Model based Simulation of Container Loading/Unloading

Soonsup Lee^{1*}

¹*Department of Naval Architecture & Ocean Engineering, Gyeongsang National University, Tongyeong, South Korea*

(Manuscript Received June 1, 2012; Revised June 30, 2012; Accepted August 7, 2012)

Abstract

Currently, most logistics use containers. The construction of new port and high speed medium size container ship for the transportation of merchandise have become very important. The problem of ship stability is also important because of its direct influence on the loss of human life, ships, and merchandise. The stability of a container ship during its operation is not a large problem because it is well considered in the design process. However, the assessment of ship stability during container loading/unloading in port still depends on the expertise of experienced personnel.

In this paper, a model based simulation system is introduced, which is able to assess ship stability during container loading/unloading, using ENVISION, a general purpose simulation system.

Keywords: Mobile Learning Model based simulation, CAD, CAE, Loading/unloading, High speed medium size container ship, Stability assessment

1. Introduction

Currently, most overseas logistics use containers, which will continue into the foreseeable future. Therefore, in order to rapidly transport containers, high speed container vessels and new large ports optimized for them are the main focus of the transportation industry.

However, in case of short distance transportation such as between Korea and China, or between Korea and Japan, use of high speed container vessels in conventional ports is more efficient choice.

Therefore, large container vessels, as well as high speed medium and small container vessels will be extensively used in the near future and the problem of the stability of small and medium container vessels will increase while loading and unloading containers. In addition to damaging containers, the stability problem can also cause human casualties. Although the stability problems that can occur during ship operation are sufficiently considered from

the ship design stage preventing those that can occur while loading and unloading containers still relies on the expertise of experienced personnel.

Especially in the case of containers, in order to maximize the loading capacity, the GM value does not have sufficient tolerance based on the safety criteria established by ship classification[9]. Therefore, the stability problem during loading/unloading containers is very important, and computer simulation is required to analyze it.

The information and communication technologies of shipbuilding environments are rapidly changing. To respond to this situation, a new paradigm has been matured with new concepts such as the concrete method. In particular, all of the efforts seem to be concentrated on realizing the concept of simulation based design (SBD) based on a three dimensional computer aided design (CAD) model.

In this paper, a new methodology for ship design and operation is proposed. To verify the proposed methodology, a system for assessing the stability of a ship during container loading/unloading was developed. The developed system consists of a geometric modeling subsystem, basic calculation subsystem, and computer aided engineering (CAE)

*Corresponding author. Tel.: +82-55-772-9191, Fax.: +82-55-772-9199.

E-mail address: gnusslee@gnu.ac.kr.

Copyright © KSOE 2012.

subsystem. The geometric modeling module is used model of the hull form and compartment of a high speed medium size container ship, along with the shapes of the container crane, transfer crane, and port. The basic calculation module is used to calculate the hydrostatics properties based on the extreme form associated with the displacement instill water. The CAE analyzes the kinematics and dynamics motions. An interface to a CAE/CAD/simulation system such as an in-house program and ENVISION system is also provided.

2. SBD Technologies

SBD is a new paradigm in which the total definition of a product is conceived, designed, manufactured, tested, trained, and supported for its useful lifecycle in a virtual environment.

In ship design, SBD can have a powerful impact on the overall life cycle of product development activities. By implementing SBD system based strategies and techniques, the behaviors of products and process characteristics can be simulated in a concurrent engineering (CE) or integrated product and process design (IPPD) environment [8].

In the development of a new concept ship, the SBD system will permit a detailed evaluation of product and process design early in the lifecycle, reducing expensive surprises later during manufacturing and operational service. Moreover, it provides realistic operator interaction with the product during the requirement and design process.

The use of SBD in ship design began with the U.S. department of defense. Several prototype projects in navy ships have been performed to apply the SBD concepts through the Defense Advances Research Project Agency(DARPA) and its consecutive works, which were planned to maintain concurrent engineering design concepts in order to reduce the period of design and manufacturing, economize, and upgrade the quality of ships[1]. Some well known cases are the U.S. Navy's LPD 17 simulation, General Dynamics Electric Boat Division's (GDEB's) NSSN submarine [3], and Gulf Coast Region Marine Technology Center's (GCRMTC's) Mobile Offshore Base (MOB) projects [2]. The University of Strathclyde's safety simulations of a RORO ferry ship and the University of Michigan's ship motion simulations are typical examples in the academic field.

In Korea, SBD research has generated some interest in the commercial ship building industries and in relation to naval ships. Yet, the progress is far behind the expectations.

SBD faces several technological problems. First, High Performance Computing (HPC), High Performance Visualization (HPV), and high speed networking are already being developed and it is expected that the emphasis on advancing these technologies will continue. Second, the integration of CAD/CAE/CAM is a critical element of the SBD system's capabilities as related to ship design in which the system must cope with the full spectrum of ship design engineering. Third, software standards and data exchange standards are needed for SBD to fully assimilate and utilize the large amount of existing code [4, 6].

3. Simulation of Ship Stability on Container Loading/Unloading

In this research, a system for assessing ship stability during container loading/unloading was developed using SBD technologies. To develop the assessment system, the geometric models of a high speed medium size container ship, port, and facility were implemented and interfaced to the CAE programs [5, 7].

The configuration of the system for container loading/unloading is shown in Fig. 1.

4. Graphical User Interface (GUI)

A graphical user interface(GUI) was adopted for the commercial geometric modeling and simulation systems in order to increase the flexibility and efficiency of the system.

The GUI was designed considering the following items.

- Visualization of input data
- Integration of each module
- Visualization of final output and intermediate output

Fig. 1. System configuration for container loading/unloading

The GUI of the model based container loading/unloading simulation system was developed using the graphical simulation language (GSL) and command line interpreter (CLI) functions of the ENVISION system, which is a commercial simulation system. All of the necessary commands and functions in the developed system are defined in a menu. The top level commands are in the top level menu.

Sub-menus are constructed as pull down menus. The hierarchy of the menus for the developed system is shown in Fig. 2. The input window for the main dimension, material, and stability criteria for the ship is shown in Fig. 3. In this paper, the stability assessment criteria for the ship are the GM value and collision check between the ship and port.

5. Geometric Modeling

A 3D design model for the hull form and compartment model was developed using the commercial geometric modeling system, CATIA. The cargo modeling was used to define containers. The number of loaded container was 300TEU and all of the containers were located on deck.

Fig. 4 shows model of hull form and compartment.

Fig. 2. GUI for container loading/unloading simulation system

Fig. 3. Example of definition of principal particular and criteria for stability assessment

Fig. 4. Visualization of hull form and compartment

6. CAE Interface

The CAE programs used in the developed system are used for a hydrostatic ship calculation, behavior assessment of the facility, and stability assessment of a ship during container loading/unloading. The stability assessment program for the ship during container loading/unloading was developed using a basic calculation program. The behavior assessment program for the facility was developed using a calculation module of the ENVISION system.

The interface between the ENVISION system and CAE programs was implemented using visual C/C++ and interface functions such as the GSL and CLI functions, in a windows environment.

Fig. 5 shows the interface process between the ENVISION system and CAE programs.

Fig. 5. The Process of interface between ENVISION system and CAE programs

```

PROGRAM coll_check
BEGIN
  main_part = 'container#1:containership'
  cli('inquire all part names')
  split_string( cli_msg, str_1, rem_str )
  num_parts = val( str_1 )
  indx = 0

  ---- collision checks and preparation of collision list
  for jj = 0 to ( num_parts - 1 ) do
    cli('add collision check between part "' + main_part + '" and part "' + part_list[jj] + '"')
  endfor

  cli('set collision checks to on')
  cli('message mode usermsg')
  co_indx = 0

  for jj = 0 to ( num_parts - 1 ) do
    cli('inquire part "' + main_part + '" part "' + part_list[jj] + '" collision status')
    if ( cli_status == CL_COLLISION ) then
      cli('clearclmsg')
      coll_list[co_indx] = main_part + part_list[jj] + COLLISION
      co_indx = co_indx + 1
    endif
    cli('clearclmsg')
  endfor

  ---- selection of specific collision and window creation
  split_string( coll_list[choice], str_1, rem_str )
  split_string( rem_str, str_2, rem_str )

  cli('create window "Containership_Collision_" + str("%g", choice+1) + ".txt")
  cli('select window "Containership_Collision_" + str("%g", choice+1) + ".txt")
  cli('track part "' + part_2 + '"')
  cli('disable tracking')

  endwhile
  cli('clearmsg')
  cli('clearclmsg')
  cli('message mode allmsg')
END

```

Fig. 6. Source of a collision examination program

7. Simulation of Container Loading/Unloading

The container loading/unloading simulation included the stability assessment for the ship, the assessment of the process, and the assessment for the optimal position of cranes during container loading/unloading.

Fig. 7 shows the procedures for simulating container loading/unloading.

Fig. 7. Procedures for simulating container loading/unloading

The following items were considered in the development of the container loading/unloading simulation.

- The container loading/unloading simulation used hullform, compartment, port, and facility models, along with CAE programs
- Constraints such as the sequence of loading/unloading and moving distance of cranes were permitted within the limits defined in the [environment] menu
- When a crane picked a container up off the deck, the stability assessment program was executed
- When ship stability disappeared during the simulation, the system terminated with a beep sound
- The viewports during a simulation could be change using a pocket menu

The results of the container loading/unloading simulation are as follows:

- A sequence diagram for container loading/unloading.
- The operation time for container loading/unloading.
- The result of a stability assessment for a ship during container loading/unloading.
- The collision examination between a ship and port during the container loading /unloading simulation.
- The optimal arrangement of cranes.

The simulation procedures for determining the number and optimal positions of cranes using the operation time are shown in Fig. 8. In this paper, the number of cranes considered is within three cranes.

Fig. 8. Simulation of operation time using three cranes

Fig. 9. Optimization of loading/unloading process

The optimization of the container loading/unloading process is shown in Fig. 9. To determine the optimal process for container loading/unloading, the developed system only considered the operation time and not the loading/unloading costs.

Fig. 10 shows a visualization of the container arrangement on deck and the visualization of the cross sections for a frame. Fig. 11 shows the procedures for the assessing the ship stability during container loading/unloading. The results of the stability assessment use the GM value. If the GM value deviated from the stability criteria limits, the system was terminated. Fig. 12 shows a visualization of the stability assessment results. Fig. 13 shows an examination of a collision between the port and ship using the intersection method.

Fig. 10. Visualization of container arrangement

Fig. 11. Stability assessment of ship

Fig. 12. Visualization of ship stability results

Fig. 13. Collision examination

8. Conclusions

In this paper, simulation based design (SBD) technology was reviewed and using this technology, a container loading/unloading simulation system for high speed medium and small sized container vessels was developed to analyze stability problems while loading/unloading containers.

First, the ship hull form, compartment, cargo, and crane were modeled using a commercial CAD system, and stability analysis program was developed.

A graphic user interface(GUI) was developed to visualize and control the data in the prototype system for container loading and unloading simulation. The developed program, GUI and geometric model were used with the ENVISION system to evaluate ship stability, motion analysis, decisions regarding container loading and unloading, and crane location.

Through the above process, an optimal container loading and unloading process that can minimize the work time was found considering the stability conditions. In addition, the possibility of applying SBD technology in the operational stage was evaluated.

The limitations of not applying the ship hull and compartment data will be supplemented in the future. Moreover, external conditions such as wind and wave conditions will also be considered in the future.

References

- [1] G. Jones and T. Hankinson, Simulation Based Design for Ship Design and Acquisition, Proceedings of ICCAS, Bremen, Germany, (1994).
- [2] John Cardner, Simulation of Mobile Offshore Base, Project Report, GCRMTC, (1998).
- [3] Ken Fast, Electronic Visualization System(EVS) at Electric Boat, Proceedings of Deneb's User Group, (1996).
- [4] Kim E.C., et al., Development of Container Loading/Unloading and Transportation System for Next Generation (III)-Development of High Speed Medium Size Container Ship", Korea Research Institute of Ships and Ocean Engineering, (2000), (in Korea).
- [5] Kim H.T., Evaluation of Safety for Container Loading/Unloading Using Modeling & Simulation Technologies", Journal of Ships and Ocean Engineering, Vol. 29, pp161-166, (2000), (in Korea).
- [6] Lee J.K., et al., Development of Model based CAE and Simulation Technologies for Ships and Ocean Engineering (III), Korea Research Institute of Ships and Ocean Engineering, (2000), (in Korea).
- [7] Lee S.S., et al., Simulation for Ship Stability According to Container Loading/Unloading, Proceedings SNAK, (1999), (in Korea).
- [8] Lee S.S, Concurrent Engineering Based Integrated Basic Ship Planning System using Internet, Ph.D. Thesis, Pusan National University (2005).
- [9] SEASAFE, SIKOB-Package for Naval Architect Calculations User's Guide, Sweden, (2003).