The role of computer simulation programs for marine engineers in hazard prevention by reducing the risk of human error in the operation of marine machinery

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Abstract

This paper describes the latest developments in computer simulation programs, designated for familiarization with marine machinery, especially taking into account the hazard mitigation aspect and the strengthening of emergency response.

The paper includes the examples of a Computer Based Training – interactive program concerning steering gear installation and a controllable pitch propeller plant where trainees have the possibility to develop operation skills, and train and refresh emergency procedures (reacting to emergency situations).

This paper’s conclusion is that the use of computer simulation - interactive programs in maritime education results in increased emergency preparedness and in consequence, leads to hazard mitigation and reduces the risk of human error in the operation and maintenance of marine equipment.

Keywords: computer based training, risk of human error, hazard prevention in operation of marine machinery

1 Introduction

Statistics prove, that up to 90% of total marine accidents at sea have been attributed to human error.

It is well known that one of the major factors of accident prevention on board is the perfect theoretical and practical knowledge possessed by engine room officers while operating engines and auxiliary equipment [1].
Nowadays, tremendous changes are taking place in computing, information technology and simulation. Maritime education and training is not isolated from such changes and ought to benefit from these tendencies.

For this reason, Computer Based Training (CBT) is more and more used in maritime academies as a valuable asset for educational process.

The basic role for CBT – interactive program is the familiarisation with individual auxiliary machinery and associated systems [2]. In comparison with traditional methods of teaching, CBT – interactive programs presents the following advantages:

- tri-dimensional graphical visualization of machinery elements for better understanding of the functioning principles
- simulation activities of auxiliary machinery, impossible to realize in maritime academies’ laboratories due to the size or the complexity of the installations.

CBT simulation possibilities play a very important role in case of auxiliary machinery interactive programs, where perfect knowledge of different operational modes is required for achieving a high level of emergency preparedness.

2 Description of CBT – interactive programs

Two CBT programs consisting of typical marine hydraulic installations in which the knowledge of basic and emergency operation modes procedure is essential for safe ship navigation shall be analysed below:

- controllable pitch propeller
- steering gear installation with variable delivery pumps

These two CBT programs are primarily designated for marine engineering trainees and their basic purpose is to develop operational skills, train and refresh emergency procedures (react to emergency situations). Such kind of the programs can also be used for training students in navigation departments of maritime academies. It is worthwhile mentioning that both programs were designed in strict co-operation with the machinery manufacturers.

On figure 1 to 6 Controllable pitch propeller installation program is presented.

These CBT interactive programs contain the following sections:

- Description
- Operating Instruction
- Test
- Simulator

Description
This part of the program describes the application, working principles and main components of the installation, together with different kinds of graphic presentation (pictures, photos, diagrams etc.).

The experience gained in the course of didactic process of marine engineers’ education proves that it is extremely important to combine the schematic diagram with the real presentation of a determined part in the form of a photo. On fig. 2 the controllable pitch propeller mechanism is presented. On fig. 3 the same part of this mechanism is shown in its real form.

2.1 Operating instruction
This program’s section includes a “step by step” detailed description of the preparation for starting the plant, starting the plant, functioning in automatic and manual control mode and stopping the plant procedure. Emergency procedures are specially emphasized as the trainee should acquire adequate reactions while being confronted with different emergency scenarios. A high level of emergency preparedness can only be obtained by repeating such emergency procedures many times until the trainee shows proper operational behaviour.

This part presents also diagrams illustrating the consecutive phases of plant operation.

2.2 Test
The test is intended to assess the knowledge gained by the trainee resulting from the two first parts of the program. In this module, the trainee should indicate the correct answer to randomly selected ten questions – see fig. 4. This enables the trainee to effectuate the test various times without having to answer the same questions. At the end of the test the trainee is given a certain mark indicating the rate of correct answers.

2.3 Simulator
In this section of the program, interactive software simulator is applied – see Fig. 5 and 6. The trainee, by mouse clicking, must set the proper valves’ position on the installation diagram and start the pump by operation of the switches and push- buttons on the panel. The trainee must follow the instructions given in the Operating Instruction. This enables the trainee to apply in practice the theoretical knowledge acquired according to the Operating Instruction. The trainee is confronted with real life reactions of the installation. Controllable pitch propeller installation program enables not only the operation in normal exploitation conditions but also the operation in emergency situations [3]. The following operational modes are possible:

- **Basic operation**: one of the main pump aggregates works with remote pitch propeller control from the bridge (follow-up or non follow-up).
- **Emergency operation**: at which one of the main pump aggregate works with local control. The pitch propeller control is done by acting manually on the sliding valve position of pitch control block by means of the lever unit.
- **Emergency operation**: at which main pump aggregates do not work and the pitch propeller control in AHEAD direction is done by means of the lubricating pump aggregate.

On figure 7 typical steering gear installation with variable delivery pump is presented.
Figure 1: Controllable pitch propeller – interactive program – general view.

Figure 2: Controllable pitch propeller – functioning principles (three-dimensional presentation).
Figure 3: Controllable pitch propeller – hub mechanism real picture.

Figure 4: Example of test question.
Figure 5: Controllable pitch propeller – ECR control panel.

Figure 6: Controllable pitch propeller – installation diagram.
This program offers the same different operation modes and simulation possibilities as mentioned in case of the controllable pitch propeller. This installation plays a vital role in the safety on board. Thus, it is very important that trainees acquire an adequate level of reaction to emergency situations. Additionally, in this CBT interactive program, there is a possibility to introduce a malfunction scenario – loss of oil in one of the oil reservoirs. In this case the trainee has a possibility to observe the system’s reaction as in reality (low level alarm activation, hydraulic system separation, stand-by pump starting-up etc.) and proceed with proper emergency procedure.

![Variable delivery pump steering gear](image)

Figure 7: Steering gear installation diagram.

### 3 Conclusion

Ten years of experience in the application of CBT – interactive programs in Gdynia Maritime University shows clearly that these programs constitute a considerable development in the training process of engine room officers. As it has been indicated above, the CBT – interactive programs introduce a new, active approach to training that shortens the learning process and facilitates the reception and understanding of operation of maritime devices.

In order to achieve the desired training results, the exercises with CBT – interactive programs application have to be conducted individually i.e. one trainee operating with one PC station [4].

The exercise classroom with 8 till 12 PC stations is optimal for proper instructor control.
As it has been mentioned before, the trainee not only acquires the knowledge regarding the operation of the equipment in normal exploitation conditions, but is also familiarised with emergency situations. In consequence, the trainee is better prepared to deal with emergencies during real operations on board. The emergency situations may be simulated and repeated as many times as it is necessary for the trainee to achieve proper preparedness.

To summarise, the use of CBT – interactive programs increases in a considerable way the preparedness to deal with emergencies and creates the positive habit of future officers to familiarize themselves with emergency procedures.

The risk of human error is mitigated in two ways. First, due to the increased familiarisation with the system’s construction and principles of operation. Secondly, due to the use of an interactive simulator, as it is possible to achieve proper trainee’s reactions to emergency situations [5].

Objective assessment of the trainees’ progresses is also a quality of the use of CBT – interactive programs.

The vast experience with the utilisation of CBT – interactive programs shows clearly that these programs constitute a considerable development in the maritime education and training process.

References


