The Three-dimensional Digital Factory for Shipbuilding Technology Research

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Abstract. The three-dimensional digital factory technology research is the hotspot in shipbuilding recently. The three-dimensional digital factory technology not only focus on design the components of the product, but also discuss on the simulation and analyses of the production process.Based on the three-dimensional model, the basic data layer, application control layer and the presentation layer of hierarchical structure are established in the three-dimensional digital factory of shipbuilding in this paper. And the key technologies of three-dimensional digital factory of shipbuilding are analysed. Finally, a case study is applied and the results show that the three-dimensional digital factory will play an important role in the future.

1 Introduction

Digital factory technology is an integrated virtual technology, which is focused on process planning and production planning. With the development of virtual reality and computer technology, the digital factory theory and technology have become matured gradually. The digital factory system has been designed and used by many shipbuilding companies and organizations in the world.

Based on the expert system, S. Akagi and K. Fujita achieved digital design for shipbuilding preliminary design [1]. Myung researched the Model-Based Definition (MBD) of shipbuilding design, and developed the software systems for design of shipbuilding [2]. Based on the CAD system, K.H Lee applied the design method to the layout for shipbuilding process [3]. Depended on the STEP data format, Kim researched database storage and data exchange for shipbuilding methods [4]. M.Y Li applied the discrete particle swarm optimization and evolutionary direction operation to realized a hybrid assembly sequence planning [5-6]. In addition, the digital technology of design industry abroad has been more mature and the powerful shipbuilding software system has been developed [7-9].

In terms of digital integration, the research is focused on the development of application software systems from the ship design to shipbuilding [10]. Along with the development of digital technology, the digital simulation of internal outfitting design, analysis and process can be realized[11]. The system of digital shipbuilding is developed by the Samsung Shipbuilding Industry, and the whole shipbuilding process can be simulated and in the virtual environment, the results are used in shipbuilding, directly.

At present, the digital factory technology is not yet fully throughout the whole life cycle of the shipbuilding. The realization of data exchange technology, information integration technology, shipbuilding cycle optimization and other functions should be researched. To realize the combination of the three-dimensional factory and shipbuilding, the hierarchy of the three-dimensional digital factory for shipbuilding is discussed, the key technology of the three-dimensional digital factory for shipbuilding is analyzed, and the shipbuilding process of the three-dimensional digital factory is established in this paper.

The rest of paper is organized as follows. Section 2 introduces the hierarchy of the three-dimensional digital factory for shipbuilding. Section 3 discusses the key technology of the three-dimensional digital factory for shipbuilding. A process flow of shipbuilding with three-dimensional digital is established in Section 4. In section 5, a verified case study is given. Finally, this paper is concluded in Section 6, and the prospect of future research is given.

2 The hierarchy of the three-dimensional digital factory

The hierarchy of the three-dimensional digital factory for shipbuilding can be divided as basic data layer, application control layer and presentation layer, as shown in Fig. 1.

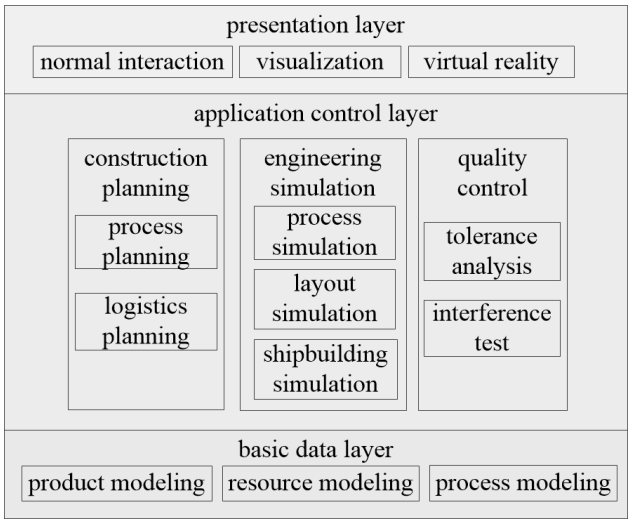

Figure 1. The digital factory hierarchy for shipbuilding

2.1 Basic data layer

The basic data layer is the foundation of the three-dimensional digital factory for shipbuilding, which is comprised of product modeling, resource modeling and process modeling. And the role of the basic data layer is to realize the interaction of basic data information.

Accompanied by the use of MBD modeling methods, the information of the traditional two-dimensional drawing is redefined by the three-dimensional digital. The shipbuilding information can be fully expressed in the three-dimensional model. And the three-dimensional model is used as the unique shipbuilding data source in shipbuilding design and process.

Resource modeling is comprised of workshop, equipment, tools and other resources, which are the necessary resources in the digital factory. The resource modeling is also comprised of virtual human resource, which is used in the virtual simulation process. The feasibility and authenticity of the digital factory can be determined by the integrity of the resource modeling.

Process modeling is the necessary crafts, which is comprised of processing craft, installation process and disassembly craft. The process modeling is the basis of the construction simulation.

2.2 Application control layer

The application control layer is the core layer of the three-dimensional digital factory technology for shipbuilding. The layer includes the construction planning, engineering simulation and quality control.

Construction planning is comprised of process planning and logistics planning. The goal of the process planning is to change product design information to manufacturing information, thus the manufacturing strategies can be determined. Logistics planning is divided into external logistics and production logistics. And the external logistics is also the factory logistics, which is comprised of material routes and bus routes. The production logistics is expressed as the process of production, products from the production step into the next, in accordance with the processing and storage process.

Engineering simulation is comprised of process simulation, layout simulation and shipbuilding simulation. The process simulation includes the changes of the forms of geometric and physical factors. Layout simulation includes the equipment layout and the location of tools layout. Shipbuilding simulation is the core of the simulation, whether the construction of products in the production line can be finished and verified by the simulation.

Quality control is comprised of tolerance analysis and interference test. The purpose of the quality control is to ensure the authenticity and validity of the simulation.

2.3 Presentation layer

The presentation layer is comprised of normal interaction, visualization and virtual reality. The purpose of interaction between human and computer can be realized. The interaction is comprised of desktop virtual construction, semi-immersive virtual construction and immersive virtual construction.

3 The key technology of the three-dimensional digital factory

The key technology of the three-dimensional digital factory is comprised of digital modeling technology, optimization simulation technology, virtual reality technology, and application production technology, as shown in Fig. 2.

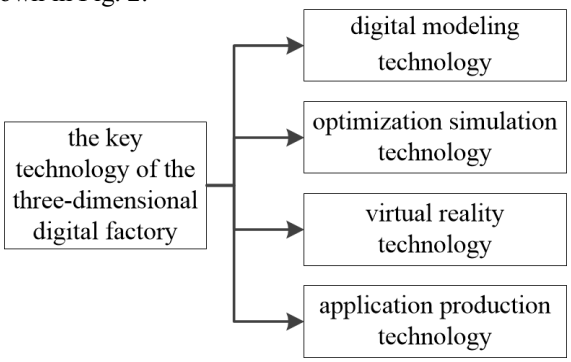

Figure 2. The key technology for the shipbuilding three-dimensional digital factory

3.1 Digital modeling technology

The digital modeling technique is the foundation for the three-dimensional digital factory. The models of products, manufacturing resources and tools are integrated with simulation system, and the underlying data of the digital factory can be established. The model of three-dimensional component is the actual component modeling in the three environments. The modeling of product function information, product structure information, product process information and other modeling methods are used in digital factory modeling technology. With the deepening of the research and application of the three-dimensional model, the two-

dimensional drawings will be replaced gradually, and the paperless drawings will be realized.

3.2 Optimization simulation technology

The optimization simulation includes simulation and optimization. The simulation technology is comprised of application process simulation, welding process simulation, assembly process simulation, ergonomics simulation, logistics simulation and verification process simulation. The purpose of simulation is to analyse the original design, and find product design defect, finally, the process of preliminary shipbuilding is put forward.

Optimization is comprised of process methods optimization, assembly sequence optimization, process planning optimization, ergonomics optimization and so on. The optimizations of the simulation are often achieved by the methods of optimization algorithm or experience optimization. And the optimization methods are established on the basis of the simulation methods. Through the analysis of the process simulation, the logistics path optimization and the efficiency can be achieved.

3.3 Virtual reality technology

Virtual reality is based on human-computer interaction, whose purpose is to realize the information interaction between real environmental and virtual environment. And the depth of design and the degree of influence to the demand can be determined by the development level of virtual reality and application depth of virtual reality in the digital factory.

3.4 Application production technology

The purpose of application production technology is to accelerate the conversion between design and application of products manufacture. And to establish a process from parts design to product manufacturing.

4 The process flow of three-dimensional digital factory

The three-dimensional digital factory for shipbuilding can be divided into information modeling, sequence planning, path planning and process simulation.

4.1 Information modeling

The three-dimensional model is the basis of the information modeling for shipbuilding. On the basis of the completion of the three-dimensional model, the three-dimensional model of attribute information is edited, in order to finish building information modeling.

Information modeling including size information, datum information, attribute information, geometric information and environmental information. As shown in Fig. 3.

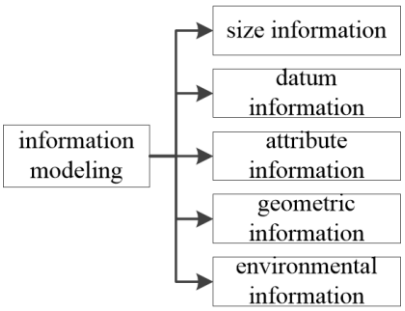

Figure 3. The constitution of information modeling for shipbuilding

4.2 Sequence planning

Sequence planning method is an important part of the digital factory. The planning method design and planning optimization are included in sequence planning of shipbuilding. And the best sequence planning of shipbuilding can be achieved by optimal simulation, finally.

Sequence planning consists of evaluation index system, sequence stability, sequence redirection number, optimization algorithms and the generation of the optimal sequence, as shown in Fig. 4.

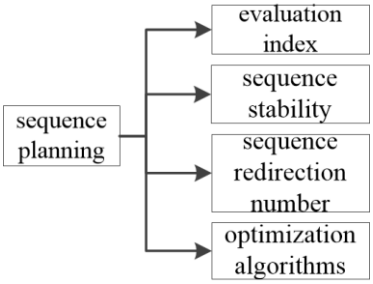

Figure 4. The constitution of sequence planning for shipbuilding

4.3 Path planning

The path planning is the equipment assembly path in the process of construction. Path planning consists of path resource planning, path optimization algorithm and the path evaluation method. The logistics planning level of digital factory shipbuilding process is determined by the quality of path planning.

4.4 Process simulation

Process simulation is used to verify and analyse the initial shipbuilding process in the construction of the virtual environment. Through the sequence optimization, path optimization and many other methods, the shipbuilding process optimization can be achieved.

Process simulation consists of assembly process interference inspection, ergonomics analysis, assembly reachability analysis and simulation environment. And the assembly reachability analysis is focused on the three-dimensional digital factory of shipbuilding. The process simulation is shown in Fig. 5.

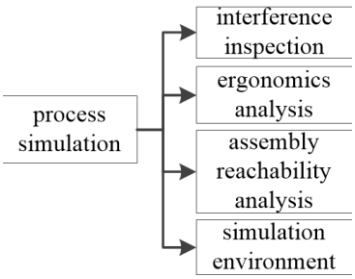

Figure 5. The combination of process simulation

The flow chart of three-dimensional digital factory for shipbuilding is shown in Fig. 6.

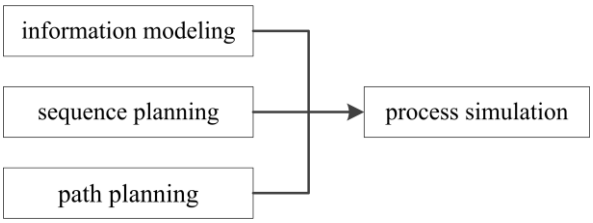

Figure 6. The flow chart of three-dimensional digital factory for shipbuilding

5 Case study

As shown in Fig. 7, a three-dimensional digital factory example was used to study and analyze, which was tested and analyzed in DELMIA software of Dassault Systemes. In this study, the information modeling was built, and the sequence planning was also optimized, the path planning was researched. Finally, the process simulation was verified completely.

The assembly process interference inspection, ergonomics analysis, assembly reachability analysis and simulation environment also are shown in Fig. 7.

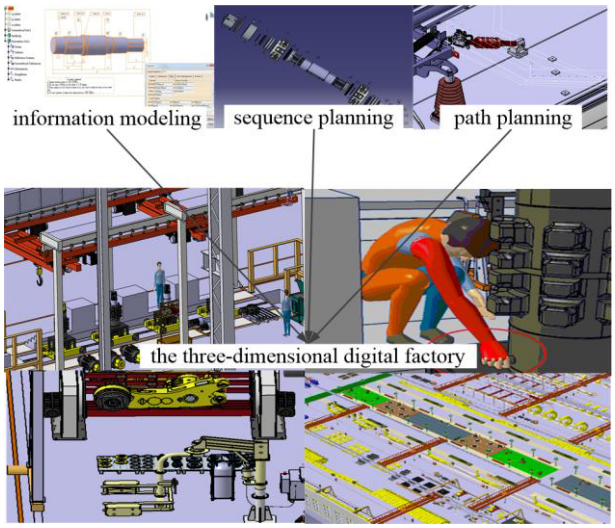

Figure 7. The three-dimensional digital factory

6 Conclusions and future work

The three-dimensional factory technology for shipbuilding is one of the hotspots in current shipbuilding. In this paper, a hierarchy of the three-dimensional digital factory for shipbuilding is researched, a three layer of structure for shipbuilding is established, the key technology of the three-dimensional digital factory for shipbuilding is discussed, and the process flow of shipbuilding is established. The case study shows that the three-dimensional digital factory for shipbuilding was suitable.

With the deep application of the three-dimensional factory technology, virtual shipbuilding, virtual maintenance and collaborative shipbuilding will be the focus of future research. As the future of shipbuilding advanced planning and mode of operation, the research of three-dimensional digital factory technology is still in the preliminary stage. The technical and systematic theoretical of three-dimensional digital factory should be discussed and studied in further.

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