Research on General Model System for Three-Dimensional Design of Transmission and Transformation Project Under Smart Grid Modeling Standards

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Abstract. The traditional design method of power transmission and transformation project based on knowledge model has the problems of rough construction quality and low economic benefit of power transmission and transformation project. Therefore, the design method of power transmission and transformation engineering based on three-dimensional digital intelligent technology is proposed, and the working mode of intelligent power transmission and transformation engineering is designed. Based on this working mode, a three-dimensional collaborative design process for power transmission and transformation engineering is obtained. The design platform is built to shorten the design cycle of power transmission and transformation projects, so that the efficiency of power transmission and transformation engineering design is greatly improved. Through the digital handover of the three-dimensional collaborative database, the transmission and transformation engineering information is sorted and sorted, so that multiple people can view and modify the information at the same time, and the three-dimensional verification process of the transmission and transformation project is designed to achieve a safe distance and collision to the transmission and transformation project. Testing to improve the accuracy of engineering design. Experimental results show that the proposed method can improve the design efficiency and quality of power transmission and transformation projects, and has a higher social and economic evaluation effect.

1. Introduction

With the development of modern science and technology, digital 3D design technology has become the basis of a new generation of intelligent design platforms. Since the 1990s, it has been widely used in many aspects such as industrial design, architectural design and equipment manufacturing [1]. China's power transmission and transformation engineering design technology has passed through the major stages of plate drawing, computer graphics and computer-aided drawing. Nowadays, with the advantages of high quality, high efficiency and high visualization, it gradually replaces traditional design technologies and continues to be used in power transmission and transformation projects. According to the content of State Grid Infrastructure ﹝2018﹞585, since the second half of 2018, the State Grid Corporation requested that the new 35kV and above power transmission and transformation projects be fully implemented in three-dimensional design; the State Grid Infrastructure Technology
and Economics issued on January 31, 2019（2019）Document No. 10 clearly stated that “from the date of publication, in principle, preliminary design review will not be arranged for projects that do not carry out design tenders and apply 3D design according to the requirements of the document.” Under this development trend, it is very important to study the application of 3D design technology in power transmission and transformation projects.

Although mainstream two-dimensional design combined with related analysis and calculation software can basically solve most technical problems in power transmission and transformation engineering design, as China's urbanization process continues to accelerate and land resources are increasingly scarce, underground and semi-underground substations will be The increase in line corridors has become increasingly tense, and the requirements for refined line path design have become higher and higher. At the same time, the widespread application of UHV AC/DC transmission technology has put forward higher requirements for design technology, which requires a new change in design technology. Three-dimensional technology is widely used in the fields of machinery, electronics, aviation, aerospace, construction, nuclear power, hydraulics, etc. Three-dimensional design can solve the problems of collision and model statistics designed by multiple majors in the same area at the same time. The inevitable trend of engineering design. On the other hand, it is subject to different professional software platforms, data standards are not uniform, and there are drawbacks such as repeated input of design information and low information utilization. Transmission and transformation engineering design is relatively short in design cycle and high in refinement. It needs to reorganize information and promote the transmission of information, thereby fundamentally improving the quality and efficiency of design. In view of this, this article starts with 3D design technology, focuses on its specific application in power transmission and transformation engineering, analyses the application prospects of 3D design technology in power transmission and transformation engineering, in order to provide the future level of 3D design technology in power engineering projects Lay the foundation for improvement.

2. Overview of 3D design technology
As a key technology that has led development and transformation in recent years, 3D design technology has been recognized, recognized and used in more and more life-cycle project management by more and more enterprises. Applying 3D design to power transmission and transformation projects, you can build a model of the entire station equipment, integrate the code, write the codes of different stages in the life cycle into the equipment model attributes, generate a standardized model library, and manage the equipment for the entire life cycle of the substation And handover work. This paper takes the secondary equipment of the substation as an example, analyses the establishment process of the standardized model library in detail, and gives an application example of the model library, which provides a basis for the digital transfer of the substation. As shown in Figure 1, it is the connotation of digital design technology [2].
3. Design method of power transmission and transformation engineering based on three-dimensional digital intelligent technology

The traditional series design model and the three-dimensional collaborative design model adopted in this paper. When the engineering designer designs the same transmission and transformation project, the designer adds the content he needs to the part of his design according to the intelligent reference method, which reduces the conflict with other majors and improves the design quality of the transmission and transformation project; Three-dimensional collaborative design transforms the past series design mode into a parallel design mode, which greatly shortens the project engineering design time [3].

3.1. Three-dimensional collaborative design process of power transmission and transformation engineering

The working environment of 3D design is based on an integrated working platform. Based on the above-mentioned analysis of the three-dimensional collaborative transmission and transformation engineering work mode, the paper uses different professional data fusion and parallel working methods to refer to the upstream and downstream design results. Set HVAC, electrical, civil construction and building as random variables, \( X_1, X_2, X_3 \) and \( X_4 \), respectively, and use the weighted average method to fuse different professional data in the form of:

\[
Y = kX_1 + (1-k)X_2 + (1-k)^2X_3 + (1-k)^3X_4 \quad 0 \leq k \leq 1
\]  

In the formula: \( Y \) represents the fusion operator of each parameter. The three-dimensional collaborative design process of the power transmission and transformation project shown in FIG. 2 is obtained.
3.2. Construction of 3D collaborative design platform for power transmission and transformation projects

The basic principle of the construction of a three-dimensional collaborative design platform for transmission and transformation projects is to integrate different professional software into collaborative management software. Based on this construction principle, the independent, one-way design model in the past has been changed, and the design of transmission and transformation projects has been shortened. The period improves the accuracy of the information and greatly improves the efficiency of power transmission and transformation engineering design. Among them, the symbiotic theory is used for the collaborative design of different management software. Assume that the symbiotic system $S$ has a qualitative parameter $X$ ($S$ system capability) and includes $m$ ($m \geq 2$) symbiotic units. In this paper, $m=4$, then there are:

$$X_s = f\left(x_1, x_2, ..., x_m\right)$$  \hspace{1cm} (2)

The total symbiosis of the system is

$$\sigma_s = \frac{1}{\lambda} \sum_{i=1}^{m} \sigma_{si}$$  \hspace{1cm} (3)

Where: $\sigma_{si}$ is the symbiosis degree of the element in the system; $\lambda$ is the symbiosis damping coefficient. The relationship between the system quality parameter $X_s$ and the unit quality parameter...
mainly depends on the symbiosis degree and characteristics of the symbiotic unit, including collaborative adaptation, interface trading, and complementary connection. The proportional relationship between the energy $E_s$ of the three-dimensional collaborative digital system and the total element $\sigma_s$ of the system is obtained:

$$E_s = f(\sigma_s)$$  \hspace{1cm} (4)

3.3. Database model establishment

The complete three-dimensional model is composed of geometric elements that express the model of the device and auxiliary geometry, constraints that express the constraints within or between the devices, and engineering elements that express the requirements of the engineering attributes of the device. The depth of the model should meet the requirements of easy identification and drawing, with the accurate outline shape of the main equipment parts, the precise size layout of the interface between the professional, meet the process installation requirements of the equipment, and take into account when the 3D model is projected into the 2D engineering drawing status. In order to improve modelling efficiency, parts that do not affect their own functional expression can be omitted, which also allows simplification of the internal structure independent of installation. For example, the camera model should draw the body, keep it in line with the real object, and adjust the external dimensions to suit the drawing environment, and give the model insertion point when it is used [4].

In order to meet the requirements of the 3D model in file management such as modelling, modification, storage, and transmission, the naming of the model should be unified rules, so that the model storage code is unique, the file name is streamlined, easy to read, easy to control and trace back, and easy to share And identification. For example: DH-HAC-HFW-2R-Z-IRE6, DH stands for manufacturer Dahua, HAC stands for high-definition analogy camera, H stands for high-definition, F stands for shooting machine (D stands for hemisphere, DB stands for explosion-proof hemisphere), W stands for infrared, 2 represents 200w pixels, R represents appearance style, Z represents electric zoom (A represents AC24/DC12V dual power supply, B represents bracket, VF represents manual zoom), IRE6 represents infrared distance 60~80 meters. The current 3D design platforms have accumulated a wealth of equipment models, but with the establishment of universal design and standardized work plans in the power industry, the 3D design platforms need to cooperate closely, constantly supplement the content of the model library, and based on the actual project data of each equipment manufacturer Constantly improve the basic model library.
4. Three-dimensional design of intelligent auxiliary control system

4.1. Three-dimensional design of outdoor intelligent auxiliary control system in substation

4.1.1. Preliminary arrangement of camera positions in the 3D model. In the two-dimensional design, the designer can only rely on the spatial imagination to design the layout of the cameras in the distribution device area and the building. There is a lack of powerful means to optimize the overall space layout, and it is impossible to determine whether the surveillance range of the camera is optimal. It is also impossible to verify the collision between the charging distance of the camera and the power distribution device and the pole base. In the three-dimensional design, all the equipment in the substation is displayed through a three-dimensional model, which more intuitively and accurately describes the spatial relationship of various types of equipment, which can help the designer to arrange the camera more intuitively. As shown in Table 1.

| Monitoring location                      | Camera type       | Equipment Quantity |
|-----------------------------------------|-------------------|--------------------|
| door                                    | Outdoor fastball  | 1                  |
| Fence                                   | Outdoor fastball  | 4                  |
| Outdoor panorama (top of main control building) | Panoramic camera | 1                  |
| Main transformer site                   | Outdoor fastball  | 1/each main transformer |
| 220kV outdoor distribution area         | Outdoor fastball  | 2–3                |
| 110kV outdoor distribution device area  | Outdoor fastball  | 2–3                |

In terms of camera layout, the whole station is divided into main transformer area, power distribution device area, secondary equipment room, gate entrance, station area perimeter, and station area panorama, to realize the combination of safety monitoring and equipment monitoring. Among them, except for the outdoor fast ball, the panoramic camera is installed on the outer wall of the main control building and the gate is installed at a height of 3.5 meters, and the rest are installed at a height of 5.5 meters [5].

4.1.2. Three-dimensional design of outdoor dome camera. Import the three-dimensional model of the substation on the three-dimensional design platform of the substation, extract the model of the outdoor camera from the model library, and arrange the camera to the corresponding equipment area according to the requirements. After determining the approximate placement of the camera, partially zoom in on a camera, including a stand (showing the relative or absolute position of the camera for easy positioning). As shown in Figure 4.
4.1.3. Verification. After the preliminary camera layout is completed, the 3D software can be used to display the camera arranged in the power distribution device area and other professional equipment (architecture, overhead line, etc.) in the outdoor at the same time, check whether it collides, meets the requirements for live distance, and sees Area dead ends.

4.2. Soft and hard collision detection
Underground substations, indoor substations, UHV DC converter stations and other complex space-intensive projects, soft and hard collision detection has a significant effect on improving the design quality.

1) Hard collision detection is mainly collision detection between solid models. It is suitable for complex space collision detection of multi-discipline handover. Application in indoor substations and outdoor substations in local multi-discipline collection areas will achieve good results. Cable trays and air ducts for internal stations, underground foundations and cable channels for outdoor substations, etc.

2) Soft collision mainly refers to the detection that the model entity needs to maintain a relative distance with other model entities during the layout process, including electrical distance verification, substation lightning protection range verification, etc., which has been designed in the valve hall of the converter station, etc. The application of electrical distance check in complex space has achieved good optimization effect; in the aspect of line design, it can be applied to cross-span detection and line-span building [6].

5. Conclusion
The improvement of 3D design in the digital design of substation projects is obvious to all, and the equipment model is the foundation of 3D design, so the establishment of the equipment model has an important role in the application effect of 3D design, and also determines the design, construction, operation Whether the various stages of Uighur can realize the overall digital handover. During the establishment of the model library, according to the correspondence between codes at various stages specified in the specifications, the material codes and scheduling codes are reflected in the naming and attributes, so that the three-dimensional technology runs through the substation engineering project, helping the digital three-dimensional design technology in power engineering. The field is truly implemented and promotes the development of the power field.
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