Measurement and Analysis of Performance of 2# Main Ventilator of East Two Shaft in Yaoqiao Coal Mine

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Abstract. According to the existing conditions of the fan installation, we used precision barometer equipment and static pressure method to make a performance test about anti-explosion extraction axial fan in East Two Shaft under the condition of no shut down. According to the parameters of the test, we drew the performance curve of output power, wind pressure, efficiency and air volume about main fans of East Two Shaft in Yaoqiao Coal Mine. By measuring the results and analyzing data, it indicates that the main ventilator is in a good performance to meet the needs of air volume of East Two Shaft. To ensure the safe and economic operation of the main fan, the corresponding improvement measures aiming at the existing shortcomings of the ventilation system of East Two Shaft are put forward. The test method and results of the ANN-2500/1250 fan performance test have certain reference significance for the test of the similar axial fan.

Introduction

Yaoqiao coal mine has been put into production for nearly 40 years, and after many reconstructions, its production has reached 4 million tons per year and its exploiting level has increased to three levels: -400m, -650m level, and the exploiting -850m level. In order to adapt the increasingly complex production systems, it has dug seven shafts to ensure the ventilation smooth because of the long route, lots of ventilation facilities and the more complex ventilation system.

The mixed ventilation way is four into three out, namely two pairs of the main and auxiliary shafts in central of -400m level and -650m level intaking air, and returning air by west air shaft in the boundary of the west wing of the mine field, East Two air shaft in the boundary of the east wing of the mine field and East One air shaft in the central border of the Mine Field. Two ANN-2500/1250-type axial fans are installed in East Two air shaft. The fan performance measurement not only meet the requirements of the Coal Mine Safety Regulation provisions, that “the measurement of the fan performance must be conducted at least once every five years”, but also grasp the relevant operating parameters and the performance of the main fans. The fan identification not only helps to be familiar with the mine ventilation management status and scientific management of mine ventilation, but also provide a reliable technical basis for the optimal adjustment, reforming of the future mine ventilation system and development and implementation of the security and technical measures [1]. On the basis of the measurement results, it can evaluate the safety performance of the fan and analyze the matching situation between the fan and the underground network [2].
Measurement Work Arrangement

Measuring Plan

To not affect the mine production, this measurement used the short-circuit method of ground airflow to measure fan’s performance. Namely firstly 2# fan in charge of the normal ventilation underground, turn off the standing gate of 1# fan to separate the ventilation circuit, in order to measure 1# fan’s performance measurement. After the 1# fan measurement is completed, swapped to measure the 2# fan’s performance measurement in the same way above.

When the measurement started, the airflow started flowing through the level gate (0-0 section) of the 1# fan, the fan drift (sections 1-1), the 2-2 section and the fan in turn, then into the atmosphere from the diffuser, shown in Figure 1.

![Figure 1. The schematic diagram of performance measurement of ventilator.](image)

Air volume is one of the main parameters which reflect the merits of coal mine’s performance of main ventilator and the main basis to select the main fan for the coal mine. The air volume measurement is one of the most important links of the main fan’s safety technology performance measurement of the coal mine. Whether the measurement of the air volume is exact or not can affect the success or failure of the main fan’s safety technology performance measurement of the coal mine directly. Taking the stability air speed in the air flue section of the Yaoqiao Mine measured fan, the larger difference area between the sections (the ratio of section 2-2 and section 1-1 is 31.9%), and easy to lead to static pressure nozzles into account, it was suitable for using the static pressure method to measure the air volume.

In the section 0-0 of the 2# fan, regulate working conditions by increasing or decreasing the level of air inlet. Arrange uniformly points in sections 1-1 and 2-2 to measure the relative static pressure. Since section 1 is close to section 2 and approximately in the same elevation, the equations are $\rho_1 = \rho_2 = \rho$, $h_1 = h_2$. According to the energy equation and the energy conversion relations between section 1 and 2, the formula to calculate the main ventilator is as follows:

$$Q = \alpha \sqrt{\Delta h_{s12}}$$  \hspace{1cm} (1)

where, $\Delta h_{s12} =$ Static pressure difference between section 1 and section 2, Pa; $\alpha =$ Coefficient, according to the field calibration, it can also be calculated by the following formula approximately:
\[ \alpha = k \sqrt{\frac{2gS_1^2S_2^2}{\rho(S_1^2 - S_2^2)}} \]  

(2) k = Loss coefficient of dynamic pressure, normally 0.98; \( S_1, S_2 \) = Area of section 1 and 2, m²; \( \rho \) = Air density, kg/m³.

The axial fans generally require measuring the static pressure characteristic curve. Select the measure point in the vicinity of section 2-2, and measure the relatively static pressure \( h_s \). The fan’s static pressure is \( H_s \):

\[ H_s = h_s - h_v. \]  

(3) where, \( h_v \) = the average dynamic pressure of pressure measurement section, and usually measured through the measurement of the air volume to calculate the average air speed.

Record the specific time of each measurement and use the barometer to measure the ambient atmospheric pressure changes, while measuring the wet and dry temperatures of the section 0-0. Starting the fan in fully open state, change the air inlet section’s area gradually according to the need until the minimum amount of air intake, and complete the measurement.

**Measuring Steps**

1. Before measurement: Organize the labor division based on the measurement program.
2. Measurement procedure: after all preparations are ready, start the fan and use the horizontal gate to adjust windage. Gradually increase wind resistance of axial fans. The level of the door fully opens when fans start. After the airflow is stable (about 3-5 minutes after starting the fan), start to measure and read measurement parameters. Then gradually increase the wood by adjusting the air inlet area to increase wind resistance on the purpose of adjusting the fan working condition. After the measurement data of a working point have all been measured, regulate working conditions and then read the values of the parameters, until the entire curve measured (typically not less than 8 to 9 measurement points. Finally stop the fan.

In order to prevent excessive pressure which can cause the wood fracture and damage the fan, especially placed 10 rails at the level of the air inlet door to prevent wood compression fracture and protect the fan.

While the door’s resistance increasing, we should pay close attention to changes in the fan pressure and motor current. When the fan goes near the maximum pressure value or the current reaches the rated current, surge shock phenomenon of the fan may occurs, and you should immediately stop the fan’s operation \(^{[4, 5, 6]}\).

3. Data collection and analysis: Input the data in the computer or calculate the measurement manually. Organize and plot, analyze the results, and complete the measurement report.

**Determination Results**

1. Given that the measured fan is an axial flow fan, it should start at the maximum air volume (operating mode adjustment section fully opens) in order to avoid an overload situation.

2. While measuring performance, the temperature and current fluctuations of the motor are monitored closely. When the motor temperature or current fluctuations approach and exceed the normal range, the electromechanical driver or person in charge of the fan must stop immediately to ensure fan safety\(^{[7]}\). If other dangers threaten the fan (including motor) safety, they should immediately stop and interrupt the measuring work.

3. Irrelevant personnel are prohibited to walk near the conditions regulator in the process of the performance measurement.

4. Check off the rigor between the vertical gate which is used to separate the underground airflow and measure the airflow before the measurement. Design plugs leakage in order to reduce the impact of the work on the underground and ensure mine production safety.

5. Pitot (piezometric tube) in the section should be fixed firmly, not skewed, connected hoses should be fixed firmly to avoid shaking or shedding \(^{[8]}\).
The Measurement Results and Analysis

The measurement of East Two air shaft main fan of atmospheric parameters and electrical parameters are shown in Table 1.

<table>
<thead>
<tr>
<th>Static pressure section1 (m²)</th>
<th>Static pressure section2 (m²)</th>
<th>Synchronous speed(r/min)</th>
<th>Rated current (A)</th>
<th>Rated power (kW)</th>
<th>Blade angle (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.6</td>
<td>3.7</td>
<td>994</td>
<td>116</td>
<td>1000</td>
<td>43</td>
</tr>
</tbody>
</table>

Input the measured data in the computer. After calculating and finishing, give the final result as shown in Table 2. According to the formula (4), calculate the fan’s efficiency:

\[ \eta = \frac{Hs \cdot Q}{1000 \cdot N} \]  \hspace{1cm} (4)

where: \( \eta \) = Fan’s efficiency; \( Hs \) = Fan’s pressure, Pa; \( Q \) = Fan’s volume, m³/s; \( N \) = Fan’s axial power, kw.

<table>
<thead>
<tr>
<th>Number</th>
<th>Fan’s volume (m³/s)</th>
<th>Fan’s pressure (Pa)</th>
<th>Axial power (kW)</th>
<th>Fan’s efficiency (%)</th>
<th>Fan’s speed (rpm)</th>
<th>Vibration acceleration (m/s²)</th>
<th>Vibration velocity (mm/s)</th>
<th>Vibration displacement (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>193.8</td>
<td>371.1</td>
<td>310.7</td>
<td>23.1</td>
<td>998.5</td>
<td>6.1</td>
<td>2.1</td>
<td>21.0</td>
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<td>2</td>
<td>189.7</td>
<td>667.4</td>
<td>336.7</td>
<td>37.6</td>
<td>1002.0</td>
<td>6.6</td>
<td>2.4</td>
<td>18.0</td>
</tr>
<tr>
<td>3</td>
<td>180.5</td>
<td>1150.9</td>
<td>366.8</td>
<td>56.6</td>
<td>997.3</td>
<td>5.7</td>
<td>2.2</td>
<td>20.0</td>
</tr>
<tr>
<td>4</td>
<td>177.4</td>
<td>1245.1</td>
<td>377.6</td>
<td>58.5</td>
<td>998.4</td>
<td>5.5</td>
<td>2.2</td>
<td>26.0</td>
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<tr>
<td>5</td>
<td>171.6</td>
<td>1578.3</td>
<td>402.2</td>
<td>67.3</td>
<td>997.9</td>
<td>5.6</td>
<td>2.0</td>
<td>24.0</td>
</tr>
<tr>
<td>6</td>
<td>154.5</td>
<td>1867.1</td>
<td>413.8</td>
<td>69.7</td>
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<td>2.1</td>
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<td>7</td>
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<td>430.8</td>
<td>75.3</td>
<td>998.6</td>
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<td>73.7</td>
<td>998.1</td>
<td>5.7</td>
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<td>120.0</td>
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<td>4.5</td>
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<td>2555.5</td>
<td>429.4</td>
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<td>998.1</td>
<td>5.8</td>
<td>2.6</td>
<td>22.0</td>
</tr>
</tbody>
</table>

Notice: Data in the table are from actual measurement.

According to the data obtained in Table 2, draw 2# main ventilator output power, air volume characteristic curve and air volume, air pressure and efficiency characteristic curve. As shown in Figure 2 and Figure 3.
Combining with Tables 1 and 2 and Figures 2 and 3, it can be seen that the East Two air shaft main fan has a good operating performance. (1) Ventilator fan increasing the diffuser, silencer facilities, thus results in increased resistance. After the long-time running, each passage components fouling and corrosion of the impeller cause fan performance decreasing.

(2) After measuring ventilation resistance of Yaoqiao coal mine, the East Two air shaft system resistance is 2354.0 Pa and return air volume is about 133 m³/s. Fans actual air conditions in the current run is greater than the theoretical air amount required because the underground tunnel deformation disrepairs or the nose and tail of the conveyor overlap joint that affects the effective ventilation section, causing too large local ventilation resistance, coupled with external leakage.

(3) Under current operating conditions, the main fan and the wind net basic match with high efficiency and can reach more than 70%, meeting the needs of the mine air volume.

Conclusions
(1) Through this measurement, the actual performance parameters and the actual characteristic curve of the ventilator device was measured, which provides a reliable theoretical basis for ensuring its safe and efficient operation and air volume adjustment. Given that the fan manufacture date and installation time is too long, and we cannot get the fan’s factory performance curve, so lack comparative information with the results of this measurement. However, the measuring result shows that the fan runs well at the current operating point and there is still a certain margin to meet the current production needs.

(2) In the process of the measurement, do not stop production and at the same time adjust working conditions by increasing the board which is simple, time-saving and high efficient.

(3) According to the operating environment of the East Two axial fans, the choice of the static pressure method measuring the amount of air is feasible, practical and reliable.
(4) East Two air current has a similar place of a right angle, resulting in large local loss and some energy consuming, which tell us that mines should try to avoid such problems.

(5) When the fan starts, the actual motor power consumption is 6-7 times as the normal operation. Moreover, the power of axial main ventilators decreases with an increase of air volume, so firstly open the level gates and fans start to work with the maximum of air volume and minimum of air resistance. When the fan speed is normal, stamp wood on the frame gradually to adjust the operating point.

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References


