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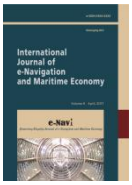

Original article

Design of LPG Remote Cargo Operation Simulator with Automatic Bargaining Function

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Abstract

Liquefied gas carrier cargo handling operations are critical to ship safety. In order to improve the quality and efficiency of cargo handling of liquefied gas carriers, the loading and unloading operation of the liquefied gas carrier was studied and a set of LPG remote cargo operation simulator with automatic bargaining function was designed. Introducing the components of the simulator: the console unit and the simulated cargo tank unit in brief, the design ideas and specific functions of the automatic barge and remote control of the core part of the system are introduced in detail. The simulator feasibility verification is carried out by comparing the error between the actual loading and unloading operation with the system simulation loading and unloading operation. The simulation training functions verification is carried out by testing people who use the simulator for training. The final results show that the error is within the acceptable range, and people who use the simulator for training can pass an authoritative comprehensive exam. It is shown that that the system can simulate the important operations in the cargo handling process and has an excellent training effect.

Keywords: LPG ship, automatic bargaining, remote control, liquid cargo handling simulator

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1. Introduction

As the world's largest developing country, China's demand for liquefied petroleum gas is showing a rapid upward trend with the continuous construction and development of the economy. At present, the main mode of transportation of liquefied petroleum gas is maritime transportation, how to train liquefied gas carriers quickly and efficiently becomes an important issue (Yang, 2018). Simulator training is an effective method in the field of crew training. Compared with real ship training, it is not only easy to operate, but also can realize the simulation of various operating conditions, which greatly improves the quality of crew training. Relevant agencies at home and abroad have successively promulgated simulator-related conventions and regulations paving the way for the design and development of simulators (Li and Dong, 2018, Gao and Ning, 2014). June 2010 in Manila, capital of the Philippines, Conference of States Parties to the 1978 Convention on Standards for International Seafarers Training, Certification and Duty, attended and proposed by 89 countries and territories, as well as 20 governmental and non-governmental international organizations. After collective consideration by all members present at the General Assembly, The General Assembly adopted the 2010 amendment to the International Convention on Standards for the Training, Certification and Duty of Seafarers, (STCW 2010). The amendment to the Convention clearly requires that all ship-related personnel must be taught and trained in practical working abilities. The simulator used for the work of LPG ship crew cargo operation training is one of the simulators required by STCW 2010. However, at present, the professional research foundation of simulators, especially LPG ship cargo handling systems, is still relatively weak. Relevant research is mainly concentrated in marine institutions and research institutes. Many universities and research institutes are breaking the foreign technology monopoly and technical blockade began to develop simulators with independent intellectual property rights that can realize loading and unloading simulation.Wu and Yin (1999) developed a simulation system for cargo handling of tankers. The simulation system includes simulation of cargo working conditions, dynamic simulation of tanker system and simulation of ship steady state. At the same time, it also meets the requirements of the IMO “STCW78/95” Convention and the “Special Training Outline for Tanker Crew” issued by the Maritime Safety Administration of China. Yang, Wu and Yang (1999) proposed a non-numeric simulation model for the piping and valve components in the cargo handling system. At the same time, it can also simulate the opening and closing states of pipes, valves during system operation. Du (2014) used VC++ as the programming language, and successfully realizes the simultaneous control and display of the main and sub-interfaces of the tanker cargo loading and unloading simulation system, which makes the operation of the simulation system more concise and clear. The cargo oil loading and unloading simulation system designed by Cao et al. (2015) not only contains the digital model related to the oil and gas valve and ship steady state, but also realizes the automatic simulation of loading and unloading operations.

In this paper, the loading and unloading operation of the liquefied gas carrier is studied, and a remote cargo operation simulator for liquefied gas carriers for simulation training was designed. The handling simulation system can not only realize the simulation of loading and unloading operations through remote control, but also has the function of automatic bargaining, which can realize the intelligent transfer of goods between different cargo tanks and provide reference for the research and development of marine simulation system.

2. The working principle of the parent ship

2.1 Ship parameter

Table.1 Main demension and technical specification of ship

Parameters	Numerical value
Length Overall	119.98m
Width	21m
Draught	7.4m
Speed	11.9kn
Deadweight	8993t
Gross Tonnage	8319

Type: All-freeze LPG;

Type of cargo: Propane, Butane, Butadiene, Ammonia.

2.2 Introduction of LPG ship liquid cargo handling system

The LPG ship cargo handling system is the core system for cargo handling operations (Wang, 2018). The system consists of a cargo tank, a cargo pump and valve parts, all of which consist of separate compartments (Mo et al., 2015). The parent ship liquid cargo pipeline mainly includes a pipeline connecting the shore gathering area and a pipeline leading to the liquid tank, the materials conveyed in the pipeline can be divided into a liquid phase pipeline and a gas phase pipeline. The pipe is connected by valve, the valve can be operated manually or by a computer terminal. Each cargo tank has a separate centrifugal pump as the main cargo pump for unloading operations. Each cargo pump can transport liquid cargo to the header area through a separate line.

Taking the loading process as an example, the loading process of the LPG mother ship is briefly described: When starting the loading operation, the oil pipeline should be connected first and the relevant valve parts should be properly opened. After the preparation work is completed and the inspection is confirmed, the terminal operator is notified to start loading. Operator should pay attention to the pressure, temperature and liquid level in the cabin during the loading process. Close all relevant valves in turn after loading (Srikanth S A, 2012).

3. System structure description

3.1. Console unit

(1) Console

The console includes an alarm unit, a data monitoring unit, a control and indication unit, an indicator unit with an LED indicator, data monitoring using an industrial integrated machine and Kingview software, an alarm using a red LED indicator (flashing) and a buzzer. The scope of monitoring includes temperature, pressure, liquid level, line pressure and power equipment. The console interface is shown in Figure 1.

Figure 1: control panel

(2) Server

The main task of the server is to collect all client data, perform comprehensive processing and send corresponding commands to the client according to the processing results, the client host controls the digital/analog output unit to control the action of the external execution unit. Server hardware configuration:

CPU: Broadcom BCM2837 1.2GHZ

Kernel: ARM Cortex-A53 64-bit 4 core

Wireless network card: 802.11 B/G/N

10/100M Ethernet port

Memory 1G LPDDR2

HDMI interface x1

USB2.0 x4

Operating system: Debian Linux

(3) PC software

The computer software adopts ZTW6.55 version as part of the total control unit of the device. It requests data from the server through the MODBUS-TCP protocol as the client. After obtaining the original data, it is processed and displayed on the interface to operator for reference. The computer interface fully presents the design principle of the cargo tank system piping system, including pipeline layout, liquid direction, position and function of various valves and switch indication of electric control valve. It is clear at a glance, which is convenient for the system to have an overall grasp. At the same time, the computer software realizes the automatic bargaining function parameter setting, which can control the automatic transfer of external goods. The software interface is shown in Figure 2.

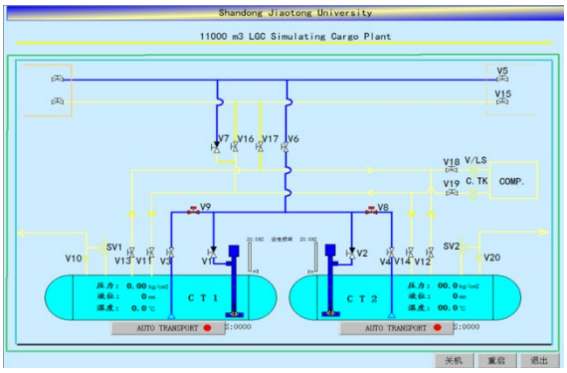

Figure 2: Software interface

3.2. Simulated cargo tank unit

(1) Cargo tank system

The tank is used to simulate a full-pressure LPG cargo tank with a breathable/VENT valve. The cargo tank piping arrangement, valve components and associated ancillary systems are based on actual ships.

(2) Liquid cargo pump system

The deep well pump is used as the main unloading pump, the pump is immersed in the bottom of the cargo tank. The start-stop control includes local manual start and stop, manual start and stop of the console, automatic start and stop of the program (when automatic bargaining), it uses variable frequency control, which can use the computer software to adjust the motor speed in between 20~50hz. It is equipped with a low liquid level automatic alarm device, when the liquid level is lower than the low low level it can give an alarm and stop the pump. The liquid cargo pump system as shown in Figure 3.

Figure 3: Liquid cargo pump system

(3) Valve piping system

The piping setup simulates the loading and unloading of the liquid phase tube and the gas phase main pipe across the left and right sides, the main pipe and the liquid and gas phase pipes leading to the cargo tank are linked as shown in FIG 4. The pipeline adopts DN40 seamless steel pipe, the pipeline, flange and valve parts are configured by the national standard series. The gas phase tube is provided with a pressure relief valve to the exhaust system to outside.

Figure4 Valve and piping system

(4) Cargo compressor system

Based on the equipment used in indoor teaching and training, the cargo compressor adopts silent maintenance-free reciprocating compressor, which can realize local and remote control, with security system, control unit in the console and local, as shown in Figure 5. The pressure gauge at the control unit of the cargo compressor shows the pressure of the compressor itself, not the discharge pressure. The unloading pressure's setting range is 0.2-1 bar according to the unloading time.

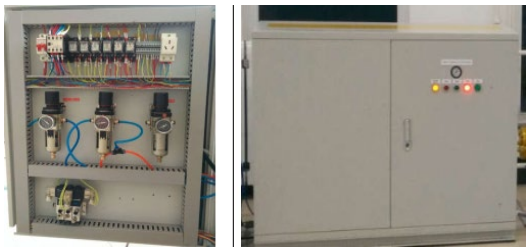

Figure 5: Cargo compressor system

4. System core function introduction

4.1. Automatic Bargaining Function

As one of the core functions of the system, automatic bargaining function is designed to simulate the mutual transfer of goods between different cargo tanks, at the same time realize the intelligent adjustment of the liquid level according to the set value. When performing the simulation operation, firstly, set the desired liquid level of a cargo tank, liquid level should not exceed the maximum or lower limit that can be loaded in the cargo tank. Run automatic bargaining command after setting is completed. The barge process uses a feedback process model. System automatically connects the liquid cargo to/from the designated cargo tank according to the difference between the actual liquid level and the set liquid level combined with the external conditions until the set level is reached. The design process of automatic bar code operation is shown in Figure 6.

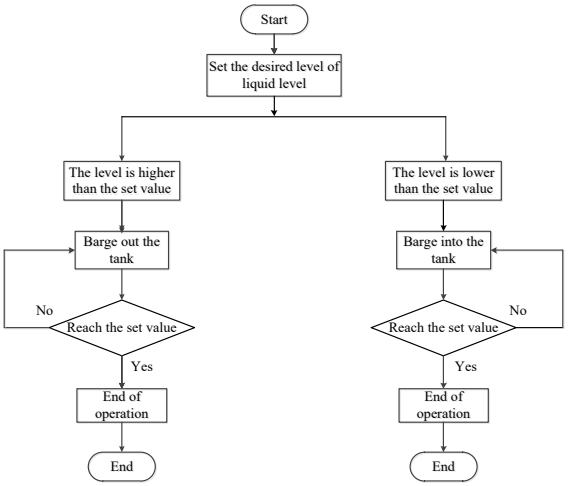

Figure 6: The flow chart of automatic transfer

The specific operation process of automatic bargaining:

(1)Preparation stage before barging: As the same with the loading and unloading preparation stage, the relevant piping and valves must be inspected and adjusted to ensure that the liquid level, pressure and temperature alarm detection system of the cargo tank is in a normal state. According to the work plan, select a reasonable set value, especially pay attention to the liquid level of the barge must be higher than the specified minimum level (Zang, 2013).

(2) The beginning of the bargaining: After selecting a reasonable set value and checking the valve line, the automatic bargaining system can be operated. The system transfers/displaces the liquid into the designated cargo hold automatically according to the set value. When the liquid level is lower than the set value, the system will barged the liquid cargo into the cargo tank. When the liquid level is higher than the set value, the system will barged the liquid cargo out the cargo tank.

(3) Data monitoring stage: Data monitoring includes level, pressure and temperature monitoring of the cargo tank. Comparing the actual liquid level value and set value of the tank, when the liquid level value in the cargo tank reaches the set value, it stops working.

(4) The closing stage of the bargaining: When the liquid level reaches the specified height or the cargo condition is not established due to external reasons, the automatic bargaining stops and the bargaining task is completed.

4.2. Remote control function

Remote control is another core function of the system, which is designed to realize remote control of the simulator. The structural framework of the system is shown in Figure 7. It consists of three parts: the operation page, the main program of simulation system and the back-end database (Weng, 2014).

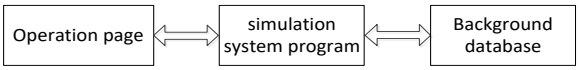

Figure 7: Structure of the simulation software

Operation page: The two-dimensional simulation interface of the remote cargo operating system is a display interface for processing raw data and displaying information to operator for reference. It can also be called a cargo tank loading and unloading interface. It mainly shows the working principle diagram of each simulation unit in the remote cargo operating system and inserts corresponding controls into it to achieve the purpose of control operation.

Main program of simulation system: The main program of simulation system simulates the input in the operation page through the mathematical model and simulation flow in the previous chapters and displays the calculation results in the background database (Shen, 2015).

Back-end database: Its main function is to calculate the input data and record the calculated related data.

The remote control system includes the following main functions, while meeting the requirements of relevant conventions and regulations:

(1)Provide the user with an overview page, so that the user can complete the input and initialization of each data and obtain the simulation results (Shi et al., 2012).

(2) The user can realize the simulation and simulation of loading, unloading and automatic bargaining operations through independent operation, and the related data can be displayed through the user interface.

(3) When the simulation system is running, it can perform real-time monitoring and numerical display on various states in the cargo tank and give corresponding alarm reminders.

(4) Users can suspend their work in real time according to their own requirements.

(5) The system can record the real-time data operated by the user for the user to consult.

5. System feasibility verification

The system is based on a mathematical model and implemented by C programming language. The main principle of verification is to divide the whole loading and unloading simulation process into several short-time work collections and get the total time and total amount of operations for the goods through a gradual accumulation method (Liu, 2013). Comparing the level height shown by the system interface with the actual level height calculated by manual operation of the corresponding cargo compartment, in order to judge whether the system can accurately simulate the actual loading and unloading operation. The liquid level comparison table is shown in Table 2.

Time min	CT1 Liquid Level mm	CT2 Displayed Liquid level mm	CT2 Actual Liquid level mm	Error %
0	547	500	500	0.0
5	532	514	515	-6.0
10	517	531	530	3.3
15	500	548	547	2.1

Table.2 Table of tank level comparison

It can be seen from the comparison results in Table 1. The simulation results basically achieve satisfactory results under the premise of ensuring the accuracy, which proves that the system can be used for the training of LPG ship cargo handling operation.

6. Conclusion

This paper designs the LPG remote cargo operation simulator with automatic bargaining function refer to the structure and function of the LPG parent ship's cargo handling system. The simulator consists of a console unit and a simulated cargo tank unit, which can realize the cargo handling and automatic bargaining through a remote control system. The verification shows that the results of the liquid cargo simulation operation are basically the same as actual cargo handling operation, the results are satisfactory. It can be used for the related work of LPG ship crew cargo operation training.

Acknowledgments

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