Dynamic response of hollow sandwich cement rod of 110 Kv transmission line

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Abstract. Taking a 110 kV transmission line as the research object, a refined finite element model of three pole two line transmission tower line system is established. Considering collision and contact between a dropped wire and ground, nonlinear dynamic analyses of the system with different break points and different numbers of broken wires were performed. The results showed that the break point location has little effects on the impact action of broken wire; the tension decay coefficient of the broken wire decreases with increase in the height of the hanging point position, while that of the unbroken wire decreases first and then increases with increase in the height of the hanging point position. The initial pretension, wind direction angle and span of the cable are selected for parameter analysis. The influence of these parameters on the nonlinear dynamic stability critical load of the hollow mezzanine concrete pole line system is investigated.

1. Introduction

At present, the requirements of modern industry for power supply reliability, safety and efficiency are gradually increasing, and the demand for power load is increasing, which makes the power transmission network and power industry face more and more severe tests; We are also faced with a series of environmental problems, such as high utilization rate of land resources, increased use of non-ferrous metals, uneven distribution of energy, low utilization rate of green energy. The demand for good power quality, reliable power supply, economic security, high efficiency and energy saving and environmental friendliness has also increased, so the power construction is also facing severe tests and various problems. The composite transmission pole has been studied in our country for a long time. Due to the limited conditions at that time, the material performance is not mature enough, and the process level can not meet the requirements, it has not been widely used. In recent years, with the improvement of fiber material production process, the "two types and three new" line construction will be fully implemented in 2009, so that composite materials are widely used in transmission towers.

At present, the 110 kV repair tower made of composite materials has been widely used in engineering. At the same time, the composite material transmission tower is used to reconstruct the 110 kV Maoqiang transmission line. This project is the first time that the composite tower is applied to the high voltage transmission line in China. In view of China's special topography, weather environment and energy distribution, the following methods can be considered to alleviate the tension of corridor lines and uneven energy distribution. In order to alleviate the tension of transmission line...
corridor, the length of cross arm can be reduced appropriately. In order to reduce the cost, the length of composite insulator should be shortened, even the suspension insulator string should be cancelled.(2) It is necessary to study the field strength and potential distribution of transmission lines under the condition of meeting the structural strength and size requirements of transmission lines. It is necessary to use finite element analysis software to analyze its electromagnetic environment.(3) This type of tower can be used in multi circuit transmission lines on the same tower in the future, and in multi circuit transmission lines on the same tower with higher voltage level.(4) Compared with all composite transmission tower, composite cross arm transmission tower can be designed conveniently without considering the problem of grounding down lead. determining dynamic stability[5-7].

2. Theoretical analysis
In order to study and analyze the influence of the lateral stiffness of the non breaking tower on the dynamic effect of the breaking tower in a tension section, the relative lateral stiffness $K$ is introduced based on the most unfavorable breaking position of the transmission tower line system determined by GE Xuzhang

$$K = \frac{K_1}{K_2}$$  \hspace{1cm} (1)

Among them, $K$ is the relative lateral stiffness, $K_1$ is the lateral stiffness of a transmission tower without broken line, and $K_2$ is the lateral stiffness of a transmission tower with broken line.

Firstly, the initial equilibrium state of the tower line system under the action of self weight and initial stress before the disconnection is calculated

$$\{K(\{d\})\}[d] = \{F_0\}$$  \hspace{1cm} (2)

Among them, \{K\} is the global stiffness matrix, \{d\} is the node displacement array, \{F_0\} is the initial state of the load vector.In the initial state, the broken line releases the strain energy of the conductor (earth) line, which is taken as the initial excitation to make the system damp free vibration:

$$[M]\{\ddot{d}(t)\} + [C]\{\dot{d}(t)\} + [K(\{d(t)\})][d(t)] = 0$$  \hspace{1cm} (3)

Where, \{M\} is the mass matrix, \{C\} is the Rayleigh damping matrix, and, \{d(t)\}, \{\dot{d}(t)\}, \{\ddot{d}(t)\} are the structural acceleration vector, velocity vector and displacement vector respectively.Assuming that the falling wire does not bounce after collision with the ground, and then the wire is dragged on the ground to form dynamic contact with the ground, nonlinear dynamic analysis is adopted, and the basic equation is as follows:

$$[M]\{\ddot{d}(t)\} + [C]\{\dot{d}(t)\} + [K(\{d(t)\})][d(t)] = \{F_f(t)\}$$  \hspace{1cm} (4)

Among them, \{F_f(t)\} is the friction force produced by ground contact.

According to the research on the most unfavorable disconnection position of transmission tower line system, it can be known that before the breakpoint 1 falls to the ground, the response of tower 2 at breakpoint 1 is greater than that of tower 2 at breakpoint 2, and the breakpoint 1 is the most unfavorable position. This paper mainly studies the impact on the tower at the moment of line break, rather than the secondary impact after line break landing. Therefore, the subsequent analysis of working conditions is based on one point of line break, as shown in Figure 1.

Fig.1 The diagrams of system before and after wire broken
3. The parameters and the form of structure
These are the hollow mezzanine concrete-filled steel tube pole and the conductors on both sides. The height of the tower is 50m, and there is no height difference on both sides of the wire. Its structure diagram is shown in Figure 2.

![Figure 2 Schematic diagram of wire and tower structure](image)

The large-scale general finite element software ANSYS is used. The conductor adopts link180 unit. The tower mainly bears compression and bending, so beam 188 element is adopted. The section form is shown in Figure 3, the outer diameter of tower bottom steel pipe is 750mm, and the inner diameter of steel pipe is 600mm. The diameter of the steel pipe changes uniformly along the height of the tower. The taper of outer steel pipe is 1 / 100 and the diameter thickness ratio is 50; The inner taper of steel pipe is 9 / 1000, the diameter thickness ratio is 40, and the hollow ratio of steel pipe rod is 0.47-0.64.

![Figure 3 Cross-section of hollow sandwich steel tube concrete](image)

### Table 1 Pole and tower material properties

| material       | Q420     | C80     |
|----------------|----------|---------|
| Elastic Modulus (Pa) | 3.50E+10 | 2.10E+11 |
| density (kg·m^-3)   | 2600     | 7850    |
| Poisson's ratio     | 0.30     | 0.24    |

### Table 2 Wire material properties

| Wire parameters       | unit       | Value   |
|-----------------------|------------|---------|
| section               | (mm²)      | 225.24  |
| diameter              | (mm)       | 15.01   |
| Single                | (kg/m)     | 0.682   |
| Coefficient of elasticity | (N/mm²) | 65000   |
| Linear expansion      | (10⁻⁶/°C) | 20.5    |
4. Dynamic response of structure under disconnection load + wind load
Considering that the wind speed is 60m/s, we analyze the dynamic response of the pole after one side of the wire is broken at the wire and the pole tower. After considering the disconnection and wind load, we analyze the dynamic response of the structure to obtain the displacement time history of the entire structure, as shown in Figures 4 to 5.

![Diagram](image)

(a) along the span direction

(b) along the Vertical direction

Figure 4 Maximum displacement of the tower top along the span direction

As the gear span increases, the unbalanced horizontal tension experienced by the transmission tower increases after the disconnection, so the maximum displacement along the gear span direction of the tower top increases as the gear span increases.
5. Conclusion
The dynamic equation established by the simplified mechanical model belongs to the category of parametric vibration, which is a typical nonlinear vibration, and the main resonance mode of the system is likely to appear in the plane. The appearance of the main resonance will make the system unstable and eventually lead to the destruction of the structure. The main conclusion is:

1) Before the conductor (ground) line falls to the ground, when the line near the tower end is broken (breakpoint 1), tower 2. The displacement at the top and the reaction force at the bottom of the tower are slightly larger than the broken line at the far end of the tower.

2) After the conductor (ground) line falls to the ground, the line is broken near the tower end, the tower top displacement and the tower bottom support. The change of reaction force is small, and the displacement of the top of the tower first decreases rapidly and then decreases. The reaction force at the bottom of the tower reverses and fluctuates violently. Near the tower. The dynamic amplification factor of end broken line is slightly larger than that of far tower end broken line. The position of broken wire has little influence on the instantaneous impact.

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