Using 3D-CAD For Simulation-Based Production In Shipbuilding

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***Abstract*—The three-dimensional computer-aided design (3D-CAD) system has been popularized in not only design but also production in many industrial fields. With simulation of 3D digital models, the Computer Integrated Manufacturing (CIM) system has improved the efficiency and safety of production at each stage of work, and achieved the optimization of manufacturing.**

This research paper describes the application of simulation-based production and digital manufacturing in shipbuilding, where the traditional 2D drawings are hardly observed the whole ship 3D complex structures due to interference between the structures and the equipment of complex shape. By simulation in shipbuilding the computer-optimized manufacturing can be possibly achieved.

***Index Terms* — 3D-CAD, Simulation, Shipbuilding Production.**

I. SIMULATION-BASED PRODUCTION AND COMPUTER-INTEGRATED MANUFACTURING

In manufacturing, the acquisition of valid source information about the main relevant characteristics and behaviors of manufacturing function is the key issue for simulation.

Other key issues are the use of simplifying approximations and assumptions for the model of simulation, and the perform of fidelity and validity of the outcomes of simulation (Winsberg, 2001). Recently, the simulated-based production have been applied due to the availability of the simulation technologies such as order-sequencing, production equipment and process, assembly, production efficiency evaluation, and currently 3D production model (Jones & Iuliano, 1997; Thiel et al, 1998; Hertel et al, 2005).

Computer simulation has been applied in ship design stage, mainly in initial planning and structural analysis while it has not been widely implemented in the ship production stage due to complicated processes in production. However, the introduction of production simulation is aimed to (a) improve quality by estimating performance of the ship in accordance with design demand, (b) shorten of lead times by shorten the construction stage, and (c) reduce the production cost. In order to achieve those objectives, the simulation based production in shipbuilding has been applied to: (Okumoto, 2002)

- analysis and evaluation of the production process,
- planning and assisting of production,
- training for skilled works in particular fields such as piping assembly, erection of complex hull block, carriage of equipment, installation of contra-rotating propeller; and
- work safety.

When Computer-Integrated Manufacturing (CIM) is applied, the functional areas of a manufacturing enterprise such as design, analysis, planning, purchasing, cost accounting, inventory control, and distribution are linked through the computer with the factory-floor functions such as materials handling and management; as result the CIM provides direct control and monitoring of all process operations. The CIM is most useful where a high level of information and communication technology (ICT) is used such as CAD/CAM systems, the availability of process planning, and its data. There are however few major challenges to development of a smoothly CIM operation: integration of components from different suppliers, data integrity, and process control (Yoram, 1983; Waldner, 1992; Singh, 1997).

A ship is the large complicated structures composing of a million of parts, which are comprised of many kinds of materials. During ship construction, it is necessary that the production method and timing should be planned based on information relating to its parts, the enterprise's human resources and the shipyard's facilities. The production planning has depended on the accumulated know-how of workers in shipbuilding, which satisfies the efficiency and quality requirements for each combination of job. However the turnover of skilled workers in shipbuilding industry is very high due to the business stagnation. So to solve that problem, it should consider the application of the CIM and its core simulation based production.

In the meantime, it is said that three dimensional (3D) CAD is effective in production simulation but from the past, it had not been realized because the cost to make 3D models might be too much due to particular job-order production. The capability of computers has improved, their prices have become cheaper, and the application software has been more popular. Hence the computer-simulation production has become easier to use in shipbuilding.

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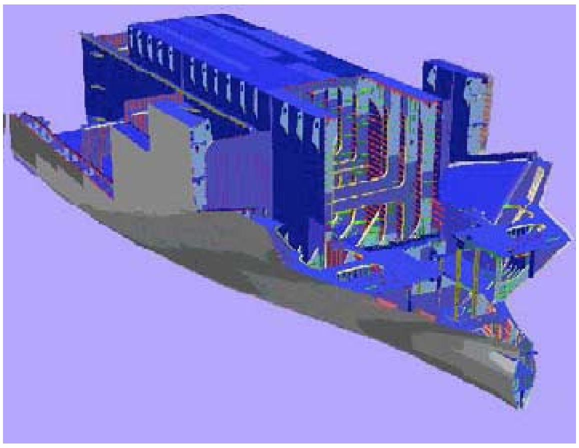

Figure 1. Structure of VLCC in building block after 2-week erection

In addition, all ship structures have been defined recently by 3D-CAD as figure 1. Using such product models, production simulation becomes possible for both hull structures and fittings, as result the further achievements of efficiency, safety, and quality.

II. COMPUTER-OPTIMIZED MANUFACTURING IN TYPICAL ASSEMBLY UNIT

The simulation-based production allows (a) checking the feasibility of the construction procedure by using dynamic moving images, (b) confirming the interference both human and structures by compensating human errors and raising the integrity of the engineering, and (c) optimizing the construction process by providing common acknowledgment and cooperation to all related workers.

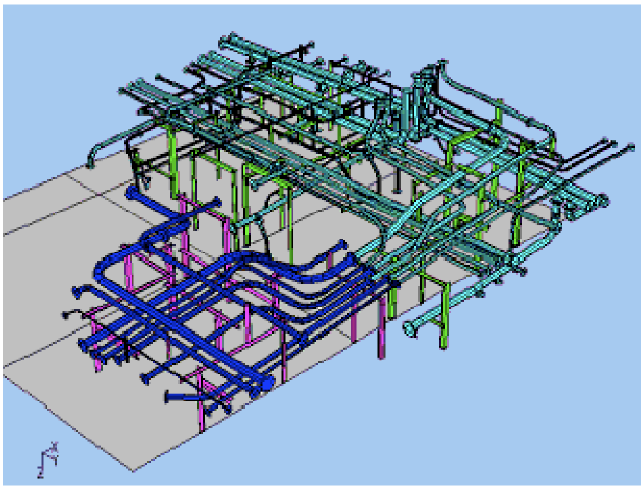

Figure 2. 3D image of bird-eye view of the pipe unit

Assembly work of fittings is a typical job-order in shipbuilding, the design and production details are almost different every time. Hence, the work has to be carried out on the basis of personal experience by observing only the drawings which traditional 2D drawing might not include detail instructions for work procedure. Hence, there might be problems: training are necessary, design errors are not found, unpredictable problems occur, schedule is interrupted, inexperienced workers can not perform the work, and so on. With the assembly simulation is deployed in the shipyard, the 3D structural tree of components is display on PC as figure 2, including related part list and relation with each component; it is comprehensible even for inexperienced workers. (Okumoto & Hiyoku, 2005).

III. IMPLEMENTATION OF SIMULATION-BASED SIMULATION IN SHIPBUILDING

To cope with international competition, the Vietnam shipbuilding industry should focus on product development and improvement by enhancing its competitiveness not only with a high quality product but also with further process improvement, leading to reliable and short delivery times and relatively low prices. In order to achieve this, shipbuilding industry should improve its process control, but the factors such as: the number of production steps, the enormous amount of parts and subassemblies, and the far-reaching interference with subcontractors make shipbuilding a very complex process.

Within the shipbuilding industry, simulation to control processes has been applied with following steps: simulation scope, simulation model, and simulation input/output. In simulation scope, the complete production complex process need to be reproduced dynamically model as figure 3. To examine this model, should take into account all dependencies and details of the complex process and product, and the conclusions can be drawn which are translatable to the real system. The internal processes such as planning, scheduling and coordinating control; and the processes chained across organizations and departments should be modeling in the dynamic production process and logistic process models. In this first instance the simulation is a decision aid for the question (a) “What happens when?” during planning, and (b) “What now?” during operation. This production simulation model offers the application possibilities such as: (Steinhauer, 2005)

- objective communication / evaluation / decision of the manufacturing plan enabled by dynamical analysis,
- cost-effective experimenting with product , organization or process technical systems without any risk,
- planning reliability and flexibility, and
- bottleneck analysis.

In simulation model, the production process can be split up in four phases: (1) collecting material flow diagrams, process parameters and dimensions of production facilities for further analysis; (2) collecting necessary product, process, and project data; (3) creating the simulation model of the targeted production areas and relevant processes; and (4) comparing the simulation model with the production process regarding the objective of the simulation project for validation & verification.

Upon completion of these above four phases, the implementation in the operational processes will take place which include (a) interfacing with existing systems, (b) introduction of the tool set, (c) organizational embedding and (d) training of employees.

In simulation inputs for a simulation model can be considered 5 static factors and 3 simulation factors.

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The first static factors are:

- the system constraints are the information collected during the analysis and data phases;
- the process description consists of process scheme which captures all different steps such as: storage, transport, waiting, actions, operations;
- route scheme which elucidates for each production station how material is supplied, how products are exported and with which means of transport;
- facility data consist of the main parameters of available plant resources; and
- generic methods are described by different assembly strategies, assembly sequences for every assembly type, and process time formulas.

The static factors will serve to the three simulation factors such as:

a) production planning will be needed to start model activities;
b) personnel planning will then assist the allocation of numbers of personnel with certain qualifications to regarding facilities; and
c) product data will be required for material supplying with the right physical attributes and to export it to its destination.

If the model is validated, the production planning and personnel planning then can be optimized via an iterative process.

Suitable simulation output as presented in figure 4 exists of tabular/graphical presentations, which quickly gives an insight in and an overview of the simulated production. The resource utilization ratios are particularly useful for bottleneck analyses by comparing the production simulation planning and the performance of the total production facility.

The combination of resource performances, comparison of planning with a simulated production realization and the possibility to trace every part in the simulated part statistics and simulated transportation table in production will enable searching for reasons for delays and disturbances, which normally are not obvious because of all dependencies in the process. From these, conclusions can be drawn regarding improvements to production planning and resource management (Zeigler, 1987; Steinhauer, 2005).

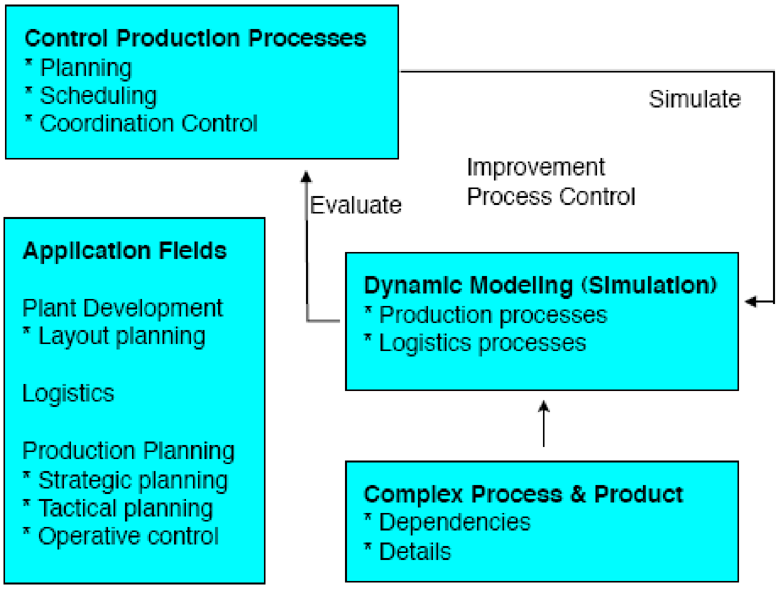

Figure 3. Production simulation scope and its applications

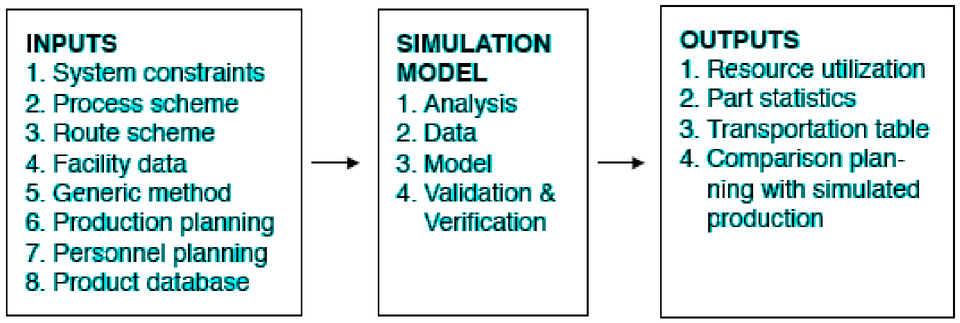

Figure 4. Simulation model and required simulation input/output

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IV. CONCLUSION

This research paper describes the development of a simulation model and its application in shipbuilding. It includes virtually the whole production process of the typical Vietnam shipbuilding but it does not describe the validation and verification process. However, from the comparison of the production planning with the output of the simulation it was concluded that the simulation model is able to approach the reality without significant deviations from the planning. The model is therefore applicable for operational control of the process and for testing alternative scenarios and analyzing various facility lay-outs.

Because of the possibility to use the object-oriented Discrete Event System Specification (DEVS) is useful. In this DEVS type of simulation, the simulation executive orders the events chronologically in an “event list”, while the simulation is running, new events are generated and inserted at the appropriate point in the list. These events may be triggered by certain pre-conditions in which case they are not scheduled but wait to be released for processing. In object-oriented software, data and mechanisms are structured different from traditional software. Anything related to a single entity are bundled together to form a class, the objects of the class can then be created. In object-oriented simulation software, the functionality developed is part of a library, not a model. Therefore the functionality can be used to build many different models quickly, especially since it can be exchanged with other users (Zeigler, 1987). The further study on the implementation of DEVS will be carried out in other research paper.

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