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4D Simulation for Nuclear Power Plant Construction

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1. Introduction

For the timely and competitive response to rapidly changing energy environment at the turn of millennium, there is a desperate need to build the nuclear power plant (NPP) in the virtual reality of digital engineering prior to commissioning. To construct a NPP is a highly integrated, voluminous project. Verification of design and initial planning is prerequisite to construction to confirm optimal fabrication and high productivity. This paper presents the design feasibility by simulating the initial construction plan of NPP using four-dimensional (4D) simulation. The virtual reality method, using three-dimensional (3D) computer-aided design (CAD) model, enables various designs in the project launching stage to be promptly and exactly previewed.

2. 4D Simulation for NPP

2.1 4D Simulation

In a 3D CAD environment, designers, planners and engineers can easily recognize the shape of construction components. On the other hand, a construction schedule is difficult for planners to produce directly from 3D CAD models. Instead, planners have to envisage the sequence of construction in their mind.

The idea that coupled the 3D CAD models with the construction schedule was conceived two decades ago [1]. 4D simulation combines 3D CAD models with time to achieve project construction planning and scheduling tasks. Thus, planners were able to produce construction schedule easily. Relevant site facilities are displayed in 4D simulation to show the status of the locations of facilities and temporary components. The 4D simulation shows exactly the contents at site locations in the 3D virtual space by tracing material status.

2.2 Advantages of 4D Simulation

Effective planning and scheduling of processes and activities are central to the success of any construction project, irrespective of its magnitude. 4D simulation is a valuable construction management method that is well suited to the analysis of the construction processes. 4D simulation allows construction planners and analysts to experiment and evaluate different scenarios during the planning phase. Much information of plant construction such as assembly is analyzed and modeled in the digital space [2,3]. The digital mock-up model is constructed graphically using a 3D CAD system as shown in Fig. 1.

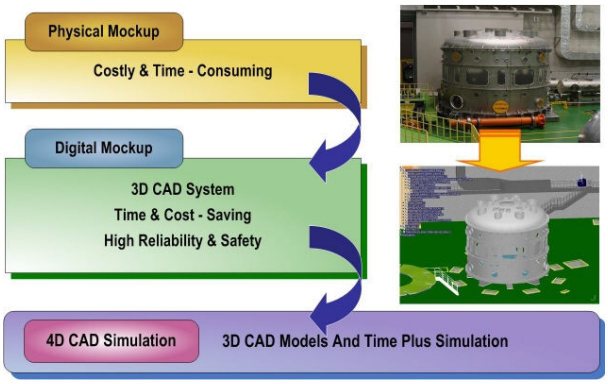

Figure 1. Digital mock-up based on 3D CAD models

Since 4D simulation knows exactly which type of resource and how much of it will be used in a specified place and at a specified time, it is possible for the model to evaluate site plans. Interferences amongst the NPP components can be checked upon early in the design stage using the 3D CAD models. Construction process can be visualized as demonstrated in Fig. 2.

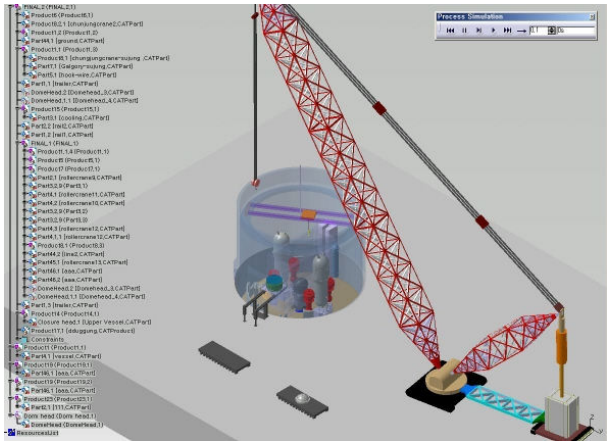

Figure 2. Visualization of the NPP construction

If a process turns out to be incorrect, planners adjust the schedule and rerun the 4D simulation to verify it. 4D simulation gives planners the capability to improve the construction sequences, identify and resolve schedule errors and manage workers and resources like concretes, trailers and cranes. It lets planners formulate a tighter, more finely tuned construction plan. 4D simulation can also help develop contingency plans to deal with delays in material deliveries or address the unavailability of resources. Important decisions concerning deadlines, sequences, and resource utilization have to be made ahead of time to avoid rework. Feedback from the construction to the design team resulting from 4D model reviews can lead to a more readily constructible,

operable and maintainable project [4]. Fig. 3 shows the basic process of construction planning using 4D simulation.

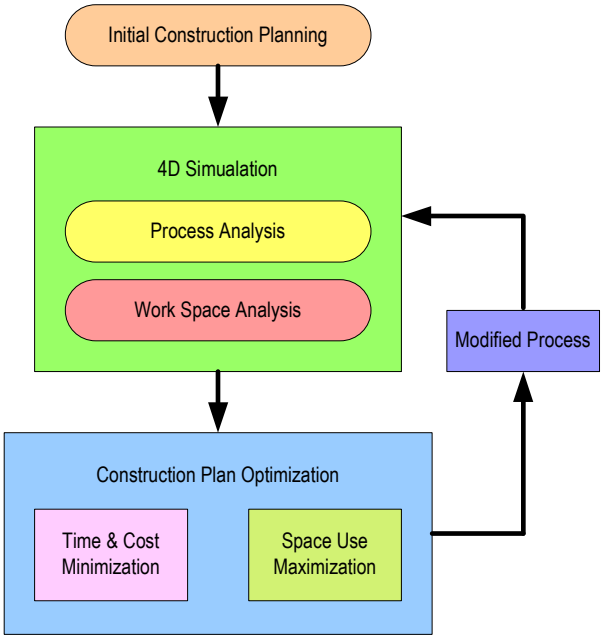

Figure 3. Basic process of 4D simulation

The 4D simulation accelerates human recognition and understanding, thus allowing for the model builder to efficiently complete the simulation task, and to explain the impacts to those not intimate with the model, such as managers, customers, and engineers in other fields. The technology can also effectively reduce the risk by increasing the level of understanding that the decision makers possess regarding the impact of problems and proposed solutions. With real-time control of the model, user can preview any potential problem areas. The greatest advantage of 4D simulation lies in that any change of the overall process procedures can virtually be tested. On the other hand, it is financially unbearable to alter the procedures consisting of plenty of structures and components, complicated detailed processes and long work hours on the physical site [2,3].

3. Conclusion

4D simulation is steadily advancing and will have a far-reaching impact on the processes of construction management as currently practiced. 4D simulation has been described, characterized by its extensions into the areas of resource management and layout assessment. Moreover, 4D simulation can be applied not only to the construction process, but to the decommission process. By using the powerful digital technology, NPP can be optimized for construction plan and the structural design. In conclusion, the use of 4D simulation is slated to bring about revolutionary change in improving the NPP life cycle starting from the conceptual design, construction, operation, maintenance all the way to decommissioning.

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