A new type of linear position measuring equipment for circuit breaker

Wang xiaohuan$^{1,a}$, Li xiaozhao$^{2,b}$, Li jianbing$^{3,c}$ and yanzizi$^{4,d}$

$^{1,2,3,4}$TIANJIN PINGGAO INTELLIGENT ELECTRIC CO., LTD. Tianjin 300300, The People's Republic of China

$^a$15222056365@163.com, $^b$lixzpg@126.com, $^c$cljbpg@163.com, $^d$yanzzpg@126.com

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Abstract: Opening or closing speed characteristics is one of the vacuum circuit breaker’s important performance indexes. A new type of linear position measuring equipment in this paper can overcome the disadvantages of occupying large space and relative position sliding between the linear position sensor and measuring equipment under traditional installation, realize the real-time monitoring of three-phase mechanical characteristics of vacuum circuit breaker, so as to accurately reflect the opening or closing speed, at the same time, it reduces the installation space required by the linear position sensor. It provides a feasible scheme for measuring the mechanical characteristics of vacuum circuit breaker in limited space.

Introduction

Vacuum circuit breaker in the power system is an important controlling components, having small volume, light weight, long life, high reliability, short arc time, no fire and explosion danger, simple maintenance, and a series of advantages, it is an important means to ensure the normal operation of power system [1-2]. The automation and intelligent of the vacuum circuit breaker are the foundation of the intelligent electrical equipment, widely used in medium pressure indoor places. Mechanical characteristics of vacuum circuit breakers are important indicators to characterize the performance of vacuum circuit breakers [3-4]. In the mid-1990s, researchers began to measure the mechanical characteristics of vacuum circuit breakers using photoelectric sensors (such as grating sampling rule and rotary Angle encoder, etc.). Due to factors such as manufacturing technology level and manufacturing cost, the sensor response speed was slow and cannot accurately measure the contact motion characteristics of vacuum circuit breakers [5]. Some professionals was exploring some new detection methods, such as infrared laser ranging, [6] of ultrasonic field acceleration sensor detection and the use of light reflex migration principle of non-contact testing way at present, the displacement sensor on-line monitoring mechanical characteristics of vacuum circuit breaker [7-15] is currently one of the commonly used method [16-19]. However, As the structure size of the vacuum circuit breaker is small and the size of the measuring mechanism is relatively large, it is difficult to install the linear position sensor on the three-phase of the vacuum circuit breaker in the conventional way, and the reliability is low, which increases the difficulty of real-time monitoring and control of the vacuum circuit breaker[20]. In order to solve the position sensor on-line monitoring problem of vacuum circuit breaker mechanical characteristic, In this paper, a new measuring device of linear position sensor is designed, which can realize on-line monitoring of mechanical characteristics of vacuum circuit breaker by using small mounting space.

Technical scheme and implementation method

At present, the traditional installation method of linear position sensor is to fix the enclosure directly on the equipment by fixing the clamp or using bolt connection, as shown in figure 1. When the linear position sensor is fixed in the traditional way, when the linear position sensor moves at a higher speed, the relative displacement between the linear displacement sensor and the fixed part is
easy to occur due to the thin thickness of the fixed clip and the small depth of the stuck groove. As a result, the position measurement data is not accurate and the stability and reliability of the linear displacement sensor is reduced.

In order to overcome the disadvantages of the traditional installation method, a new position measuring equipment based on the linear displacement sensor is designed in this paper. The equipment structure is shown in figure 2. The overall structure is composed of mounting base, sensor, liquid rubber, auxiliary slide block, movable slider and slide column.

![Figure 2](attachment:image2.png)

**Fig. 2** The new measurement equipment of linear displacement sensor

Reliability test verification

In order to verify the measuring reliability of the new linear position measuring equipment, the traditional installation method and the new installation method are respectively used to compare the test using the existing test platform of the unit. Prototype 1 and prototype 2 vacuum circuit breaker in the same state were used as test carriers, and sensor A and sensor B were installed successively on prototype 1 and prototype 2. Sensor A was installed in the traditional installation mode (as shown in figure 1), and sensor B was installed with the new linear displacement measuring device (as shown in figure 3). In the test process, it is guaranteed that prototype 1 and prototype 2 are operated separately under the same external environment, and the data is read through the sensor for comparative analysis.
Through comparison test, the mechanical characteristic parameters of prototype 1 and prototype 2 were obtained. The measurement results are shown in table 1 and table 2. According to the measured data in the table, the opening speed of the two installation methods was analyzed. In the prototype 1, the average opening speed was 2.156m/s, and the average opening speed was 2.186m/s. The maximum difference of sensor measurement data under the two installation methods is 0.1, and the maximum error rate is about 4.7%. In the prototype 2, the average tripping opening speed was 2.08m/s, and sensor B was 1.996m/s. The opening speed of the two installation methods was 0.084m /s, and the average error rate was about 4.2%. The maximum difference between the two sensors is 0.13 and the maximum error rate is about 6.6%. According to the comparison of test data, two prototypes were drawn to measure the opening speed curve under different installation methods, as shown in figure 4.

### Table 1 The mechanical characteristic parameters of the prototype 1 with different installation

<table>
<thead>
<tr>
<th>Parameter requirements</th>
<th>Measuring project</th>
<th>Contact stroke</th>
<th>Opening Speed (0~12mm)</th>
<th>Switch off oscillation</th>
<th>Switch on oscillation</th>
<th>Closing speed(6m-contact making)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>18±1 mm</td>
<td>1.6~2.3 m/s</td>
<td>≤3 mm</td>
<td>≤3 ms</td>
<td>1.2~1.8 m/s</td>
</tr>
<tr>
<td>sensor A</td>
<td>1</td>
<td>18.76</td>
<td>2.12</td>
<td>2.17</td>
<td>0</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>17.79</td>
<td>2.15</td>
<td>2.22</td>
<td>0</td>
<td>1.46</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>17.90</td>
<td>2.22</td>
<td>2.08</td>
<td>0</td>
<td>1.47</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>17.11</td>
<td>2.13</td>
<td>2.11</td>
<td>2.0</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>18.10</td>
<td>2.16</td>
<td>2.05</td>
<td>0</td>
<td>1.47</td>
</tr>
<tr>
<td>sensor B</td>
<td>1</td>
<td>17.44</td>
<td>2.18</td>
<td>2.14</td>
<td>2.0</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>17.53</td>
<td>2.11</td>
<td>1.82</td>
<td>0</td>
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<tr>
<td></td>
<td>3</td>
<td>18.06</td>
<td>2.28</td>
<td>2.40</td>
<td>0.5</td>
<td>1.48</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>17.90</td>
<td>2.23</td>
<td>2.39</td>
<td>0</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>18.35</td>
<td>2.13</td>
<td>2.39</td>
<td>0</td>
<td>1.48</td>
</tr>
</tbody>
</table>

The closing speed of prototype 1 and prototype 2 was analyzed. The average closing speed of sensor A in prototype 1 was 1.446m/s, and the average closing speed of sensor B was 1.456m/s, difference of both is 0.01 m/s. The average error rate was about 0.7%. The maximum difference between the two sensors is 0.07, and the maximum error rate is about 4.9%. In prototype 2, the average closing speed of sensor A was 1.588m/s, and the average closing speed of sensor B was 1.688m/s, difference of both is 0.1m /s, and the average error rate was about 6.3%. The maximum difference between the two sensors is 0.13, and the maximum error rate is about 8.3%. According to the closing speed parameters in table 1 and table 2, the closing speed curves of the two samples under different installation methods were drawn, as shown in figure 5.
In the comparison test, the mechanical characteristics of the prototype were measured by the traditional installation mode and the new installation mode respectively. According to the parameter requirements set by the arc-extinguishing chamber of the core part of the vacuum circuit breaker, the mechanical characteristics measured by the two vacuum circuit breakers of prototype 1 and prototype 2 met the technical requirements. According to the data in table 1 and table 2, the maximum error rate of the measurement data of the opening and closing speed of the vacuum circuit breaker is about 8.3%. The measurement error of the two ways is mainly caused by the difference in the total travel of the vacuum circuit breaker during each time of opening and closing operation, resulting in the difference in each measurement data. The possibility of relative sliding between the sensor and the object under test in the traditional installation, will also cause measurement error. Ignoring the minor error caused by different mechanical characteristics and fixed modes, sensor B with new installation mode can achieve the same measurement effect as sensor A with traditional installation mode. Therefore, the new linear displacement measurement device can complete the mechanical characteristic measurement of vacuum circuit breaker in a small space under the condition of overcoming the disadvantages of the traditional installation mode of poor reliability and stability.

Table 2 The mechanical characteristic parameters of the prototype 2 with different installation
Conclusion

(1) Based on the analysis of the shortcomings of traditional measurement methods, a new linear position measuring equipment is designed according to the practical engineering requirements. This measuring equipment reduces the installation space required by the linear position sensor and improves the reliability and stability of the measuring equipment.

(2) Through comparison test, it is proved that the new linear position measuring equipment can realize real-time on-line monitoring of the three-phase mechanical characteristics of the vacuum circuit breaker, and reflect the mechanical characteristics of each phase, which is conducive to the integration of the online measuring equipment and the vacuum circuit breaker, and has certain reference value for practical engineering.

References


