DETECTION AND PREVENTION OF AIR LEAKAGE FROM SINTER PLANT EP

BY

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SYNOPSIS:

The function of double cone valve (DCV) below the electrostatic precipitator (EP) in sintering plant is for collecting the larger dust inside EP. The DCV leakage will reduce EP efficiency thus cause the dust emission from the stack. Therefore, it is quite important to replace the DCV appropriately for avoiding leakage owing to a longterm mechanical abrasion. In the past, the field staff determine this leakage by means of listening. However, it is time-consuming, laborious and not effective necessarily.

This study set up a capillary type of differential pressure gauge to DCV for examining the leakage situation. The criteria for determining leaked DCV and the patterns for replacing the DCV were proposed to offer field staff a basis of maintaining or renewing via a longterm observation of differential pressure.

Keywords: Double Cone Valve, Air Leakage, Differential Pressure Pattern, Electrostatic Precipitator

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1. Introduction

Iron ore sintering process is an agglomeration process to convert iron ore fines into lumpy agglomerates, which is charged into blast furnace as a major iron materials. Iron ore fines, fluxes and coke breeze are mixed with water to form granules, which is laid onto a moving sinter strand through a surge hopper, roll feeder and segregation device as a pack bed. The sinter strand moves along a series of windboxes, which are connected to a suction fan. The bed is first ignited from the top while airflow is sucked through the bed into the windboxes. In this way, coke breeze is combusted and the flame front progressively moves down the bed, and the fine particles of iron ores and fluxes are heated by burning coke breeze and melted. Therefore, a significant amount of waste gas including dust, sulfur oxides (SO$_x$) and nitrogen oxides (NO$_x$) are released to the air with a negative impact on the air environment. Electrostatic precipitators (EP), De-SO$_x$ and De-NO$_x$ systems have been installed to reduce exhaust emissions from sintering plants.

Double cone valve (DCV) is a kind of dust discharging valve of EP, the major function is for collecting the larger dust inside EP in sintering plant. DCV leakage will reduce EP efficiency thus cause the dust emission from the stack. Therefore, it is quite important to replace the DCV appropriately for avoiding leakage owing to a longterm mechanical abrasion. In the past, the field staff determine this leakage by means of listening. However, it is time-consuming, laborious and not effective necessarily. This study was aimed to set up a gauge and a method for examining the DCV leakage as indicator to timely replace the DCV.

2. Experimental Procedures

A capillary type of differential pressure gauge was installed on the DCV below the EP of NO.4 sinter plant in CSC. It was examined by identifying the pressure pattern to detect air leakage inside discharging valve and the stability of the device during the periodic operation of DCV. The sensor of differential pressure gauge was mounted directly external to the pressure source to measure pressure variation (input), then the digital signals (output) was transmitted to microcomputer by the capillary. The main advantage was that no dust clogged the pipe conveying the pressure signal
to general pressure transmitter. However, if a large amount of dusts or pollutants appeared in the pressure source, the sensor may be polluted and worsening the measurement accuracy. Therefore, the franges (embedded sensors) were used to connect to DCV in 45-degree angle down for reducing dust pollution. (Fig. 1)

3. Theoretical analysis

The geared motor drives the roller rotation periodically, and the roller drives the mechanical arm connecting the above and below discharging valve of DCV, which discharges the dust particles caught from EP in the operation cycle as following:
(a) Top and bottom cone both remains closed and materials are collected over top cone.
(b) Top cam opens and closes with bottom cam remaining closed. As soon as the geared motor starts, the roller will push the top cam lever to rotate along with the spindle thus opens the top cone and allow the materials to fall and be collected over bottom cone. As soon as the roller leaves the cam lever, the top valve closes completely.
(c) Top and bottom cone remain closed during the intermediate span of roller travel before it touches the bottom cam lever.
(d)Bottom cam opens while top cone remains closed, and discharges the collected materials. The smooth closure of the bottom valve cone will be similar to that of the top cone.

The schematic diagram is shown as Fig.2. From the diagram, the theoretical pressure pattern inside DCV can be predicted as Table 1 and Fig.3.

4. Results and Discussion

4.1 The conversion of digital signal and differential pressure

The range of direct current (DC) signal and differential pressure were 4-20 mA and 0-6000 mmWC, respectively. The equation for the calibration curve is shown as following.
Differential Pressure (mmWC) = 375000 \times (\text{DC signal}) - 1500 \quad (1)

4.2 Analysis of differential pressure

The variation of differential pressure inside DCV is shown in Fig. 4. The absolute value of negative pressure inside top cone is lower when the air leakage in top cone has become more serious, and the value of differential pressure at “a” point in Fig.4 is shown to be lower. The air leakage degree in top cone can be displayed as curve i and curve ii. Curve ii means a more serious air leakage has occurred in top cone because of the sudden decline of differential pressure. On the other hand, the negative pressure inside bottom cone is decreased due to the larger air leakage in bottom cone, and the “b” point in Fig.4 also shows the lower differential pressure. Similarly, the curve iii and curve iv indicate the air leakage degree in bottom cone, curve iv shows a larger air leakage has occurred in bottom cone due to the sharply ascent of differential pressure.

Fig.5 shows the diagram of variation of differential pressure inside DCV as a function of time in DCV operation cycle. It is time to take replacing DCV into consideration when either curve I or curve II occurs, or they both occur at the same cycle for a period of time. Therefore, the main criteria to judge the serious air leakage in DCV are enough low value of “a” point and “b” point in Fig.5, in addition, curve I and curve II are also on the concave in Fig.5.

4.3 Stability test of differential pressure gauge

The stability test was mainly to observe the signals decay of differential pressure after installing the pressure gauge for a period of time. Fig. 6 shows the comparison of initial measured data and the data after installing for six months. The result indicates the difference is insignificant, that means the sensor is not affected by dust pollution. It is also proved that the device can maintain its function under the conditions of dust and vibration inside DCV more than six months. As the replacement cycle of DCV is three to six months, thus, the dust on the sensor inside DCV can be cleaned at the same time to resume the function of air leakage monitoring by reusing the differential pressure gauge.

4.4 Comparison of actual measurement and theoretical analysis

Fig. 7 shows the measured data from May to November in 2008, it illustrates that
the pattern of differential pressure changes gradually with time, and the most obvious change is that the time of high differential pressure increases in per operation cycle. This measured result can be explained from the pressure pattern (III) in Fig.3, which means the top cone has had an air leakage. (It can be seen in curve 8/30, curve 10/15 and curve 11/25.) As to the degree of air leakage, comparing the curve 10/15 and curve 11/25 in Fig.7 with the pressure pattern (I) in Fig.3, it demonstrates that the degree of air leakage inside top cone is more serious along with operation time.

4.5 Observation after removing DCV

In order to understand what factors contribute to air leakage inside DCV, the DCV was removed to observe the surface of the cones when the pattern of differential pressure was appearing like the curve 11/25. Two cases can be found between the cone and its above contact ring, that is, mechanical abrasion or dust accumulation as Fig. 8. Further investigated the main mechanism for air leakage, the removed DCV (which was not cleaned) was reinstalled, then observing the water leakage by pouring water from the top of DCV. Similarly, the case of cleaned DCV was also tested. The results displayed that both cases were obvious water leakage as Fig. 9, however, the latter case was more serious. It can be deduced that the main factor causing air leakage is the gap between the metal cone and metal ring due to the mechanical abrasion. Hence, the criteria for determining leaked DCV and the patterns for replacing the DCV were developed and proved in this study, and it has been proposed to offer field staff a basis of maintaining or renewing via a longterm observation of differential pressure.

5. Summary and Conclusions

The capillary type of differential pressure gauge was installed and long-time examined on the DCV below the EP of NO.4 sinter plant at CSC, the conclusion can be drawn as following.

(1) It is proved that the differential pressure gauge can maintain its function under the conditions of dust and vibration inside DCV up to six months or more.
(2) The main criteria to judge the serious air leakage in DCV are developed, and it is
(3) The main factor causing air leakage is the gap between the metal cone and metal ring due to the mechanical abrasion.
(4) The criteria for replacing the DCV have been proposed to offer field staff a basis of maintaining or renewing, and it is expected to promote EP efficiency and reduce the dust emission from the stack.

6. References
Figure 1. Installing of differential pressure gauge on the DCV in CSC NO.4SP

(a) Top cone close, bottom cone close  
(b) Top cone open, bottom cone close  
(c) Top cone close, bottom cone close  
(d) Top cone close, bottom cone open

Figure 2. The diagram of DCV operation cycle
Table 1. Theoretical pressure variation inside DCV in operation cycle

<table>
<thead>
<tr>
<th>DCV leakage</th>
<th>Pressure variation</th>
<th>Top cone close Bottom cone close</th>
<th>Top cone open Bottom cone close</th>
<th>Top cone close Bottom cone close</th>
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<td>Bottom cone</td>
<td>Pa</td>
<td>Pa</td>
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<tr>
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<td>Pa</td>
<td>Pa</td>
<td>Pa</td>
<td>Pa</td>
</tr>
<tr>
<td>Top cone normal</td>
<td></td>
<td>Top cone</td>
<td>(Pa +αP_{EP}, 0&lt;α&lt;1) to (Pa +P_{EP})</td>
<td>(P_{EP}+Pa) to Pa</td>
<td>Pa</td>
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<td>Bottom cone</td>
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<td>Pa</td>
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<tr>
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※ Pa : Atmospheric pressure,  P_{EP} : Negative pressure of EP
   α : Leakage parameter of bottom cone,  β : Leakage parameter of top cone

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Figure 3. Diagram of theoretical pressure pattern inside DCV (Y direction) versus operation cycle (X direction)
Figure 4. Diagram of air leakage degree of DCV by observing pressure pattern

Figure 5. Diagram of pressure pattern for judging the time to replace DCV

Figure 6. Comparison of initial measured data with the data after installing differential pressure gauge for six months
Figure 7. Observation of measured data from May to November 2008

(a) Mechanical abrasion
(b) Dust accumulation

Figure 8. Observations after removing DCV

(a) Removed DCV is not cleaned
(b) Removed DCV is cleaned

Figure 9. Observation of water leakage by adding water from the top of DCV

(a) Removed DCV is not cleaned
(b) Removed DCV is cleaned