Prospects and Management Strategies for High Noise, Soft Geological and Strong Earthquake Environments

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Abstract. With global warming, environmental degradation is becoming increasingly severe, and the impact on power transmission and transformation equipment is increasing. The changing environment will also have cross impacts, and people are paying more attention to environmental protection. Therefore, under complex environmental conditions, research on new technologies continues, and the emergence of new technologies can improve efficiency and reduce costs. This article focuses on three typical environments: noise environment, soft geological environment, and seismic environment, with a focus on analysing their latest technological situation and management strategies. At the same time, it proposes future development directions, guides the emergence of new business models and service methods, and promotes industry innovation and change.

1. Introduction

Environmental factors such as terrain, climate, and soil will have a direct impact on the planning and construction of power transmission and transformation projects. For example, complex terrain may increase the difficulty and cost of route lying, while extreme weather conditions may pose a threat to construction safety and quality. In addition, the properties of soil can also affect the construction of infrastructure, such as the site selection and grounding method of substations. Secondly, various pollutants and emissions generated during the construction and operation of power transmission and transformation projects can also have an impact on the environment. During the construction period, construction noise, dust, solid waste, and wastewater may be generated, causing certain interference to the quality of life and ecological environment of surrounding residents. During operation, it may generate electromagnetic radiation, radio interference, noise, etc., which have potential impacts on the ecosystem and human health. Finally, environmental factors may also pose challenges to the operation, maintenance, and management of power transmission and transformation projects [1]. For example, harsh weather conditions may lead to an increase in equipment failure rates, requiring increased inspection and maintenance efforts. The implementation of environmental protection policies may also pose higher requirements for the operation and maintenance of power transmission and transformation projects, such as limiting emissions and improving energy efficiency.

In order to reduce the impact of the environment on power transmission and transformation projects, it is necessary to fully consider environmental factors in various stages such as project planning, design, construction as shown in Figure 1, operation, adopt reasonable engineering and management measures. For example, optimizing the route, using environmentally friendly materials, strengthening construction supervision, implementing energy conservation and emission reduction. At the same time, it is necessary to strengthen environmental monitoring and assessment, timely identify and solve environmental problems, and ensure the sustainable development of power transmission and transformation projects.

Therefore, under complex environmental conditions, there is a huge requirement on new technologies research. The emergence of new technologies can improve efficiency and reduce costs, such as artificial intelligence, big data analyse, which can improve production efficiency and reduce operating costs through automation, intelligence, and other methods; Improving safety and reliability, such as detection and evaluation equipment, can enhance the safety and reliability of the system and reduce the possibility of accidents; Promoting innovation and change, new technologies can not only solve existing problems, but also stimulate new business models and service methods.

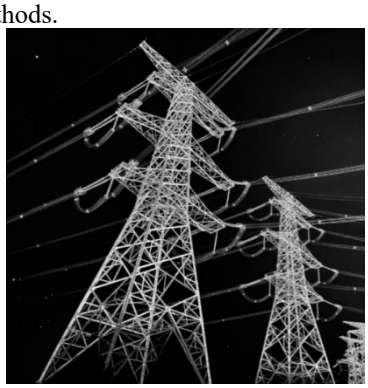

Fig. 1. Transmission tower and transmission line constructor.

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2.Environmental characteristics and influences

These complex environments have brought many challenges and problems to the construction and operation of power transmission and transformation. According to the characteristics and requirements of different environments, technical and management measures need to be taken to ensure the safe and stable operation of power transmission and transformation facilities. As show in figure 2.

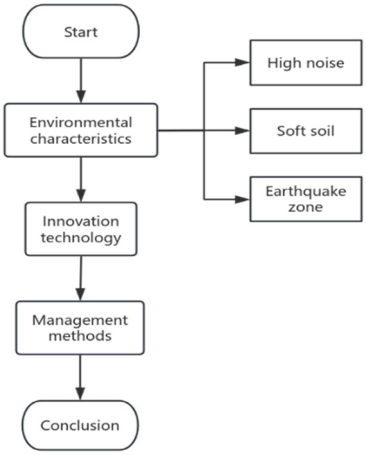

Fig. 2. Transmission tower and transmission line technology management flowchart.

2.1. High noise environment

High noise environments are mainly generated by industrial equipment, transportation vehicles, etc., which have adverse effects on human life and health [2]. These environments are widely distributed in urban industrial areas, on both sides of main roads, and airports. Noise intensity exceeding 85 decibels can cause damage to the ears, and long-term exposure to high decibel noise can also lead to neurological problems, insomnia, decreased thinking and learning abilities, etc.

The impact and main issues on the construction and operation of power transmission and transformation:

1. High noise affects the health and safety of workers, reducing work efficiency.

2. Noise may interfere with the normal operation and monitoring of equipment, increasing the risk of malfunctions.

3. It is necessary to take noise control measures, such as sound insulation equipment and noise reduction technology to increase construction costs.

2.2. Soft geological environment

Soft soil geology has high water content, loose soil, poor solidification, instability, and is prone to deformation and settlement [3]. These environments are mainly distributed near rivers, lakes, and coastal areas. The poor bearing capacity of soft soil foundation can easily lead to foundation settlement and structural instability, posing a threat to the safe operation of power transmission and transformation facilities.

The impact and main issues on the construction and operation of power transmission and transformation:

1. The difficulty of foundation treatment is high, and special foundation reinforcement measures need to be adopted.

2. Foundation settlement may cause equipment tilting, deformation, and even damage.

3. The soft soil geological environment requires high stability of power transmission and transformation facilities, and requires strengthened monitoring and maintenance.

2.3. Strong earthquake zone environment

The environment in strong seismic areas is characterized by frequent seismic activity and severe surface damage. These environments are mainly distributed near earthquake zones, such as Sichuan and Yunnan in China [4]. Earthquakes may cause severe damage or even paralysis of power transmission and transformation facilities, posing a great threat to the stable operation of the power system.

The impact and main issues on the construction and operation of power transmission and transformation:

1. Earthquakes may cause serious consequences such as equipment damage and line breakage.

2. High seismic performance requirements are required for transmission and transformation facilities, and it is necessary to strengthen equipment fixation and foundation reinforcement.

3. It is difficult to restore power supply after an earthquake, and it is necessary to develop comprehensive emergency plans and rescue measures.

3. Current status and future development trends

3.1. Innovation technology

The foundation phase is the most initial stage in the state of construction work. Satellite remote sensing inspection should identify four operational states in the basic stage.

3.1.1. High noise environment technology

A survey on the environmental noise of a 110kV semi-indoor substation found that the sound pressure level of the noise inside and outside the enclosure structure of the transformer room differs by more than 12dB (A) [5, 6], indicating that the sound insulation performance of the enclosure structure is a very important factor in preventing transformer noise from being emitted into the factory boundary. The sound pressure level difference between the starting and stopping noise of the fan is about 2dB (A). It indicates that fan noise has a certain impact on factory boundary noise emissions, but it is not the main factor here. Therefore, the sound insulation performance of the enclosure structure plays a decisive role in the

emission of factory boundary noise. Due to the open environment of the semi-indoor substation, the noise emitted will merge with the surrounding sound environment. The noise environment is significantly affected by the surrounding sound environment.

The sound insulation effect of the material is usually evaluated by the transmittance coefficient τ or the sound insulation *R*, and its magnitude can be expressed as:

$$\tau = \frac{E_t}{E_i} = \frac{I_t}{I_i} \tag{1}$$

$$R = 10\lg\left(\frac{E_i}{E_t}\right) = 10\lg\left(\frac{1}{\tau}\right) = 10\lg\left(\frac{I_i}{I_t}\right) \tag{2}$$

where: E_t is the transmitted energy; E_i is the incident energy; I_t is the permeability strength; I_i is the incident intensity. The smaller the transmission coefficient, the higher the sound insulation, and the better the sound insulation effect of the material.

Through testing the acoustic environment of the low noise 110kV indoor substation in China, which uses a new non-metallic surface enclosure wall, it was found that the sound pressure level of day-time noise differs by about 15dB inside and outside the enclosure structure of the substation transformer room, and the sound pressure level of night-time noise differs by about 20dB. This further indicates that the sound insulation performance of the enclosure structure is an important factor in preventing transformer noise from being discharged into the factory boundary. The day-time substation is located on the side of the main urban road, and the noise pressure level is relatively high. The main factor causing this phenomenon is not the internal noise source of the substation, but the traffic noise in the surrounding environment.

3.1.2. Soft geological environment technology

The western region of China has a wide area of saline soil with a large temperature difference between day and night [7, 8]. The distribution of precipitation shows seasonal changes, and concrete foundations may be damaged by single or multiple actions such as sulfate corrosion, steel bar corrosion, and freeze-thaw. Existing concrete structures in such environments are prone to concrete corrosion, cracking, and steel reinforcement corrosion caused by sulfate and chloride salt erosion. Concrete buildings in these areas suffer from severe sulfate and chloride salt erosion, resulting in "one year pulverization and three years collapse". For concrete structures with lower strength, corrosion damage is more likely to occur.

Due to the long installation mileage of transmission lines, the complexity and diversity of the service environment and action levels they cross, the current specifications and standards have high concrete strength and are not easy to mix manually on site, which is not fully applicable to transmission lines. Therefore, empirical design is still widely used for the durability of foundations in saline soil areas, and there is no systematic and quantitative scientific durability design method, resulting in the inability to use key indicators to constrain the preparation and service performance of concrete. In addition, the cast-in-place concrete for transmission lines is mainly pre mixed on site, with difficult construction conditions, difficult control of raw materials, and diverse protective effects (the key reason is the difficulty in unifying the usage environment and ensuring maintenance). Low water cement ratio technology is also not easy to achieve under simple construction conditions on transmission line sites. In addition, due to the limited verification of the applicability and coordination of some engineering anti-corrosion technologies, the construction quality control is uneven, resulting in unsatisfactory protective effects.

3.1.3. Strong earthquake zone environment technology

The installation of the bypass switch includes a combination of wire rope dampers and viscous dampers for vibration reduction [9, 10]. The installation is simple and does not require reprocessing of the foundation. The combination damper is installed on a rigid foundation, and then the upper structure is installed on the installation plate connected to the damper. As show in figure 3.

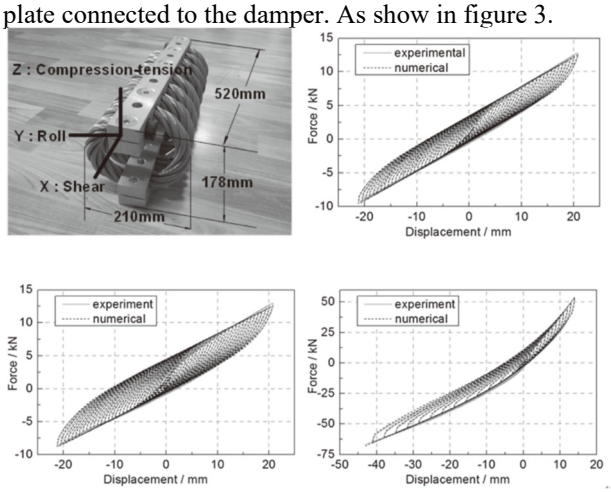

Fig. 3. Three way hysteresis curve of steel wire rope damper.

3.2. Future development trend

Under the environmental impact, the future development trend of new technologies in transmission line engineering will move towards a more environmentally friendly, efficient, and sustainable direction. Specifically, the following technological trends are worth paying attention to:

1. The widespread application of environmentally friendly materials and technologies: With the increasing awareness of environmental protection, transmission line projects will pay more attention to the use of environmentally friendly materials to reduce their impact on the environment. For example, we can use biodegradable or low pollution insulation materials to reduce pollution emissions during construction and operation. Meanwhile, new environmental protection technologies, such as ecological restoration technology, will also be widely applied in engineering to reduce damage to natural resources such as land and water sources.

2. The deep integration of intelligence and automation technology: Intelligence and automation technology will play an increasingly important role in transmission line engineering. By applying advanced sensors, communication, and control technologies, real-time monitoring, early warning, and intelligent scheduling of transmission lines can be achieved. This can not only improve the operational efficiency of transmission lines, but also reduce maintenance costs and minimize human interference with the environment.

3. Continuous innovation of high-efficiency and energy-saving technologies: In transmission line engineering, high-efficiency and energy-saving technologies will continue to be innovated and applied. For example, by optimizing the design of transmission lines, reducing line losses; Adopting advanced transmission technologies, such as high-temperature superconducting transmission technology and flexible transmission technology, to improve transmission efficiency; Utilizing renewable energy for power generation, reducing reliance on traditional energy sources, and thus reducing environmental pollution.

4. Integration and application of cross domain technologies: In the future, transmission line engineering will pay more attention to the integration and application of cross domain technologies. Through cooperation and exchange with new energy, information technology, materials science and other fields, we will jointly promote innovation and development of transmission line engineering technology. For example, using IoT technology to achieve remote monitoring and management of transmission lines; using big data technology to analyse and mine operational data of transmission lines, providing scientific basis for decision-making.

5. The combination of ecosystem protection and restoration technologies: Transmission line projects inevitably have certain impacts on the ecosystem during construction and operation. In the future, new technologies will pay more attention to the combination of ecosystem protection and restoration. For example, adopting ecological compensation measures to repair and rebuild damaged ecosystems; utilizing biotechnology to enhance the self-repair ability of ecosystems.

In summary, under the environmental impact, the future development trend of new technologies in transmission line engineering will pay more attention to environmental protection, efficiency, and sustainability. By widely applying environmentally friendly materials and technologies, deeply integrating intelligent and automation technologies, continuously innovating efficient and energy-saving technologies, integrating interdisciplinary technologies, and combining ecosystem protection and restoration technologies, we will promote the development of transmission line engineering towards a more green, intelligent, and sustainable direction.

4. New technology management measures

The management method for new technologies in transmission line engineering is an important means to ensure the effective application, management, and optimization of new technologies in transmission line engineering. Here are some suggested management measures [11]:

1. Establish a mechanism for introducing and evaluating new technologies

Establish a dedicated technology evaluation team responsible for screening, evaluating, and introducing new technologies. The evaluation team should conduct a comprehensive analysis of the feasibility, economy, safety, and environmental friendliness of the new technology to ensure that it meets the engineering requirements.

2. Develop new technology application specifications and standards

Develop corresponding application specifications and standards based on the characteristics and engineering requirements of new technologies. Ensure that construction personnel can follow regulations when using new technologies, ensuring construction quality and safety.

3. Strengthen training and guidance on new technologies

Provide new technology training to construction personnel to enhance their understanding and mastery of new technologies. Establish a technical guidance group to provide answers and guidance on problems encountered during the application of new technologies.

4. Establish a regulatory mechanism for the application of new technologies

Real time supervision of the application process of new technologies to ensure that construction personnel operate in accordance with regulations. Regularly evaluate the effectiveness of new technology applications, adjust application strategies in a timely manner, and ensure the effectiveness and applicability of new technologies.

5. Promote new technology research and innovation

Encourage construction units to cooperate with research institutions, universities, etc. to jointly carry out new technology research and innovation. Establish a technology innovation reward mechanism to recognize and reward individuals or teams who have achieved significant results in the application of new technologies.

6. Strengthen the sharing and exchange of information on new technologies

Establish a new technology information sharing platform to facilitate construction personnel to access the latest technical information and materials. Regularly organize new technology exchange meetings to promote technical exchange and cooperation between construction units.

The implementation of the above management measures can effectively promote the introduction, application, management, and optimization of new technologies in transmission line engineering, improve

engineering quality, efficiency, and safety, and promote the sustainable development of the power industry.

5. Conclusions

In summary, the application prospects of new technologies in complex environments are broad, but at the same time, it is also necessary to develop reasonable management strategies to address various challenges. By comprehensively evaluating, strengthening risk management, enhancing talent cultivation, and cross-border cooperation, we can effectively promote the application and development of new technologies, and contribute to the progress and development of society.

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