Application Exploration of BIM Technology in Integrated Fusion Power Supply System

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Abstract. BIM technology has gradually been widely applied in all aspects of social production and daily life. Especially in terms of engineering management and design requirements. However, adding BIM technology to a project will inevitably increase the cost to some extent. In order to maximize the implementation efficiency of engineering projects and ensure their high-quality completion, different projects will focus on using BIM technology in certain processes. For example, in the field of fusion power supply, after years of exploration and application of BIM technology, a project management process and integrated design method based on BIM technology have been developed. In engineering management, the focus will be on confirming the accuracy of BIM data, and in integrated design, the focus will be on project reliability analysis based on BIM data.

Keywords: magnet power supply, BIM, engineering management, integrated design

1 Introduction

BIM is the abbreviation of Building Information Modeling (BIM), defined by the National BIM Standards Committee NBIMS in the United States as: BIM is a digital representation of the physical and functional characteristics of a building facility, used to create a shared information knowledge resource, thereby forming a reliable decision-making foundation that runs through the entire building lifecycle from conceptual design to final disposal and demolition [1] - [3]. The application of BIM technology is particularly necessary in the implementation process of multidisciplinary collaborative cooperation in complex systems.

Fusion power supply system is a system that provides power supply and protection strategies for large inductance devices, involving professional technical aspects such as high voltage, high current, strong magnetic field, circulating cooling water, etc. By using BIM technology, complex system integration design involving multiple disciplines can be effectively managed, and accurate data references can be provided for each stage of complex system integration design implementation. So in the integrated design of ITER polar field converter system, BIM technology based on CATIA soft-

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ware is applied to track and manage the design integration of this complex system. In China, the government led CRAFT fusion host key system research facility is currently building a magnet power supply for CSMC coils. In order to track the implementation of integrated design, BIM technology based on CATIA software has also been applied.

2 Integrated Design of Magnetic Power Supply Based on BIM

In the integrated design of the magnet power supply, the basic process follows the process of Fig.1, with green, blue, and yellow labels corresponding to the survey, design, and construction stages in sequence. The survey phase corresponds to the first and second steps, with the aim of ensuring the accuracy of data in BIM. The design phase corresponds to steps three to five, with the aim of analyzing and managing the technical details of system integration through BIM technology. The construction process is the sixth to eighth steps, with the aim of recording and managing the system construction process through BIM, providing feedback and solving problems in integrated design, and verifying the reliability of integrated design.

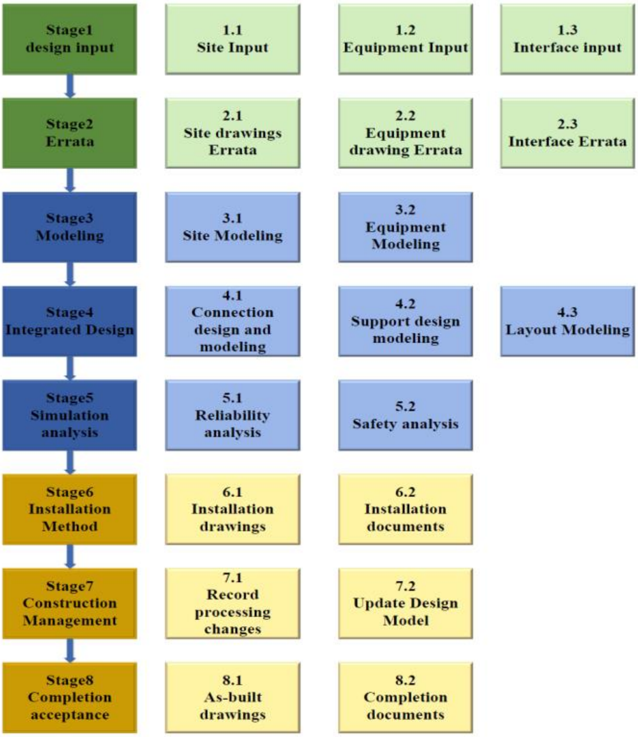

Fig. 1. The process of the integrated design of the magnet power supply

2.1 Design input and correction Phase

This stage is the stage of analyzing the project task book, clarifying the requirements, and collecting data, surveying, organizing, and analyzing. Taking CSMC power supply as an example, the entire power system needs to be installed in a space of 960 square meters (24x40). The main equipment includes 35kV switchgear (one incoming cabinet, one PT cabinet, and two outgoing cabinets). Two 35kV dry type transformers. Two sets of 30kA/250V converters. Two reactors, two false loads, one explosion switch, one vacuum fast switch, one set of energy transfer resistors, a total of 7 control cabinets, signal cabinets, and distribution cabinets. The main circuit topology is shown in Fig.2.

The magnet power supply system not only involves 35kV high-voltage equipment, rectification equipment with a total output of 50kA, reactor pseudo load converter that generates magnetic field, but also cable pipelines connecting control equipment and deionized circulating cooling water pipelines for cooling and heating equipment. Before modeling all equipment site interface information. It is particularly important to verify the consistency between the physical object and the site drawings and equipment drawings. The verification information is divided into three categories: 1. Interface information of the installation site, including waterway interface flanges, interface valves, cable trench positions, site height, foundation flatness, foundation materials, site size, etc; 2. Installation interface information of the device, including device interface location, interface connection method, device fixation method, device fixation position, etc; 3. Parameter information of the equipment, including weight, size, material, etc.

Most of the investigation work should be completed at this stage, and the next stage of work will be based on this for model drawing.

Model drawing includes equipment models not provided by the manufacturer, revisions to inaccurate models provided by the manufacturer, foundations of major equipment, power transmission line systems and supports, signal transmission systems and supports, and water circulation systems and supports.

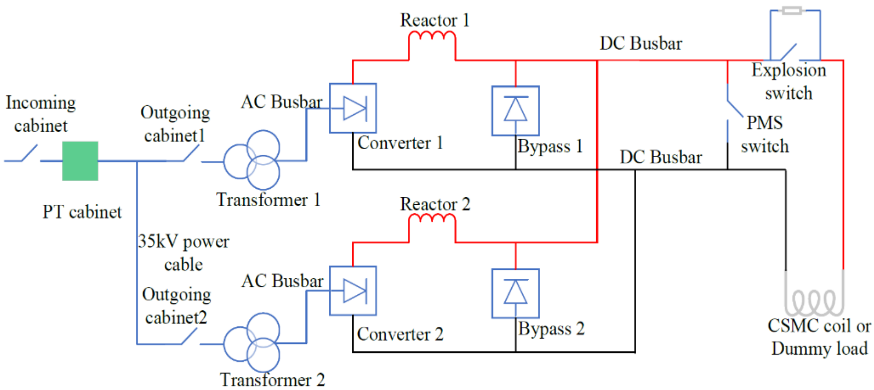

Fig. 2. The main circuit topology of fusion power supply

2.2 Modeling and Simulation Phase

The work of this stage is to establish a 3D data model based on the design input from the previous stage, and conduct corresponding professional analysis of the entire system based on the established BIM data to verify the reliability of the design. The CSMC power system has established BIM data based on CATIA software. The BIM data model is shown in Figure 3. Design reliability analysis will extract the corresponding model in Figure 3, then select a simplified model according to the analysis needs, and finally use analysis software for simulation calculations. According to the experience of fusion power integration, simulation calculations are conducted using Ansys software as the platform. The reliability analysis steps of integrated design are generally shown in Figure 4. The reliability analysis content involved in the integrated design of CSMC power system is mainly included in Figure 5.

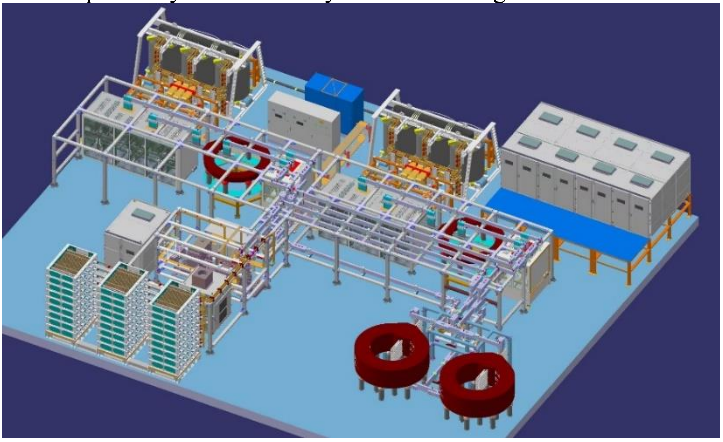

Fig. 3. The BIM data model of CSMC power supply

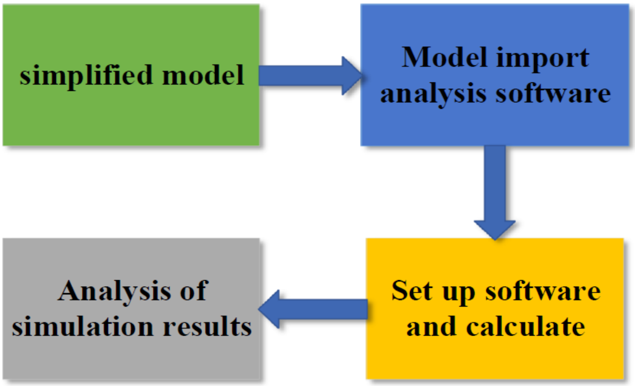

Fig. 4. The reliability analysis steps for integrated design

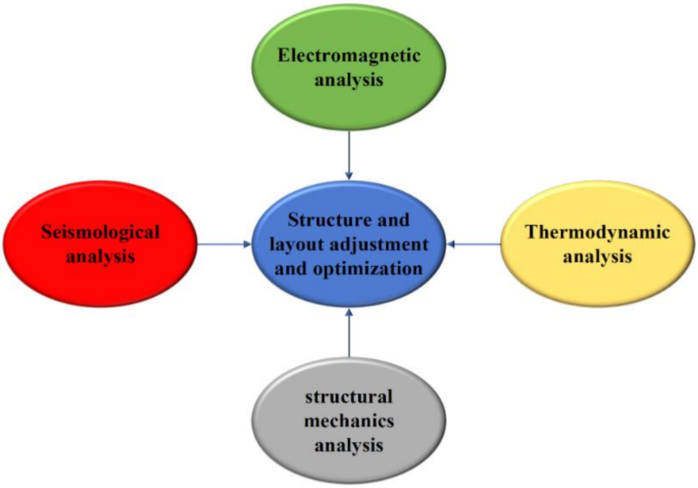

Fig. 5. The reliability analysis content involved in the integrated design

The main method of seismic analysis is to use the response spectrum method to calculate the maximum deformation and maximum equivalent stress of the equipment and support components of the power system under seismic waves, which has many advantages. Fast calculation speed, wide applicability, and high accuracy of results [4].

Electromagnetics analysis shows that the environment magnetic field in which the fusion power supply system is located is relatively complex, and in addition, the power supply system itself may generate a magnetic field due to the output current. Especially the magnetic field generated by changes in communication can generate eddy currents on metal equipment, including cable trays, supports, equipment shells, etc. In addition, strong magnetic environments also have a certain impact on equipment reliability. These problems also need to be optimized and avoided through electromagnetic simulation. Analyze the simulation results to determine the final design plan. The usual methods to solve the problem include: 1. replacing the components that have a significant impact with non magnetic components; 2. Change the structure of the affected components; 3. Adjust the distance between the affected equipment and the source of the magnetic field [5].

Thermodynamic analysis shows that in power supply systems, reactors, false loads, rectifiers, and other equipment with internal resistance are all involved in the problem of current heating. The system uses deionized circulating cooling water to complete the cooling of the equipment. By thermodynamic analysis, selecting appropriate waterway pipelines and water flow rates can ensure that the system operates safely and efficiently.

Structural mechanics analysis shows that in power systems, the main equipment of the power supply is mostly assembled using copper bars, aluminum bars, and flexible connections. They have a self weight of several tons and generate a certain amount of electric power when powered on. So the support, support components, and connecting components of the main circuit must undergo material strength analysis, static analysis, elastic analysis, stability and bearing capacity analysis, etc.

In addition, the comprehensive layout of the power supply system pipeline can also be simulated and optimized through BIM technology to reduce interference with equipment and effectively avoid major rework in the later construction process[6].

2.3 Construction Management Phase

After the integration design is completed, the installation drawings can be drawn directly by calling the information in BIM and describing the corresponding installation methods to form an installation file. In addition, the integrated design has been completed, and the cost accounting of its installation and integration has correspondingly become simpler. The description of system equipment using BIM data can be accurate to the quantity and material of bolts, and detailed quotation references can be released according to installation requirements. However, during the installation process, some equipment and site defects, as well as unforeseen circumstances, may have an impact on the installation and integration work. These cannot be completed through on-site adaptation, and it is necessary to provide a solution for on-site changes, and then update the changed information in BIM. Finally, based on BIM, issue completion drawings and documents [7].

3 Conclusion

The integration of fusion power supply systems based on BIM technology has advantages such as project visualization, process traceability, and design refinement, which has positive significance for the entire project implementation process. In order to accurately and reliably apply BIM technology, a BIM modeling and management team has been specially established to conduct cross platform data simulation and multidisciplinary collaborative management. BIM technology is already indispensable in the integration of fusion power systems. This has been verified during the long-term project implementation process. This experience can also be extended to high-tech projects in other fields.

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