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Concept of an advanced simulation-based design for engineering support of offshore plant equipment industries and its realization method

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ABSTRACT

This paper introduces the concept of an advanced simulation-based design, "Feedback Loop Design", and its realization method. The conventional simulation-based design was used for verification of the proposed design because the proposed design has a single process consisting of a design and the design verification. The feedback loop design involves a circular process consisting of the design, design verification, and design modification using an optimization design algorithm and multidisciplinary analysis tools. Optimized solutions can thereby be obtained through a circular design process. A software integration framework, which can combine various design algorithms and analysis tools as well as their interface methods is needed to realize the feedback loop design system. In this study, the software integration framework used is the Remote Component Environment (RCE) (DLR, Germany), and the analysis tool used is the commercial software, DAFUL & ANSYS, for verification of the developed concept.

1. Introduction

The Korea Research Institute of Ships & Ocean Engineering (KRISO), which is a Korean government-funded research institution, established the Technology Center for Offshore Plant Industries (TCOPI) in 2014. The main missions of this institute are technology support of offshore plant equipment enterprises and resolutions to problems including the lack of professional labor and research and development (R&D) tools for design. The difficulties of offshore plant industries, as determined from the results of a survey carried out by the technology center are shown in Table 1. Typical difficulties include the lack of design skill, equipment, and labor (Research Korea, 2015).

To tackle this problem, we suggest the application of a simulation-based design method for offshore plant equipment. The aim of the simulation-based design is to combine all steps of the design, manufacture, test, operation, and maintenance by simulation technique using 3D CAD models in a virtual environment; this is a novel concept and technique of computer based engineering. The simulation-based design has being actively done research and applied to increase the production efficiency, improve design techniques and verify developed products (Kruger, 2007; Wu and Ceccarelli, 2009; Bozca and Fietkau, 2010; Liscouet et al., 2011; Suh et al., 2013).

In the 2000s, simulation-based design was studied and applied to enhance the efficiency of design engineering and controller development of ship in the shipbuilding industry, to match that of offshore plant, and its effect was verified in the various steps of design, manufacturing, and testing, etc. (Sohn and Shin, 1999; Lee and Kim, 2001; Altosole et al., 2009; Lee et al., 2010; Oh et al., 2014; Ertas and Yilmaz, 2014; Ertas et al., 2014; Alessandri et al., 2015). In offshore plant industry, many advanced researchers are studying application methods of the simulation-based design, because simulation-based design has emerged as a key technology to reduce large budget, manpower and development period needing to develop huge offshore structures. Sohn and Shin studied a new object-oriented methodology, ESBD (Evolutionary simulation-based design), for the development of an automated manufacturing system in shipbuilding (Sohn and Shin, 1999). Altosole used simulation-based design, using RT-HIL (Real-time Hardware in the looped) simulation, for the development of the propulsion controller. Consequently, this led to a significant reduction in the development phase of the controller design (Altosole et al., 2009). Ertas studied that the strength of a mercantile vessel shipboard has been investigated under working conditions by using FEA technique (Ertas et al., 2014)

Especially, offshore plant equipment which is affected by complex loads requires multi-body dynamic simulation-based

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Table 1
Survey of technology center for offshore plant industries.

Component	**Average** [point]	**Difficulties problems**				
		Very difficult (%)	Difficult (%)	Normal (%)	No difficult (%)	No answer (%)
Lack of design skill	3.17	8.5	29.2	34.6	23.1	4.6
Lack of equipment and software	3.13	9.2	27.7	33.1	25.4	4.6
Lack of design human power	3.32	10.0	37.7	29.2	18.5	4.6
Difficulty of prototype	3.03	6.2	27.7	35.4	26.2	4.6
etc.	2.16		0.8	5.4	8.4	85.4

The higher the score, the higher the difficulty (Max. Point is 5).

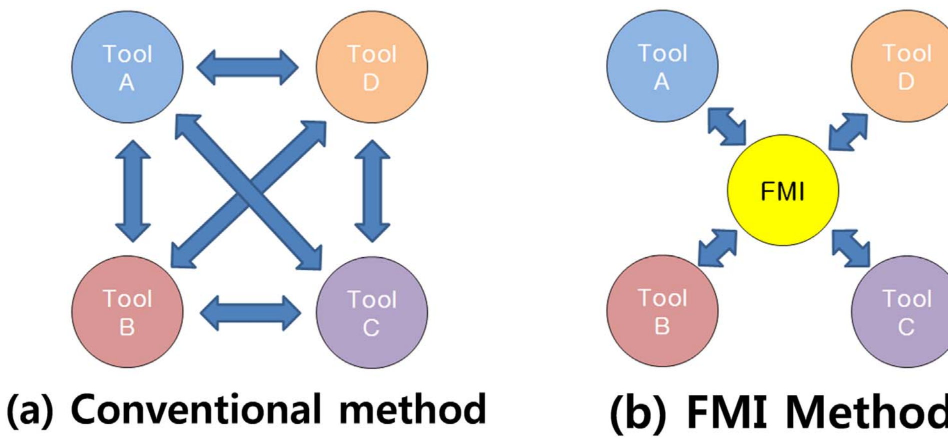

Fig. 1. Comparison of co-simulation methods: (a) conventional method, (b) function mock-up interface (FMI).

Table 2
Tools supporting FMI.

ADAMS	Dymola	ControlBuild	Simulation_X
AMESim	EneryPlus	CosiMate	TLK TISC Suite
Atego Ace	ETAS-INCA-Flow	Cybernetica ModelFit	xMOD
CarMarker	GT-SUITE	Silver	MATLAB
CATIA	LMS Virtual.Lab Motion	SIMPACK	TWT Co-simulation Framework

design to replicate a real environment (Cha et al., 2010; Wang et al., 2015). The multi-body dynamic simulation of mechanical systems can be rapidly performed due to the growth of computer performance and numerical methods. A simulation-based design using multi-body dynamics is a useful skill in otherwise impossible cases, which are verified by experiments. This technology is an excellent means of understanding qualitative optimization design, and avoids the process of test model production, which is costly and time-consuming (Oh et al., 2014).

However, the simulation-based design has a temporal inefficiency during the re-design and re-modeling of equipment after the verification of the design weakness because the simulation-based design has a single design process. If the design process is a circulation process, which is composed of the design, design verification, re-design, and re-modeling, the temporal inefficiency will be solved. In addition, the design and manufacturing costs can be reduced, and we can obtain optimized products easily and rapidly. This technique, which is composed of simulation-based design, optimization design and circulation design, is called "Feedback Loop Design (FLD)".

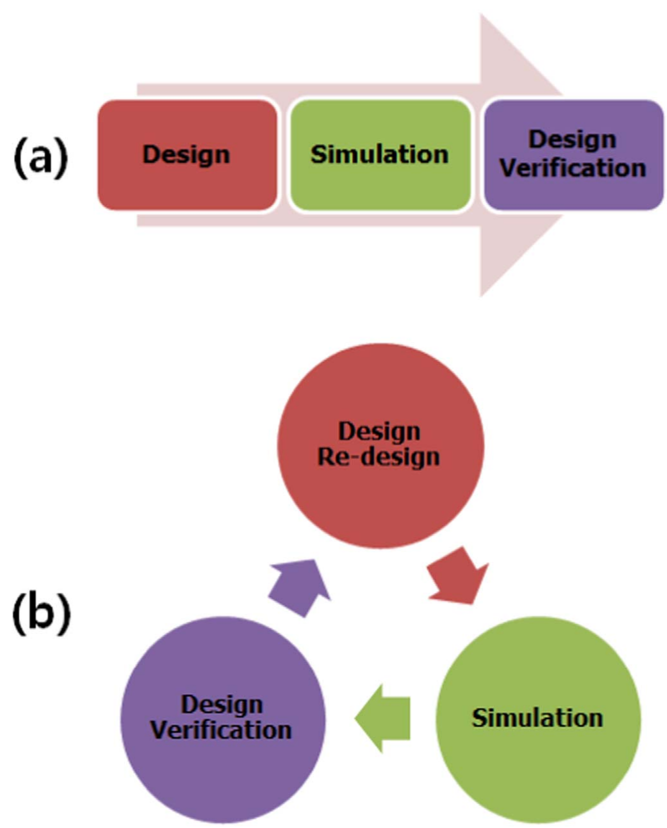

Fig. 2. Conceptual diagram of simulation-based design methods: (a) is the conventional SBD, (b) is the advanced SBD, Feedback Loop Design.