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Digital Technology for Construction Period Reduction of Nuclear Power Plants

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1. Introduction

PHILOSOPHIA, Inc. and Seoul National University have jointly developed a first-of-a-kind engineering (FOAKE) solution [1-8]. The solution lends itself to the four-plus-dimensional (4^+D) Technology™ resorting to three -dimensional (3D) computer-aided design (CAD) digital mockup (DMU). The aim is to minimize the working hours via process optimization by real-time exchange of design and process information in the ubiquitous system. The 4^+D Technology™ in the 3D virtual reality (VR) space and time plus cost coordinates, is developed to reduce the construction time as well as cost of nuclear power plants (NPPs) by optimizing the manufacturing procedure and construction process.

The 4^+D Technology™ anchored to the 3D CAD DMU allows the interference of the NPP components to be checked upon early in the design stage, and the process sequences to be optimized. Moreover, its ergonomic and robotic technologies enable simulation of all the aspects of the workers, robots and machines involved in the construction process. One of the greatest advantages of the 4^+D Technology™ lies in that any change of the overall process procedures can virtually be tested. On the other hand, it shall financially be unbearable to alter the procedures consisting of plenty of structures and components, complicated detailed processes and long work hours in the physical space.

2. Solution

The Plant Ubiquitous Modular Assembly (PUMA) is a leading-edge digital process management solution for NPP systems optimal design and construction resorting to the 4^+D Technology™. PUMA exploits detailed 3D DMUs to visualize their assembly process. In this paper PUMA is applied to modularization and construction of the Optimized Power Reactor 1000 MWe (OPR1000) developed by the Korea Hydro and Nuclear Power Co., Ltd. to optimize the equipment production and plant construction process. Interferences among the OPR1000 equipments are checked upon, and their exemplary process schedule is demonstrated.

The 4^+D Technology™ is definitely the centerpiece in reducing the NPP construction period. Prerequisite is creating 3D DMUs and systems of NPP. When the engineers strive to put together the elements of NPP for modeling and simulation, the enormous scale of NPP simply defies the use of commonplace small scaled tools. CATIA and DELMIA are utilized in this work for the digital process management of the OPR1000 resorting to their full comparability in sharing 3D files and work history.

3. Application and Results

The 4^+D process simulation starts with CAD DMU of the concrete unit, steel structure and equipments of NPP as demonstrated in Fig. 1. In constructing the concrete structures, modularization method of construction is now in common use. This is because construction can be advanced simultaneously in each section through modularization so that its assembly and construction period can possibly be shortened considerably.

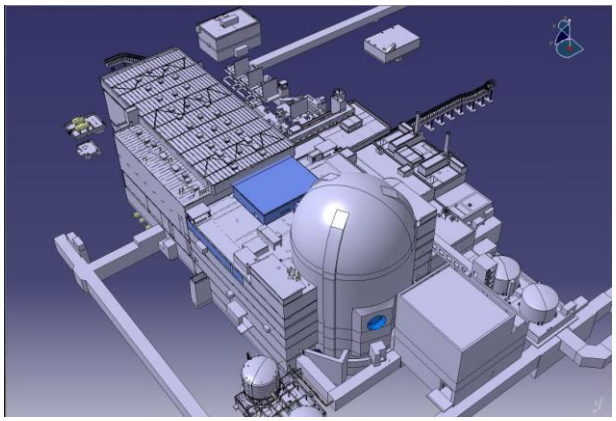

Fig. 1. CATIA model of OPR1000.

Once assembly of the CATIA models for OPR1000 is completed, the 3D concrete model is then cut and split section by section according to the drawing instructions. The 3D models can this way be imported to DELMIA as product resources.

DELMIA carries interfaces for producing simulations. First, the engineers generate the process items called activity linked to each product item made of CATIA 3D model files. These activities are the key items for setting up the order and time, and the main character of the simulation. DELMIA provides sequence interface to set up the activities as the order of simulation lies. With sequence interface, there is a time chart interface which lets the user set up the duration of each activity as the progress schedule depicted in Fig. 2.

In this work two simulations are made. One is the original OPR1000 Ulchin construction simulation that took 56 months. The other is a reduced 48 month period construction simulation in which some new construction methods are applied from a demonstration point of view.

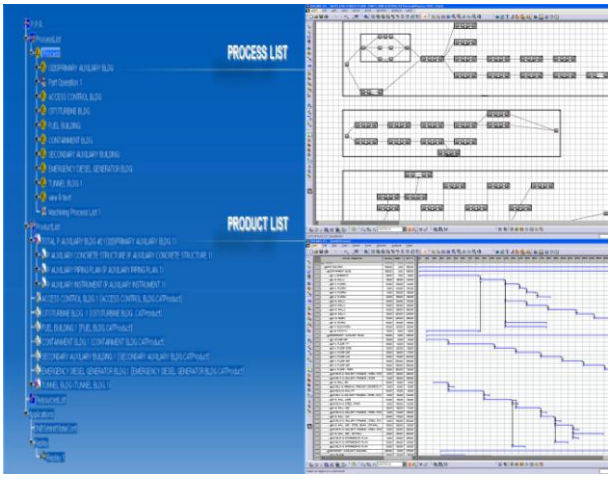

Fig. 2. Interface of 4+D simulation tool.

Considering the scale and construction period of NPP, the planning is crucial of the overall process. In the course of the construction planning, if the constructor can see the whole process of construction site and set up the process as one's intent, one can without difficulty identify an optimized way of constructing the NPP. As aforementioned, the 4+D Technology™ can be used in detailed process visualization as demonstrated in Fig. 3. The visualized NPP construction process is thus vital to coming across an apt way of shortening the construction period. Finding and fixing errors of construction plan prior to the actual construction through simulation is also a smart idea to reduce the period with.

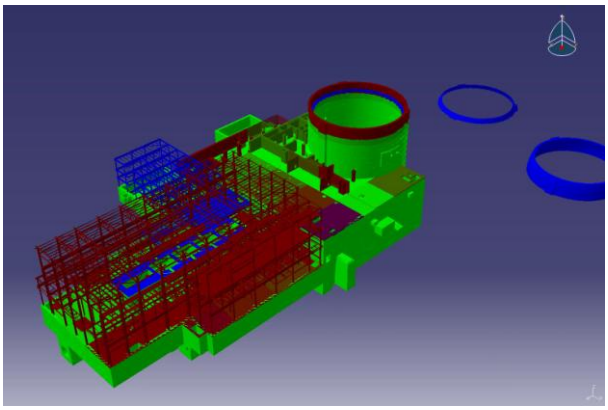

Fig 3. OPR1000 construction simulation.

4. Conclusions

The digital method of coupling the CAD DMU and 4+D construction simulation sheds light on possibilities in constructing the NPP. If one starts with accurate real construction information to carry detailed construction simulation, the 4+D Technology™ can be adopted in minimizing the trial and error in the construction stage, developing a blueprint for new construction methods, and reducing the engineering and construction periods of the NPP.

ACKNOWLEDGMENTS

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