Research on 3D digital design of AC filter field application in Qingnan ± 800kV converter station

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Abstract: Qingnan ± 800kV converter station AC filter bank adopts the improved "Tian" type layout scheme. Through the summary in different majors' modeling, equipment layout, two-dimensional drawing and material statistics methods, the design efficiency and quality can be effectively improved. However, at present, the data transmission between 3D design software and some professional calculation software is not smooth, and a large number of models run slowly after the final assembly. Some software functions are more cumbersome and other issues are still restricting the development of 3D design. This needs to constantly optimize the software function and design process, promote the development of 3D digital design mature.

1.Preface
Qingnan ± 800kV converter station is located in Gonghe County, Hainan Tibetan Autonomous Prefecture, Qinghai Province. The project is an ultra-high voltage transmission channel specially built for Qinghai clean energy transmission. It's a green project for the CPC Central Committee to carry out targeted poverty alleviation in Qinghai Province, and a new generation of ultra-high model project proposed by State Grid Corporation. Therefore, the project requires high design quality and reasonable scheme.

There are 18 groups of AC filters in the project, and the improved "Tian" type layout scheme is adopted. The AC filter bank consists of circuit breaker, disconnector, grounding switch, outdoor flexible bus bar, capacitor, reactor, resistor, current transformer, arrester, tube bus, etc. In this area, all kinds of equipment and wires are crisscross and very dense.

Therefore, through the application of 3D digital design, it is helpful to improve the design quality and efficiency[1-3]. This paper introduces the 3D digital design of AC filter field in Qingnan converter station, and introduces the 3D design method and drawing of equipment model, layout, structure and support, buildings and underground pipe trench. The optimization and development of 3D design methods are also prospected.

2. 3D digital design

2.1. Brief introduction
With the development of cloud services and big data technology, substation design technology has entered the stage of comprehensive 3D digitization. The object-oriented information processing mechanism is adopted to objectify all equipment and facilities in substation. It can organize all kinds of information in the form of object attributes, and save the attributes of objects by means of database. At the same time, digital design integrates all the engineers in different majors on a unified working
platform to realize the collaborative design of the whole professional process. 3D digital design technology can realize the transfer and reuse of design data in the whole engineering design process, realize the real collaborative design, and improve the quality and efficiency of engineering design[4-7].

2.2. Standards for 3D modeling and design
At present, the State Grid Corporation of China has established relevant specifications for 3D modeling. The 3D design of AC filter field in Qingnan converter station is in accordance with the code for “3D design and modeling of power transmission and transformation engineering Part 1: substation (converter station)”, “Interactive specification for 3D design model of power transmission and transformation engineering”, and “Technical guide for 3D design of power transmission and transformation engineering Part 1: substation (converter station)” and “Basic function specification for 3D design software of power transmission and transformation engineering”.

2.3. Basic requirements of 3D digital design
First of all, the 3D digital collaborative design requires that all the engineers in different majors adopt a unified coordinate origin and measurement unit. At the same time strictly implement the modeling standards required by the specifications, and adopt a unified model hierarchy, color matching principles and attribute definition methods.

Secondly, a unified geographic information system should be adopted, including coordinate system, elevation and data format. The coordinate system and elevation are consistent with the actual requirements of the project, and the data format meets the requirements of the relevant specifications of 3D geographic information.

3. Modeling and layout process of civil engineering and hydraulic engineering

3.1. 3D Modeling
Through the professional civil engineering model building software, we can quickly create the models of the relevant components such as walls, plates, doors, windows, stairs, roof apron, steps, etc., as well as the structural components such as beams, columns and foundations related to structural engineering. For the 3D information model of the building, the model includes the spatial layout of each floor, column grid, room layout, walls, doors and windows, etc. In addition, the building name, design service life, fire risk classification and fire resistance rating, roof waterproof grade, building area, building floors, building height, main building materials and other attribute information will also be input into the model. The complex building’s model is shown in figure. 1.

![Figure 1. 3D model of the complex building](image)

After the completion of the building model, hydraulic engineering, heating and ventilation engineering, building electrical and other disciplines can carry out collaborative design on the building model[8].

The structural model includes the information properties such as specifications and materials of beam, slab, column and foundation. According to the structural calculation, the equipment or building
foundation model is established in the 3D design software, and the foundation layout is derived. Framework adopted STAAD.Pro to carry out the professional design, including the calculation and design of main materials and auxiliary materials of steel structure beams and columns, and completes the statistics of engineering quantity. Then, the model is imported into the 3D design platform to realize collaborative design.

For the site, road, retaining structure, underground pipe trench, etc., parametric modeling can also be used. The design of water supply and drainage system includes the pipe diameter, material, elevation, slope and other information. At the same time, according to the general assembly model, the soft and hard collision of underground facilities is checked.

4. Modeling and layout process of the primary electrical part

4.1. 3D Modeling

The 3D model of electrical equipment is completed according to the basic element and parametric modeling method, and the model needs to meet the requirements of data sharing among different application software. Basic element refer to the smallest basic graphic units used in 3D modeling, such as cuboid, sphere, cylinder, ring, cone, prism, etc. These can also be modeled by setting parameters, and the required model can be obtained through combination and splicing. The geometric model should better reflect the geometric information such as the shape, size, position and structure of the equipment, and establish its basic attribute and extended attribute for the equipment model. According to the requirements of State Grid Corporation of China, the modeling needs to meet the requirements of GIM modeling format to achieve high versatility[9-10].

Figure 2 and figure 3 are the GIM format model of AC filter of Qingnan ±800kV converter station.

![Figure 2. Capacitor bank, resistor and reactor model of the AC filter](image1)

![Figure 3. Disconnector, arrester and current transformer model of the AC filter](image2)

4.2. Equipment layout and wire connection

3D equipment model layout is a very important link in the process of modeling. According to the overall functional requirements of the substation, the equipment layout should be completed from the perspective of reasonable beauty and easy maintenance. Coordinate zero point must be determined at the beginning of equipment layout, and attention should be paid to the coordination with civil engineering in the process of determining zero point, so as to ensure that the same zero point is used in the project.

After the equipment layout is completed, the cross-line and the connection between the equipment can be connected. Cross-line is mainly used for inter frame and outgoing line interval. Before connection,
conductor model, insulator strings and fittings at both ends shall be set. Designers shall comprehensively consider factors such as project voltage grade, pollution area of substation, altitude, etc. to determine the length of insulator string, type and spacing of fittings.

The connection between devices is used for small jumpers between different spans and the interconnection between main equipment. Single phase or three-phase connection can be selected for the connection process of cross-line and equipment. The efficiency of three-phase connection is higher, but it is inconvenient to modify. Therefore, three-phase connection can be selected under the condition of accurate positioning.

The following figure 4 and figure 5 show the AC filter bank and the AC filter field that completes the equipment layout and wire connection.

![Figure 4. AC filter bank that completes the equipment layout and wire connection](image1)

![Figure 5. AC filter field that completes the equipment layout and wire connection](image2)

In the process of AC filter field layout, it is necessary to carry out all-round live distance verification for the cross-line of different floor heights, between equipment and surrounding buildings. In the past two-dimensional design process, due to the limitation of perspective, designers need a lot of calculation to get the space distance to be verified. At the same time, because the expression is not intuitive, there are many difficulties in examine and verify. In the 3D assembly model, the charged space entity can be automatically generated by inputting the verification information such as altitude, voltage level and safety value type, so as to carry out the live distance calibration work efficiently and conveniently.

The sample of the safety clearance checking is shown like figure 6.
4.3. Automatic two dimensional drawing and material statistics

In the final assembly drawing, by setting a reasonable cutting section, the spatial plane section and axonometric drawing in PDF format can be easily extracted from the 3D digital model shown in figure 7. In the process of drawing, it is necessary to pay attention to the accuracy of the cutting position and the rationality of the cutting height setting, so as to ensure that the section drawing is consistent with the three-dimensional model.

At the same time, the automatic statistics of equipment and materials can be realized in the cutting section drawing. Through the design with database as the core, the problems of "wrong selection", "missing items" and "wrong quantity" in the process of equipment and material statistics are completely avoided. Under the premise of correct design scheme and input conditions, the correctness of design and the accuracy of statistics can reach 100%, which greatly improves the quality and level of the design work.

5. Conclusion and Prospect

This paper introduces the process and method of the 3D digital design for AC filter field of Qingnan ± 800kV converter station, and summarizes the experience of various specialties in modeling, model attribute, collaborative design, general assembly and material statistics. Adopting 3D digital design can effectively improve the design efficiency and quality, and solve some disadvantages in traditional design.
But at the same time, due to various limitations, there are still some problems, including poor data transmission with some professional calculation software, slow running of software after a large number of converter station models are installed, and some software functions are more cumbersome. In the future, in view of the engineering application level, the software use process should be further optimized to improve the operation friendliness. At the same time, the interaction between 3D digital design software and relevant professional calculation software and technical and economic software should be strengthened. It is believed that with the continuous efforts and promotion of all parties, 3D digital design will be able to comprehensively promote the change of design industry.

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