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Investigation on the failure analysis of crimped composite insulators used in "V"type string

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A R T I C L E I N F O

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A B S T R A C T

The failure mechanisms of the crimped composite insulators of leeward side used in "V" type string (CCILSUVS) are analyzed by considering: the characteristics of the fiber structure inside the mandrel, manufacturing process, structural characteristics, load characteristics, experimental research and numerical simulation. It was found that no matter whether the crimped composite insulator (CCI) is damaged in the production process, the stress concentration caused by the mass mutation at the junction of the fitting and the mandrel is unavoidable. The fibers laid along the mandrel axis determine that the tensile strength of the core material is much greater than the compressive strength. The maximum stress is located at the exit of the connection between the mandrel and the fitting (BMF). Under the situation of strong wind, the CCILSUVS is subjected to great pressure and is easy to bend. Under the electromagnetic field environment, if the mandrel has defects, then the temperature of the defect position is the highest in the whole insulator. The leeward side of the CCI sets of "V" type is prone to fatigue failure due to the dynamic compressive loads. The fatigue failure occurs first at the outer surface of the connecting zone BMF. When the residual strength of the CCI is insufficient, the mandrel directly pulled off.

1. Introduction

The crimped composite insulators used in "V" type string (CCIUVS) have been widely used in the 500 kV transmission lines. These types of insulator sets on the steel tower have a variety of benefits for the compact transmission lines. Primarily, it can reduce the width of the line corridor and improve the transmission capacity of the transmission line unit corridor. On the other hand, it may decrease the house demolition required and land compensation costs due to the transmission lines, easements. The advantage of this type of transmission line is achieved by the following techniques: by optimizing the arrangement of wires, the three phase conductor is placed in the same tower window, and there is no grounding component between the three phase conductors, so as to improve the natural transmission power, reduce the width of the corridor and improve the transmission capacity of the unit corridor. Therefore, he compact transmission lines are popular in engineering applications, especially in china.

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The research on the fatigue failure of the composite insulator, composite insulator core rod and CCI by means of numerical simulation and fatigue test has been reported [1–10]. Alain et al. [1] applied the numerical simulation method and the experimental method to study the stress distribution and failure characteristics of the crimp composite insulator under bending loading. Wen et al. [2] applied the numerical simulation method to study stress distribution at the joint of the mandrel under tensile loading. Lucas et al. [3] studied the factors influencing the mechanical properties of acid-resistant insulators by means of experiments. L. Kumosa et al. [4] studied the effect of moisture absorption on the mechanical properties and electrical properties of composite insulators using numerical simulation and experimental methods. The optimum compression condition of the composite insulator is studied by D. Duriatti et al. [5], in his article, the stress distribution of the joint of the composite insulator is simulated by the finite element software. Alain et al. [6] studied the stress distribution of the compression joint of the CCI, the bearing strength of the CCI and detection of acoustic emission device during crimping process. G. Portnova et al. [7] theoretically studied the effect of stress concentration of the joint on the load-carryring capacity of round pultruded rods, He pointed out that improving the stress distribution in the connection zone can effectively improve the carrying capacity of the CCI. Xie et al. [8] studied the evolution law of fatigue failure of compacted composite insulators, and predicted the location of the stress concentration of the insulator by numerical simulation. The acoustic emission monitoring and control technology of composite insulator crimping process is studied by Adrain [9], and a new method is proposed, which can effectively reduce the damage of the composite insulator. Based on the results of finite element analysis, a semi empirical formula for predicting the axial load of composite insulators is presented by A. Bansal [10], and the conclusion of this paper shows that the excessive axial load will lead the mandrel to slip out of the inner cavity of the fittings. But these articles do not analyze the mechanism of fatigue occurrence and development of CCI from different perspectives. Further, it is not enough to analyze the mechanical properties of the composite insulator from the single factor or two or three factor, and the fatigue failure mechanism of the composite insulator cannot be fully realized.

In recent years, extreme weather, local areas of strong winds, strong convection and other extreme weather, occurs frequently. Transmission towers locate the microtopography and micrometeorological region, that is the transmission towers locate regions, such as wind gap and pass area of high-altitude region, in these regions, Strong winds, strong convective weather is very easy to appear. Those bad weather led to a new failure mode of V-type series composite insulators, that is fatigue failure (as shown in Fig. 1).

In order to understand the fatigue mechanism and characteristics of CCIUS, in this paper, the optimum load mode of the composite insulator will be analyzed based on the characteristics of the inner fiber of the V series composite insulator. From the point of view of production technology and structure, the stress distribution of composite insulator will be studied. CCIUS is in a new working condition, which will be confirmed by force analysis of V series composite insulator on transmission line. The situation of the internal temperature field will be obtained based on the electromagnetic field. The variation trend of the stress at the joint of CCI will be

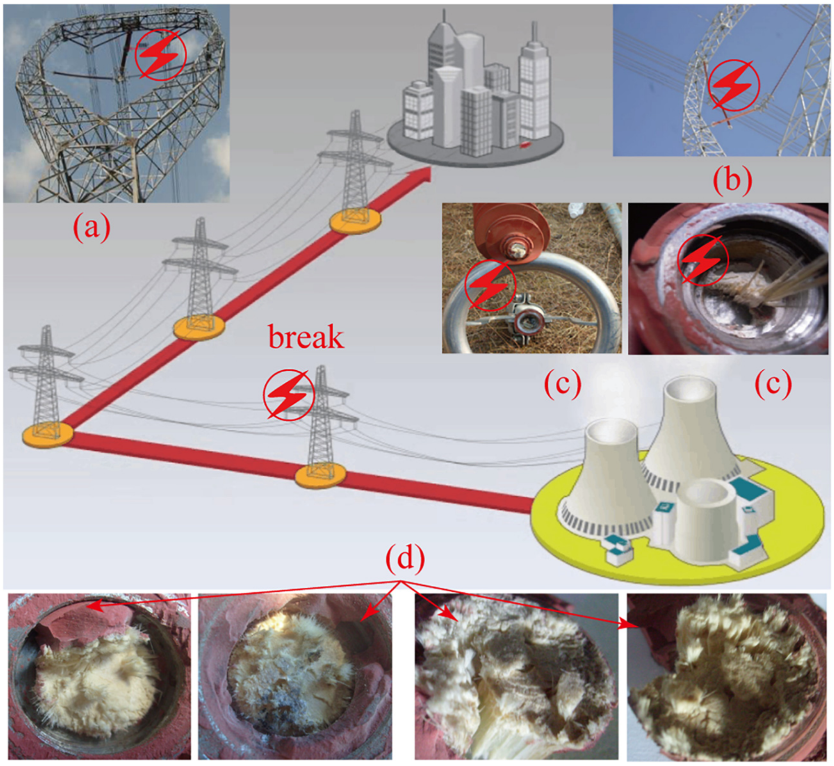

Fig.1. (a) Observed accident in a Double “V” insulator string due to fatigue. (b) The failure in an insulator installed on a 500 kV compact transmission line (named Changfang.) due to fatigue. (c) Fracture failure of composite insulators due to fatigue. (d) The macro map of the online CCIs set on the fatigue location.