety status of the entire pipelines in central control room, and wireless automatic monitoring has been realized. The paper refers to the design and installation of wireless sensors, the structure of monitoring system and application effect with real-time curves. The monitoring results show that this system has a very high accuracy and sensitivity and provides objective measuring data for the pipeline status judgment, especially the deformation data coming from wireless displacement sensor are essential to research the dynamic stress variation of the pipelines. This system increases work efficiency obviously, ensures the safety of the hot blast pipelines and the stability of blast furnace production and has very high application and popularizing value.

Key words: Blast furnace; Temperature; Deformation; Monitoring.

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1 INTRODUCTION

Shougang Jingtang united iron & steel co., ltd. has two of China's most advanced blast furnaces with effective inner volume of 5500 m^3, also the first two blast furnaces using hot blast above 1300℃. High temperature reduced the coke rate greatly, and the technical and economic indexes of two blast furnaces have improved steadily[1]. Supply stably hot blast above 1300℃ has become an important guarantee of 5500m^3 blast furnace efficiency, economy and stability production, and the safety of hot blast pipelines is a key factor of that. On the other side, it is always lacking effective automatic monitoring tools for hot blast pipelines in China. Commonly we use manual inspection, and it is difficult to get real-time safety status of the entire pipelines. As high temperature and high pressure pipeline, safety accidents occurred frequently, such as deformation, cracking and blast leakage[2], even pipeline fracture, resulting in significant economic losses and casualties.

In order to avoid fluctuation of hot blast temperature, non-scheduled blow off and accidents because of the safety status of the hot blast pipelines, it needs to adopt automatic monitoring tools to measure the deformation and temperature of key position on pipelines real-time. At the same time, the pipe lines layout of hot blast system are complex and extensive under harsh environment, traditional wired sensor monitoring system is unsuited. So 5500m^3 blast furnaces of Shougang Jingtang developed a wireless monitoring system based on wireless sensor network (WSN) covering the entire hot blast pipelines, realized wireless automatic monitoring, obtained a very well monitoring efficacy.

2 METHODS AND SYSTEM FEATURES

Wireless monitoring system is a combination of wireless communication technology and sensor technology uses a large number of integrated sensors as WSN nodes. With features such as high density of sensor nodes, network topology changeable and low power consumption, WSN has a wide application in industrial monitoring [3]. In wireless monitoring system the common network includes GSM, GPRS, Bluetooth, RFID etc. using different frequencies. We find that the network based on 433MHz have many advantages on signal penetration, propagation distance, net nodes capacity, power consumption and cost, which is considered as the best choice for industrial application. The hot blast pipelines monitoring system also chooses 433MHz network achieving data communication.

The hot blast pipelines monitoring system is composed of wireless displacement sensor, wireless temperature sensor, wireless repeater, wireless data collector, network gateway, host monitoring computer and monitoring software. Avoiding signal jam, two blast furnaces use independent network, but only one monitoring computer and software.

Figure 1 shows the schematic diagram of monitoring system.

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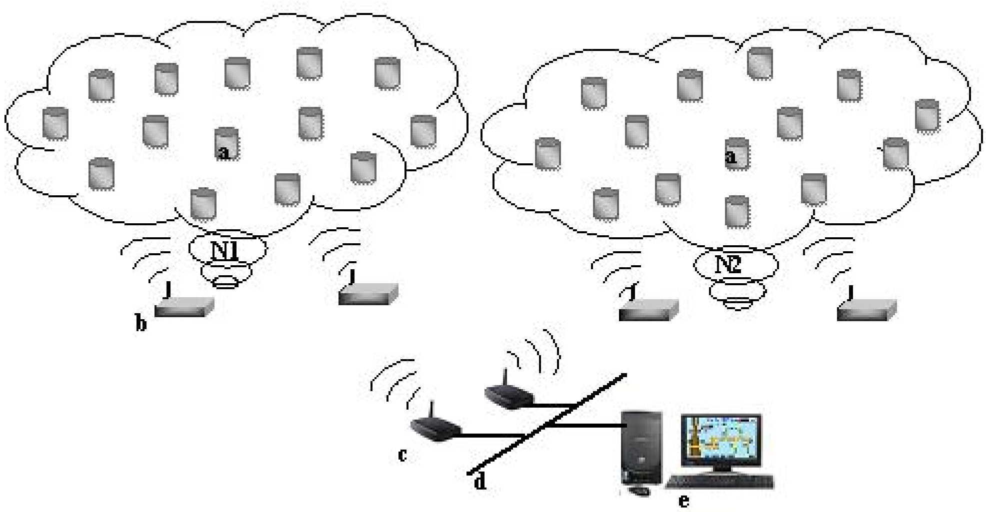
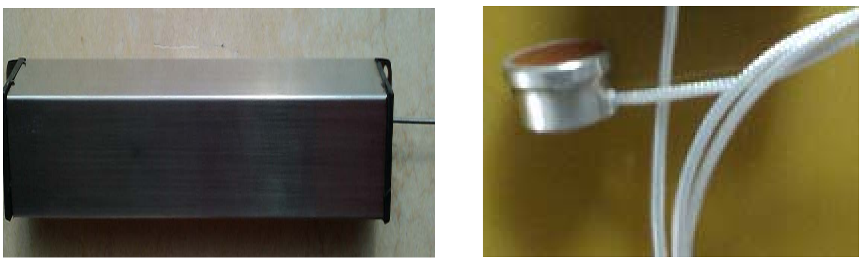


Figure 1. System schematic diagram.

Figure explication as follows:
a--Wireless Sensors (displacement and temperature)
b--Wireless Repeaters,
c--Wireless Data Collectors,
d-- Wireless/wired Gateway,
e--Monitoring Computer and Software,
N1-- WSN of No.1 BF,
N2-- WSN of No.2 BF.

Wireless displacement sensors, shown in Fig.2(a), using high-performance resistive displacement sensor measure the axial displacement of corrugated expansion joint on blast pipelines. Wireless displacement sensors are installed on the base plate welding on pipelines near to one side of corrugated expansion join, the measuring probe of displacement sensor gets to another base plate welding on pipeline near to another side of corrugated expansion join. To protect the sensor from heat radiation, the base plates keep some distance to the surface of pipelines.

Wireless temperature sensors, shown in Fig.2(b), stainless steel packaging, using high accuracy digital sensor measure the surface temperature of pipelines. Wireless sensors are installed under the flexible pressing plate welding on pipelines. Tightening the screws on the pressing plate, the sensor can impinge on the surface of pipelines, so the surface temperature measuring is achieved.



(a) displacement sensor **(b)** temperature sensor

Figure 2 Wireless sensors.

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Wireless repeaters are used for information transmission between wireless sensors and data collectors. Because of wireless sensors are installed on the complex pipelines and far away from the central control room (the farthest about 300m), every repeater manages a group of sensors nearby, so the network stability can be ensured. The quantity of wireless repeater is adjusted according to the layout of the sensors site.

Wireless data collectors are used for receiving the measuring data from the repeaters by antenna, and sending data into host computer by RJ45 network wire, are the interface between wireless network and wired system.

All wireless sensors are battery-powered and intermittent working, have battery voltage monitoring function. The measuring cycle can be software setting, we choose 60 sec. Wireless repeaters and collectors need work continuously, so use power supply.

Data package coming from wireless sensors includes the following information, the sensor ID, measuring data, battery voltage and verification code. Though integrated 433MHz communication module wireless sensors send data package to corresponding repeater, then repeaters send it to collector.

Host monitoring computer and software is the data terminal and the man-machine interface, achieves data recording, processing, analysis, display and alarm output. Monitoring software can display real-time monitoring data, the various curves, alarm status information and sensor battery voltage by monitoring interface, as shown in Fig.3, Fig.4 and Fig.5.

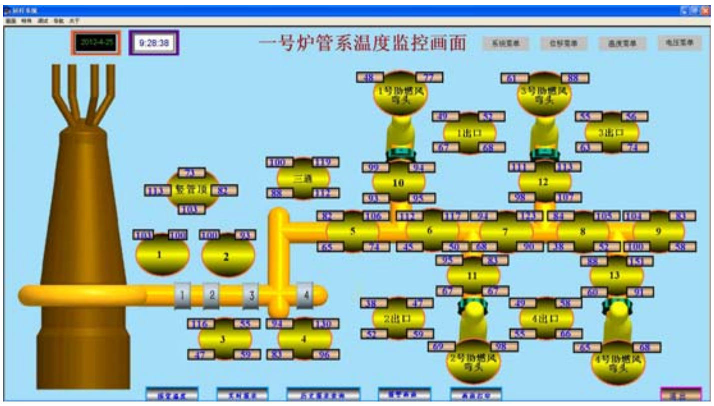

Figure 3 Pipelines temperature interface.

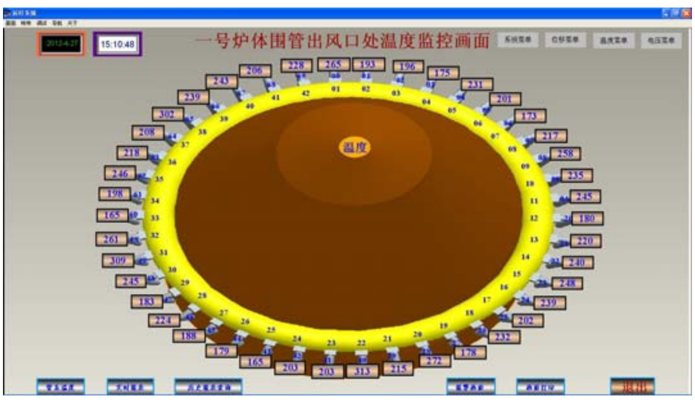

Figure 4 Ring pipe temperature interface.

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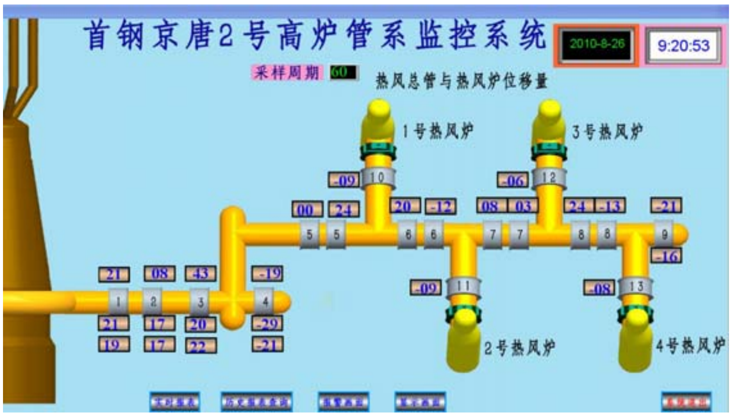

Figure 5 Deformation monitoring interface.

3 APPLICATION AND ANALYSIS

Firstly, we installed hot blast pipelines deformation monitoring system as a test, before the No.2 blast furnace blowing-in, on June 26, 2010. After parts of improvement, we completed all of installation work until Feb. 2012. It is basically of the same sensors quantity and installation site for No.1 blast furnace and No.2 blast furnace, including 26 wireless displacement sensors and 122 wireless temperature sensors every blast furnace. Also we prepared about 100 spare part every BF, could add monitoring points in future. Application results and data analysis as follows:

3.1 Surface Temperature Current of Hot Blast Main

In the hot blast main, there is always about 1300℃ blast, except for blowing-off, so the surface temperature of blast main shows a set of stability curves, as shown in Fig.6 (X-axis indicates surface temperature, Y-axis indicates time, the same as in Fig.7). From the measuring data, we find that the upper surface temperature of blast main is always higher than the bottom from about 20℃ to 60 ℃. Now the upper surface temperature is about 110℃, and the bottom is 80℃. If any surface temperature came to 250℃, system will give an alarm signal by changing the data color to red.

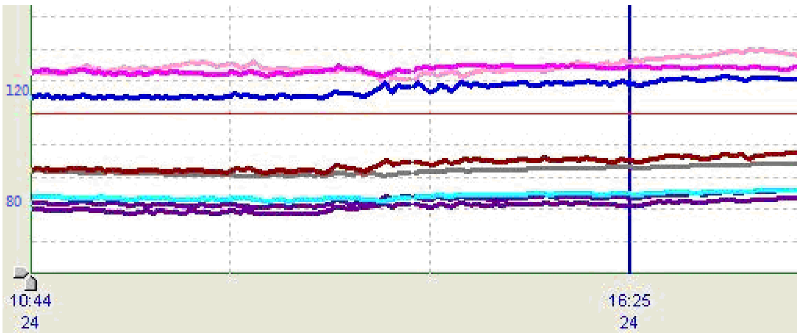

Figure 6 Surface temperature curves of hot blast main.

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3.2 Surface Temperature Current of Hot Blast Branch

Each BF is equipped with four BSK top combustion stoves, two burning and two supply blast. So in every hot blast branch, the surface temperature shows a set of wave curves, as shown in Fig.7. The uptrend curve means the stove is in burning period, and downtrend means in supplying blast period.

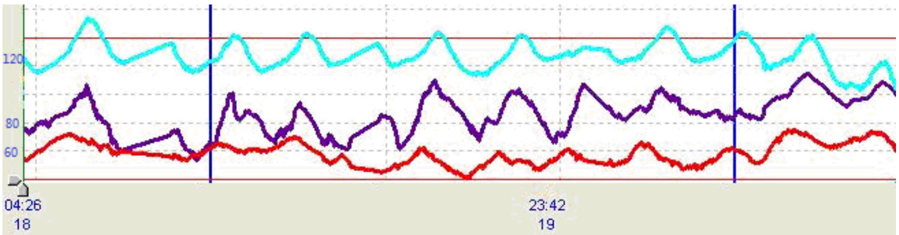

Figure 7 Surface temperature curves of hot blast branch.

3.3 Axial Deformation of Corrugated Expansion Joint on Blast Main

Axial deformation of corrugated expansion joint on blast main is always less than 30mm, and the curve shows two different shapes, coherence and symmetry, as shown in Fig.8 (X-axis indicates the output of displacement sensor, Y-axis indicates time, the same as in Fig.9). The value of the output of displacement sensor is different from the number displaying in Fig.5, because the displacement sensor has initial value when installed. In the blast main, there are several corrugated expansion joints, so the axial deformation in different corrugated expansion joints is synchronal flex. Two kinds of curves all means the blast main is in a well dynamic state process.

In Fig.8(a), three curves keep a highly coherence, whose data came from three displacement sensors installed on one corrugated expansion joint in proportional spacing. The uptrend and downtrend reflect the dynamic tensile and compressive process in blast furnace blowing-off and blowing-on.

In Fig.8(b), two curves keep a highly symmetry, whose data came from two displacement sensors installed in the same position of two corrugated expansion joints in together. One corrugated expansion joint was expending and another compressing, all in the same quantity.

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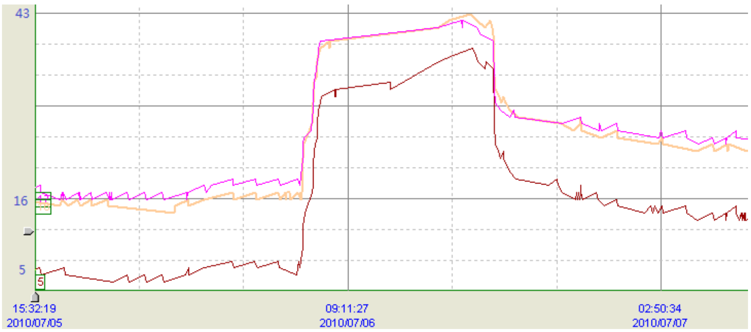
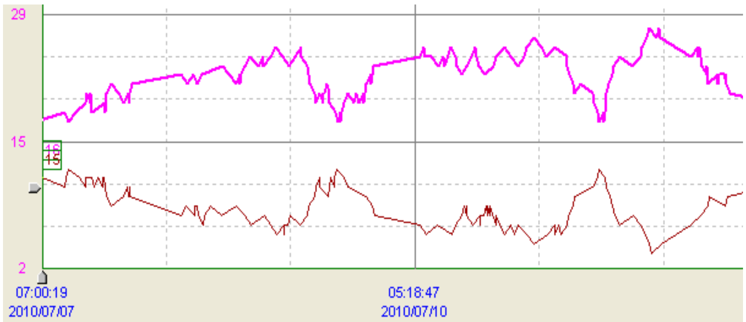


(a) Coherence curves



（**b**）Symmetry curves

Figure 8 Axial deformation of corrugated expansion joint.

4 VERTICAL DISPLACEMENT OF BLAST STOVES

Vertical displacement of blast stoves can reflect the deformation of stove body between burning period and supplying blast period. We found the quantity of vertical displacement is always less than 11mm. In Fig.9, two curves show the shapes of two symmetry pulse, whose data came from two displacement sensor installed on two stoves. One stove was in burning period, as the wave crest in pulse curve, and another was in supplying blast period, as the trough.

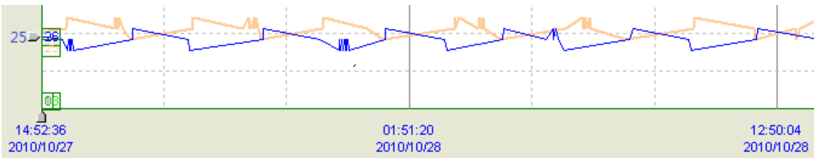


Figure 9 Vertical displacement curves of blast stoves.

5 GENERAL ESTIMATE

After running the hot blast pipelines monitoring system, the operator can monitor the safety status of the entire pipelines real-time in central control room. The monitoring results show that this system has a very high accuracy and sensitivity, For example, on July 6, 2010, No.2 blast furnace had a overhaul, at 6:35 blast furnace began to blowing-off, and 17:00 began to blowing-on, just as shown in Fig.8(a). Even

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the weather changing, such as raining and cooling, this system can monitor the temperature and deformation change of pipelines.

6 CONCLUSIONS

The hot blast pipelines monitoring system of Shougang Jingtang 5500m^3 blast furnaces achieved the automatic monitoring of blast pipelines surface temperature and deformation. This system provides objective measuring data for the pipeline status judgment, this is the first time in China, especially the deformation data coming from wireless displacement sensor are essential to research the dynamic stress variation of the pipelines. This system increases work efficiency obviously, ensures the safety of the hot blast pipelines and the stability of blast furnace production and has very high application and popularizing value.

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