Improving the safety of weapon operation based on the example of MMDP training simulator – a marine measuring bottom mine

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SUMMARY:
The article tackles the issue of the training for operators of devices and systems with a complex operation mode and a high degree of complexity. It presents the characteristics, capabilities and general mode of operation of the marine measuring bottom mine MMDP. Taking into consideration the experience from previous courses, the next part of the article will describes a new MMDP simulator adapted to the operators' needs. The solutions applied in the simulator enable operators to familiarize themselves effectively and efficiently with safe exploitation of MMDP simulators.

1. INTRODUCTION

Nowadays carrying out any kind of courses and trainings requires a comprehensive system that guarantees safety of the educational process, from providing school equipment with theoretical knowledge to practicing to operate a given device. It is even more important when it comes to teaching of how to operate different kinds of highly advanced equipment of complex construction that require thorough theoretical knowledge. In that case the best way that guarantees the effectiveness of any training is practice on models similar to the real device, or most preferably train on the real device.

Taking into consideration current training methods [1], we identify:

- Methods based on lecture, story, description, discussion, book
- Methods based on observation and measurement: demonstration and measurement
- Methods based on practical performance of trainees: laboratory, classes
- Activating methods: brainstorming, case-study, drama, problem-solving etc.

Regardless of the method that we decide to apply, with relation to training the operators of specific devices we always need to select certain stages of the training process. The first stage entails presenting theory that explains how a given device operates, on-going phenomena, interdependence of different processes etc. This stage is to guarantee safe exploitation of a particular device or system in further stages of educational process.

In most cases the stage finishes with a conclusion and summary or a test on the covered theoretical material that has to be successfully passed as it is the condition to follow up to the next step, i.e. learning to operate a device or system.

In this stage a trainee learns how to operate a given device and, basing on acquired theoretical knowledge, he or she learns about safety issues concerning the device exploitation.

At present an operator (soldier) is allowed to attend the second stage of the training involving practical use of weapon equipment on condition that he or she has completed a training course and attended a required number of trainings, and, if possible, has practiced with the training equipment and simulators [7]. The way of applying those tools depends to a huge extent on creativity of the instructor, for it is the instructor who plays a decisive role in choosing the equipment, the teaching method and when to use a devise as to achieve the envisaged training goals.

Many years of experience in running a number of different courses and trainings of operating devices, weapons in particular, have shown that the aforementioned two-stage training model is not always efficient nor effective. In the first stage a trainee acquires theoretical knowledge and is ready to move to the next stage, namely practical workshop.

At the outset of the second (practical) stage the training process rarely yields any effective results, and sometimes even appears futile. Today's devices and weapon systems are very complex, with different levels of complexities that require not only the ability to operate a device but also thorough theoretical knowledge.

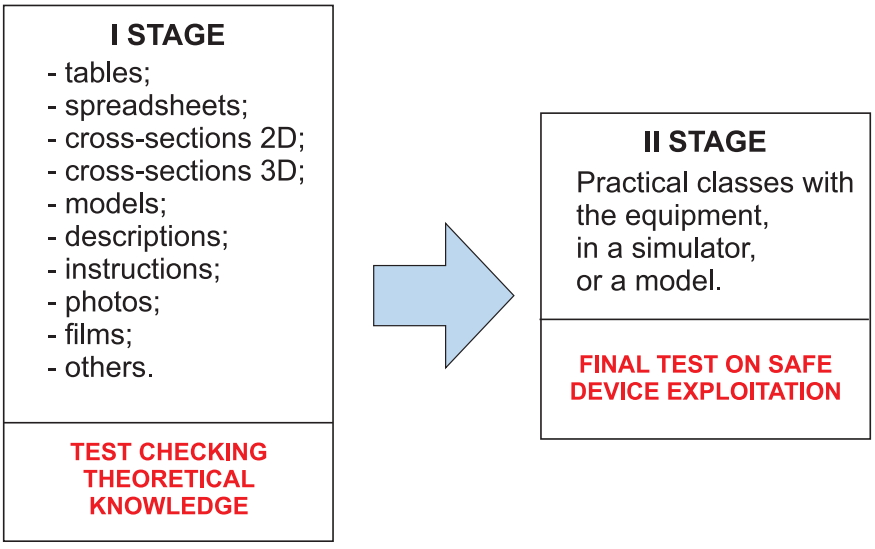

Figure 1 The plan of the training process for operators concerning safe operation and exploitation of the weapon equipment

In a number of cases safe exploitation of a device requires performing certain actions in a specific sequence and on-going analysis of parameters, all of which guarantee the correct operation of a device.
Yet many a times even the most advanced simulators do not give a true view of how their authentic counterparts operate. During the training process one needs to acquire certain habits so that the real device is operated and used in a safe and proper way. Therefore, the second stage is almost always characterized by subcomponents identification that a trainee is familiarized with in the first stage of the training.
The participants need time to verify all the knowledge and learn to operate a real device. The training process is not disrupted if the introduction and identification of subcomponents goes fast and smoothly. Yet, it often happens that the practical part of the training is disrupted due to excessively long time of subcomponents identification and the necessity to confront the acquired theoretical knowledge with reality.
In that case it is recommended that the training is conducted with the use of authentic devices but:
– operation of an authentic (weapon) device for training purposes is not possible because it belongs exclusively to the user of the device;
– there is the risk of damage ;
– there may appear undetermined state and condition;
– other people have to be involved in handling the device;
– a small number of people can be trained at a time;
– trainees need continuous monitoring;
– training costs rise considerably, etc.
The alternative to this situation is the use of simulators, for they provide many educational benefits in the training process that include:
– increased safety owing to the repetition of tasks that create certain pattern of behaviour and enable implementation of emergency procedures without the risk of being imposed to danger;
– gradual reduction of mental strain as a consequence of stressful situations during the training (transitions within stages of the training);
– the opportunity to become acquainted with the equipment as well as its proper exploitation;
– getting to know the specifics of a given device;
– reduction of costs as regards to personnel trainings in the long term process;
– lower costs as compared to trainings that use authentic devices.
Taking into consideration the experience from previous years, a change has been introduced in course preparation of MMDP exploitation (a marine measuring bottom mine). The change involves the introduction of an authentic technically fit device constructed in the form of cross--section into the first stage of the training.

2. DESCRITPION OF THE DEVICE

Marine Measure Bottom Mine (MMDP) is a relatively new type of MW armament (anthropogenic object [6]) dedicated to measuring and registering physical fields, but also evaluating the effectiveness of training for the ship crew. The principles of mine war related exploitation and operation have been thoroughly specified in literature [3, 4].
The knowledge of its structure, methods of preparation for use, programming as well as the skill of analysing the registered information concerning the location of physical fields of ship units are indispensable and crucial elements of an effective and successful evaluation of the echo--location station towage trawling systems in anti--mine actions.
General principles of MMDP mine operation entail registering analogue trajectory of ship physical fields included in the mine construction and operation process/courses of particular canals and further saving all this information in memory of the mine. MMDP is, therefore, a multi-canal sensor equipped with the same systems as fuze in the real mine. In addition, it enables to register parameters from all sensors and activate the data any chosen moment. The work of specificMMDO sub-componenents and the sequence of the performed operations are controlled and navigated by the central computer.
Having placed MMDP in the sea, once the time and astronomic time have been synchronized with the date and time of the first measuring cycle, the power supply is connected to the mine electronic system.
The moment the value of acoustic pressure exceeds the registration level, subprogrammes of the analogue process registration are initiated. Also the subprogramme that ensures the operation of MMDP as “a fighting weapon” is initiated.

The supportive canal of the mine plays the role of an acoustic canal, and fighting canals are: hydrodynamic, magnetic and electric. When a specific fighting canal is working (depending on the operating mode of MMDP) a signaling device is turned on, which by swimming out on the surface signalizes trawling of the real mine. Once the astronomic time synchronizes with the end of the measuring cycle, power supply is turned off until the next measuring cycle.

As soon as the astronomical time synchronizes with the time when the mine stops operating, a special valve is turned on through which the air from the bottle is conducted into the mine hull. Afterwards water is blown from the mine hull and the mine swim out onto the surface. If it does not do it within 10 minutes from the time the mine stops operating, the emergency rescue system is turned on. It is signaled by a floater that appears on the surface of the sea, which is connected with the mine trolley by a rope. After using the rope, the MMDP can be pulled out manually or by capstan.

The register also saves the digital course that shows operation signals of particular canals.

The registered courses contain information that enables to evaluate trawling process. MMDP can also be used to measure physical fields of different types of ships and naval vessels. It is suitable for basins with the depth between 10 and 50 m and it is capable of gathering all the information generated by swimming objects in the all the four aforementioned scopes.

3. THE CONSTRUCTION OF THE DEVICE

The most crucial elements that are included in the MMDP set are as follows (Fig. 2): the distributor, special valve, rescue emergency system, emergency system clock with power system, two air bottles, equipment compartment, ship physical field sensors (acoustic, hydrodynamic, magnetic, electric sensors) , the case with electronic unit, the valve control system, power unit, track bolts and signal launchers. The MMDP hull is composed of a tank that is used for automatic sinkage and swimming out of the devise on the surface of the sea.

Figure 2 MMDP with the trolley and equipment

The equipment compartment contains a box where sensors and electronic unit are placed. In the lower part of the hull there are a slot that transmits signals to the distributor and connection feedthroughs with two electric sensors and a special valve.
The sensors (acoustic, hydrodynamic, magnetic, electric) are used to process: underwater hum of swimming units and acoustic trawls, pressure change caused by a ship or sea waves, and also reception and processing of magnetic and electric field speed of low frequency tension.
The electronic system of the mine, which is placed in the equipment compartment box, contains, apart from the ignition system, simulators system of physical fields destined to carry out mine diagnosis without the use of outside diagnostic devices. Additionally, the distributor contains the control system of electro-pneumatic and electric valves.
The electronic system of the module is used to implement the following tasks: convert slow-change courses from particular MMDP measuring canals into digital size, save courses from particular measuring canals and the mine operation courses in the digital register that has flash memory, control the special valve to make MMDP either sink or swim out, control the valve of the emergency floater, control over the signals ''launch" informing about the mine course and control over swimming out action of MMDP or emergency floater after sending the order by the remote control system.
The real time clock system conducts tasks related to time frames setting in further settings, the beginning of MMDP work, the beginning and end of the four measuring cycles, the end of the mine work.
The special valve is used while placing and swimming out of the MMDP. When MMDP is placed the valve is open. Water coming into the mine hull through the opening in its lower part causes that the air is pulled outside of the special valve. The mine slowly sinks until it settles on the bottom of the sea. Reversely, when the valve is closed the compressed air is pulled inside the mine hull, which causes the water to go from the mine hull though the opening in its lower part and, as a result, makes the mine swim out onto the surface of the sea.
There are two power stations used to power MMDP subsystems, which are composed of NMiH accumulator cells. The accumulators have the capacity sufficient to ensure the required working time of the mine.
The trolley is used to move MMDP on mine trails of the vassal. It also plays the role of ballast that puts the mine in vertical position both on surface and on the bottom of the sea. The following subcomponents are installed on the trolley: the distributor, signal launcher set, two four-litre cylinders with compressed air, the emergency system clock, the emergency rescue unit. The emergency rescue unit pulls out the measuring mine in case it does not swim itself out. Its basic elements are the floater with rope attached to it, at the end of which there is a mandrel with a special grind, and a valve operated by an electric engine. The emergency system clock is connected to the emergency rescue unit that additionally protects MMDP against its disappearance.

4. THE DISCRIPTION OF MMDP SIMULATOR

The presented description shows how complicated the MMDP device is. The training process for those who are going to operate the device requires a complex and multi-level training, which ensures further safe exploitation of the mine. In order to optimize the training process, a number of changes have been introduced in the existing training scheme.
The successful use of simulators in the training process proves that it is the most effective didactic tool and its exploitation in different versions yields the best educational results [5].
A new training station has been designed and constructed – MMDP simulator. In all the training systems for operators that would train on MMDP device it has been established that from the very beginning an operator will learn with the help of the working cross-section of mine. The whole learning process is based on a real MMDP device, designed in cross-section in such a way as to enable a trainee to learn with a real device how MMDP is constructed and operated.
What is important in safe exploitation of MMDP is the sequence of processes (procedures) that occur one after another. It involves the knowledge and awareness of the sequence of operations that should be initiated in each stage of the process. The cross-section with additionally attached signal diodes signalizing the start of the subsystem facilitates faster understanding of

how the device works and helps remember the sequence of initiating particular subsystems. In addition, one can easily show which MMDP elements are started and where they are placed in the mine hull.

The training station for safe exploitation of MMDP is composed of the following subsystems:

– Training station no1 – functional training model of MMDP mine that uses apparatus of control-measuring station in laboratory conditions (without the actual use of the mine in real conditions);

– Training station no2 – the functional model of MMDP mine;

– Control-measuring station – allotted to the process of preparing the mine to be placed (including programming), retrieving and analyzing the registered measuring data;

– Presentation station – designed to explain procedures and actions performed on training stations no 1 and 2 and control-measuring station;

– Multimedia station – it aims to show simulation procedures and actions related to the process of preparing the MMDP mine for exploitation with the use of fighting simulator of naval systems of underwater weapon equipment;

Training station no 1 – it presents cross-section of MMDP mine with functional subsystems, which enables to thoroughly get acquainted with the mine construction and how its operation (Fig. 3). The station simulates the MMDP operations in terms of preparing it for use.

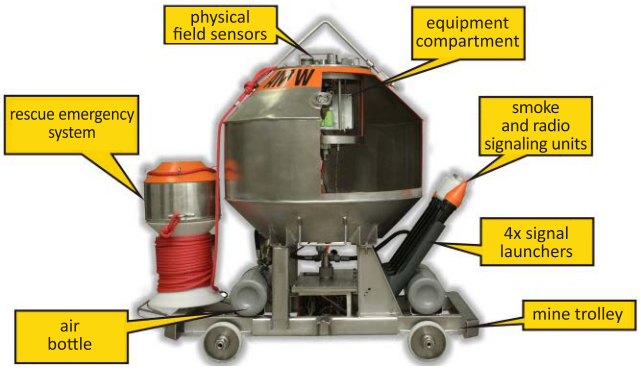

Figure 3 Station no 1 – MMDP with a trolley and equipment compartment

Training station no 2 – the functional mine model that is used for training purposes with the use of apparatus from the control-measuring station in the laboratory and real conditions. It is also used to conduct trainings and tasks related to the exploitation of the real device in real conditions (Fig. 4).

Figure 4 Station no 2 – MMDP with the trolley and equipment compartment

The station is composed of:

– a labelled MMDP mine hull, equipped with operation indicators (smoky and radio), the device registering mine work, the device that pulls out the mine from water;

– the equipment compartment containing mine electronic systems

– trolley-anchor with the distributor, electronic and pneumatic units.

Control-measuring station – in terms of the programme and equipment chosen, the station is equipped with the equipment that corresponds to the real one that is used in MMDP mine. It is composed of:

– a PC portable computer (notebook) with the MS Windows operation system and the programme for operating MMDP mine;

– inkjet colour printer A4;

– a communication device (interface) and an accumulator charger;

– a portable power generator 2,4 kW;

– connection units

Figure 5 The control-measuring station

The control-measuring station is used to carry out the process of preparing the mine to be settled (including programming), retaining and analyzing the measuring data.

Presentation station (Fig. 6) – is used to present procedures and actions performed at training stations no 1, 2 and control-measuring station. It is composed of:

– a large-format screen LCD/LED of 50'' diagonal;
– a wireless projector;
– connection cables.

Rysunek 6 MMDP presentation station

When connected to the computer from control--measuring station, the presentation equipment is used to present the procedures of preparation and operation of subsystems of the mine. It enables to present on a big screen the procedures referring to the mine operation and at the same time the way of operation particular mine subsystems (of the cross-section model). This solution is very handful when there are more than five participants and not everyone can directly observe what is going on inside the mine. Everything is presented on the screen owing to the camera and the instructor who explains the operation of subsystems.

Multimedia station – it is an additional element designed to simulate the implementation of the procedures and actions related to the preparation of MMDP mine for use by using another fighting weapon of marine underwater systems. The station is programme implemented in the existing programme of the simulator and enables a programmed visualization of the real devices and its elements that are operated in the process of preparing MMDP mine for use with the existing operator console of the simulator ordnance. The ordnance operator console enables to introduce particular settings (parameters) that are adjusted to MMDP mine and that ensure its proper exploitation. The introduced operation settings are adjusted during the simulated use of MMDP mine in the simulator. The simulated mode of MMDP mine model corresponds algorithm of its real operational work.

5. CONCLUSIONS

The training designed for operators who learn how to operate different types of devices is a long-term process and it requires the engagement of additional sources. In the time of computerization such teaching tools as classical manuals, display boards and models presented on posters are becoming obliterated. Contemporary simulators, equipped with additional 3D glasses, are the systems that seem perfect training tools, especially in case of operating ordnance.

The presented MMDP device is an example of the technical thought that being a very advanced device requires long, complex and multi-level preparation for use. The implementation of the simulator in the learning process based on two devices

has provided very satisfactory training results. There are many advantages of this solution – the main of which is the direct contact with the device from the very beginning of the training process, which significantly shortens the time of elements identification after the theoretical stage. Depending on trainees perception abilities in any moment of the training the instructor may shorten or extend the time of training stages. Certain actions can be repeated and practices many times and those that are acquired fast may be shortened.

It should be mentioned that the cost of such a simulator with additional cross-section and a device stand in opposition to this solution. Yet it has many advantages that outweigh high costs. The presented simulator is a unique device and in times of 3D printers and less complex devices such a model of training is cost-effective.

Having said that, when we consider the training for MMDP operators conducted in an academic lecture hall and the possibility of practice at the harbor basin, the new method is incomparably cheaper and more cost-effective than the existing method. Until now the ship and the whole crew of the ship have been included in the training process in which the crew that worked for the school operator went into the sea in order to teach trainees how the operate the device and after three further stages of the MMDP training were carried out.

LITERATURE

[1] Kupisiewicz Cz., Metody programowania dydaktycznego, PWN, Warszawa 1974.
[2] Litwin W., Okrętowe systemy broni podwodnej, cz. I, Pola fizyczne, Gdynia 1990.
[3] Królicki J., Okrętowe systemy broni podwodnej, cz. II, Opis i eksploatacja min morskich, Gdynia 1989.
[4] Jankiewicz M., Kulis J., Kurpiel S., Szady J., Podstawy wojny minowej na morzu, cz. II, Działania przeciwminowe, Gdynia 2008.
[5] Chmieliński M., Haberek R., Kasprzycki O., Systemy symulatorów i trenażerów ukierunkowane na poprawę bezpieczeństwa oraz obsługi sprzętu wojskowego, Gospodarka Materiałowa i Logistyka 12/2017.
[6] Baryłka A., Introduction to engineering safety of anthropogenic object, Chłodnictwo 6/2015.
[7] Baryłka A., O sposobach uwzględniania wymagań obronności i bezpieczeństwa państwa w systemie planowania przestrzennego kraju, Aparatura Badawcza i Dydaktyczna 4/2016.