

Application and study of 3D visualization model on nuclear power plant construction

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Abstract. 3-D visualization model is an advanced tool which addresses a digital expression to the project entity and functional characteristics by integrating the relative engineering data. Construction units lead this technique in the equipment installation activities of the first unit of AP1000 Nuclear Power Plant Project in the world. 3-D technique proved its advantages in construction scheme preparation, second design, collision simulation, construction logic, etc. Through the introduction of the main characteristics and superiority of this technique, the solution and suggestions for some project insufficiencies have been proposed. This will represent a benefit for its application in the future.

1. Forward

Large commercial Nuclear Power Plant (NPP) construction is a complex engineering system, which is characterized by strong investment, long cycle period, complicated interfaces, overcrowded people and crossover operation, among others. It means that there are lots of difficulties and complexities in the construction management, such as collision check, construction simulation, crossover operation, the second detail design, etc. 3-D visualization model has been drawn step by step in AP1000 (Advanced Passive) NPP Project construction management, showing that some practical difficulties had been solved by the new technique. However, some inefficiencies like insufficient planning and the application range and depth, appeared during the application. It proves that it will be necessary to gather and sum up experience and lessons, analyze the problems and make a more effective use in the future.

2. Summary introduction of technique

3-D visual model technique, based on the three-dimensional digital technology, can provide a digital expression of the project entity and functional characteristics by integrating the relative engineering data. It can solve the consistency and global shared problems between the distributed, heterogeneous engineering data-base.

Four levels can be summarized in 3-D visual model technique, including visual simulation, performance simulation, virtual simulation and virtual reality. For detail, the visual simulation (also known as the 3-D visualization) presents the inner-architecture, shape, material, color, lighting and environment in the form of 3-D automatic navigation. The performance simulation can show the traditional scientific computing process and result as an intuitive way of 3-D information model which also can carry out a test of the simulation, including the material structure calculation, acoustic testing,



thermal performance and physical environment factors such as sunlight and wind pressure. The virtual building and virtual reality can represent the process of real building construction, including all the physical properties such as gravity, friction, atmosphere and its change, in order to minimize the difference between the construction design effect, process and target.

3. Application on Nuclear Power Project

3.1. Overall objective

Revolving around the project operation, the overall policy of introducing the 3-D visual model technique into the nuclear power engineering is to solve the key technology and difficulties in the project, make sure that the technology works in all fields and ensure the risk control management works in the whole construction process. In order to complete the above target, during the construction phase, the 3-D model of all main subjects should be created. It will be optimized with the combined data from the electric, piping, large-scale equipment, ventilation and valve teams, etc. The strict compliance between the 3-D visual model and the drawing should be confirmed. According to the needs of construction, the difficulties and mile-stone activities can be showed in the 3-D visual model after the intensive study and technical clarification by each subject team. Once this step is completed, the 2-D detail drawing used for the construction on-site can be issued.

3.2. Model Building

Solid modeling technique describes the internal geometry of the object with the stereoscopic thinking instead of plane thinking. The spatial object is first abstracted as a series of adjacent 3-D geometry, and then assembled by another method^[1]. The main modeling methods include scanning, boundary representation, dimensional geometry, mixed representation and others.

In addition to the construction of 3-D visual model, the most important aspects of 3-D visualization model building is to construct the model base with geological, building, plant and equipment parameters and to build the information database^[2]. Due to the complexity of the model, the modeling process is tedious and should be repeated by stretching, lofting, geometry Boolean calculation and arraying. The information model, in this way established, can be combined with the virtual simulation technology and achieve the overall planning of the construction site and formulating emergency plans. In general, the parameters should be modeled separately. For example, REVIT software is more suitable for building 3-D visual information model of the plant, but attention should be paid to the detailed models of structures and installed equipment.

3.3. Construction General Layout Management

There is no reference project for the construction of China AP1000 NPP due to the fact that it is the first unit of its kind in the world. As the most important content of the construction management, construction general layout management should use the 3-D visualization model. The construction site planning, design and layout can be optimized by inputting the time and space arrangement information based on the related machine tool and the NPP structure and equipment. This information includes the layout of 3200t large-scale crawler crane, 500t crawler crane, elevators, concrete hoist, box change and other equipment.

3.4. Solution Proposal and Processing Simulation

Regarding to the operations, such as large-scale hoisting, which are too difficult to control but easy to cause accidents, the 3-D visualization model technology could be used to prepare the large-scale structural module hoisting program, to simulate the operation process and calibrate the safety measures (shown in Figure 1). It can greatly reduce and effectively control the occurrence of safety incidents and improve the construction safety management level. In addition, the 3-D visualization model technology could also be used to simulate the construction process of installation of important

equipment in nuclear island and high-precision embedded parts. The 3-D visualization makes the preparation, demonstration, review and clarification of the construction program more intuitive.



Figure1. Simulation of the large-scale lifting in a NPP project

3.5. Technical Clarification by Visualization

Construction units should manage the involved staff to understand the relevant drawings and technical documents and integrate the original design information through an intuitive, complete and highly integrated project design information platform^[3] in order to obtain the useful management information. This approach can shorten the technical preparation time for the construction team and improve the efficiency and accuracy of drawing technical documentation. Practice has proved that technical clarification by visualization is particularly useful for low-level education workers.

3.6. Construction Logic Research

Modular construction is one of the technical characteristics of the AP1000 NPP construction. Civil engineering and installation are overlapping at the beginning of the project. Two teams should first plan their respective construction activities in the same area of the nuclear island^[4] and then rearrange them after careful discussion. The building can be capped after all large-scale equipment has been installed and most of the installation work has been done so it could be said that the construction logic is much more complex. For example, in a system installation process, engineering and technical personnel with the help of 3-D visualization technique can intuitively find that several pieces of pipe need to be installed after the installed module; otherwise it will hinder the module in place. This clearly reflects the three-dimensional technique is an appropriate means of construction logic superiority.

4. Suggestion for improvement

Through the preliminary application of 3-D visualization model system in AP1000 NPP project, the construction unit solves a large number of practical engineering problems; speeds up the development and utilization of enterprise information resources; makes the design information resources to the best configuration and construction of enterprise management and operation with higher efficiency and lower costs. However, 3-D visualization model system application could be improved in the following ways:

- Technique application scope can be widening. Using system management methods could extend the range of application of 3-D visualization model system to schedule management, quality management, safety management, procurement management and so on. Furthermore, it can develop the function of automatic retrieval and statistical chart generation. 3-D visualization model system can provide the best means of information management for the construction materials, equipment preparation and engineering statistics.
- The promotion of the technique application. Through business management process analysis and reorganization, the 3-D visualization model should be upgraded from a single technology application

to the engineering system management application^[5]. It will raise the value of 3-D visualization model.

- Attention to the accuracy of database. As China AP1000 NPP Project is the first one in the world, the design has to be modified at the same time with the construction activity. Accompanied with the engineering drawings frequent modification, the original model information has to be updated and supplemented. This means that a certain technical force should be prepared to guarantee the accurate data base is available on time or it will easily result in decision making biases.
- Enhance the share of information. The construction of NPP needs the cooperation of the operating units, general constructors, civil construction units, installation units, supervision units, equipment manufacturers, design units and other construction enterprises. The 3-D visual model technique will play a more significant role if all the participating units have used the same information platform.

In short, the application of this new technology should be explored, developed and extended step by step together with the NPP project in the future. The user should make feedback experience summary in order to improve and represent the potential advantages of the 3-D visualization model technology.

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