Analysis on Data Characteristic and Mechanism of Wind Vibration Disaster of Power Transmission Line

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Abstract. In this paper, characteristic identification and mechanism analysis on wind vibration disaster of power transmission line are carried out by using the data driving method. To provide technical support for prevention and control of wind vibration disaster to power transmission line, statistics are made in this from three dimensions, i.e. meteorology & geology, line structure and disaster characteristics to the wind vibration data of power grid conductors. Then frequency distribution characteristics of wind vibration disasters for conductors under different parameter conditions has been analyzed, and the correlation between various factors and wind vibration disasters according to analysis results has also been discussed.

1. Introduction
A certain recording data of wind vibration disasters of conductors in China has been accumulated [1-2] during the running of power transmission line over years, including structural and non-structural data of multiple types, such as character, table and picture, and the types of wind vibration disaster involve aeolian vibration[3], sub-span oscillation[4] and windage yaw[5]. In recent years, under the background of power grid intelligence and energy network development, it is urgently necessary to implement deep exploration and machine learning to data of conductor wind vibration disasters, so as to realize the characteristic identification and mechanism analysis on wind vibration disasters of conductors of power transmission line from the perspective of data driving [6], thus providing technical support for prevention and control of wind vibration disasters of power transmission line.

This paper will sort the recording data of several typical types of wind vibration disasters of conductors of power transmission line such as aeolian vibration, sub-span oscillation and windage yaw, make statistics of data distribution characteristics from meteorological and geological environment parameters and line structure parameters, and talk about the relationship between wind vibration disasters of conductor and the environmental and structural parameters.

2. Statistical Rule of Disaster Data Information
The fault recording information about wind vibration disasters of conductors collected in this paper includes three types of data, i.e. aeolian vibration, sub-span oscillation and windage yaw, and the quantity of collected data is 191 pieces in total. The data time distribution is relatively wide, and the data contents mainly include basic information of line, meteorological and geological information, conductor structural parameters and description of three kinds of wind vibration disasters.

The basic information of line includes line name, voltage class, terrain (plain, mountainous region and hill), altitude (grading as per height), line tendency and years of operation; the meteorological
information includes wind speed, wind direction, included angle between wind direction and line, temperature, humidity, precipitation type, conductor ice coating thickness; and structural parameters of conductor include quantity of loops of pole tower (single loop and double loops), conductor model, conductor arrangement mode, and quantity of conductor ] bundles (single-bundle, two-bundle, four-bundle, and six-bundle); the description of wind vibration disaster information includes disaster occurrence duration (insulation windage yaw duration, aeolian vibration duration, sub-span oscillation duration), section No., pole tower No., span, and anti-vibration device installation situation, spacer installation situation, windage yaw angle, insulator type, ground wire model, anti-vibration device type, damage type (conductor or ground wire breaking, strand breaking, and anti-vibration device), spacer distance, quantity of spacers, tripping or not, description of other faults (machinery, electrical apparatus, etc., including fault distance measurement, damage detail description, etc.), and description of adopted measures.

Targeting artificial recording data, conduct quantitative processing to the descriptive language in the Table, and the table corresponding to the processing is as shown in Table 1.

| Name of Parameter                         | Example | Formatting Rule                           |
|------------------------------------------|---------|------------------------------------------|
| Line Tendency                            | 0       | The due east refers to 0°, and the angle refers to antilockwise direction. |
| Wind Speed                               | 25.7    | Unit: m/s, set comparison table          |
| Wind Direction                           | Northeast |                                            |
| Included Angle between Wind Direction and Line | 55     |                                            |
| Temperature                              | 2.5     | Unit: °C                                  |
| Humidity                                 | 90%     | Percentage                                |
| Precipitation                            | 20      | Unit: mm, set comparison table           |
| Pole Tower Interval                      | 40-48   | Pole Tower No. - Pole Tower No.           |
| Span Length                              | 155-535 | Minimum - Maximum, Unit: m                |
| Wind Vibration Duration                  | 21      | Unit: h                                   |
| Quantity of Pole Tower Loops             | 1       | 1: Single loop; 2: Double loops          |
| Conductor Arrangement Mode               | 1       | 1: Vertical; 2: Horizontal; 3: Triangular  |
| Quantity of Conductor Bundles            | 2       | 1: Single-bundle; 2: Two-bundle          |
|                                           |         | 4: Four-bundle; 6: Six-bundle            |
| Terrain                                  | 1       | 1: Plain; 2: Mountainous Region; 3: Hill  |
| Altitude                                 | 2       | 1:0-20; 2:21-40; 3:41-60; 4:61-80; 5:81-100; 6:101-200; 7:151-200; 8:201-300; 9:301-400; 10:401-600; 11:601-1000; 12:1001-2000; 13:2001-3000 |

3. Statistical Result of Disaster Data

According to data contents, the statistical analysis of fault data is conducted according to three dimensions, i.e. meteorology and geology, line structure and disaster characteristics, and the histogram is adopted to represent disaster distribution characteristics.
3.1. Meteorology and Geology Dimension

In Figure 1, the wind speed statistics adopts grade for division, and see Table 1 for the scope of wind speed which the grade corresponds to; the quantity of samples with wind speed grade of 6 is the most, while a certain proportion of samples are distributed within the wind speed scope of grades 9-12 in a centralized way.

In Figure 2, the scopes of peak values of included angle between wind direction and line are 40°-50°, 60°-70°, and 80°-90°; in which, the quantity of data samples within the 80°-90° is the most; therefore, it is preliminarily judged that the wind vibration disaster of conductor may occur more easily when the included angle between wind direction and line is almost vertical.

In Figure 3, the temperature is distributed within the scope of -10 to 10°C in a centralized way, so the line disaster will occur more easily at relatively low temperature, and there is the data of -30/30 temperature data recording; this data refers to the scope of temperature of recording data of a time, and it is preliminarily inferred that the line in the environment where the temperature difference is relatively large may have line disaster easily. Explaining from the perspective of dynamics, at low temperature, the tension and internal force levels of conductor are high, and there will be fatigue and wear under aeolian vibration easily; when the temperature is relatively high, the conductor sag will be increased, and the windage yaw amplitude will also be increased obviously, and then the windage yaw discharging fault will occur easily.
Figure 4 is the statistical histogram of wind vibration terrain, includes three terrains, i.e. plain, mountainous region and hill. In a word, the proportion of wind disasters of lines in plain terrain is relatively large.

Figure 5. Statistical Histogram of Altitude

From Figure 5, it can be known that the altitudes of lines suffering from wind vibration disaster are mainly centralized within the scope of 1,400m, and another part of lines are in the regions with altitudes of 0m — 800m; in which, the altitudes are centralized within the scope of 400m. This paper believes that the above mentioned distribution pattern is mainly determined by natural distribution characteristic of lines, and the influence of altitude on wind vibration of conductor is not taken into consideration temporarily.

3.2. Line Structure Dimension

In Figure 6, the years of operation of line is within 10 years generally, and that of a small number of lines is 15-20 years, and some lines have operated for 35 years, which is relatively long. It is preliminarily judged that the wind vibration disaster of conductor has relatively poor correlation with years of operation of line, and the wind vibration damages of current most lines are mainly caused by severe environment and structural defect factors, the wind vibration faults of only a small number of lines are caused by material aging and degradation of materials for they have been put into operation for a long time.

Figure 6. Statistical Histogram of Years of Operation of Wind Vibration Line

Figure 7. Statistical Histogram of Quantity of Loops of Wind Vibration Pole Tower

Figure 8. Statistical Histogram of Quantity of Wind Vibration Conductor Bundles
From Figure 7, it can be known that among the data this time, the quantity of lines of pole tower with single loop and that with double loops are 80 and 110 respectively, and the data distribution of samples is relatively balanced. It is preliminarily inferred that the influence of quantity of loops of pole tower on different types of wind vibration is relatively low.

From Figure 8, it can be known that the proportion of data amounts of single conductor, two-bundle and six-bundle in the wind vibration sample data is relatively large, and the proportion of four-bundle and eight-bundle sample data is relatively low.

3.3. Line Structure Dimension

From Figure 9, it can be known that the windage yaw angle of insulator is mainly centralized within 10-30°, and the quantity of data samples with angle greater than 30° is relatively small.

From Figure 10, it can be known that the duration of samples which undergo aeolian vibration among the data is 8 hours mainly, and the duration of a small number of samples which undergo aeolian vibration is 1 hour.

From Figure 11 and Figure 12, it can be known that the duration of sub-span oscillation fault is mainly centralized within two time periods, i.e. 1-2.5 hours and 7-8 hours; the sub-span sections where the sub-span oscillation may occur most easily are 35m-40m and 60m-70m.
4. Brief Summary
Based on the structural data statistic rule, this paper makes classified statistics from three dimensions, i.e. meteorology & geology, line structure and disaster characteristics to the wind vibration data of power grid conductors over years, thus giving frequency distribution characteristics of wind vibration disasters for conductors under different parameter conditions, and talking about the correlation between various factors and wind vibration disasters according to analysis results, so as to provide reference for the subsequent characteristic identification and forecast of wind vibration disaster of power transmission line.

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