permeability, auxiliary power plant room,
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Waldemar MIRONIUK[1]
Zbigniew ŁOSIEWICZ[2]

THE METHOD OF DAMAGED WARSHIP'S COMPARTMENTS PERMEABILITY DETERMINING

The paper presents research on damage stability and unsinkability. In the paper, the method of calculation a volume of damaged compartments is presented. On the basic of the built computer program, a simulation model of the damaged compartments ship's type 888 was shown. To calculate a real quantity of the water, the permeability of flooding compartment μ is used. Permeability of damaged compartments was estimated on the basis of preliminary research presented in the paper. Its value depends on the height of the water inside the compartment. The results of the experiments can be a base to define general rules to make proper decisions during the process of damage control.

WYZNACZANIE WSPÓŁCZYNNIKA ZATAPIALNOŚCI USZKODZONYCH PRZEDZIAŁÓW OKRĘTOWYCH

Referat dotyczy badań niezatapialności i obrony przeciwawaryjnej okrętu wojennego. W referacie zaprezentowano metodę określania objętości uszkodzonych przedziałów okrętowych. Przedstawiono opracowany komputerowy model siłowni pomocniczej i głównej okrętu typu 888. Do obliczeń rzeczywistej ilości wody, jaka może dostać się do wnętrza uszkodzonych przedziałów zastosowano współczynnik zatapialności przedziału okrętowego μ. W referacie omówiono metodę określania współczynnika niezatapialności uszkodzonych przedziałów, których wartość uzależniono [1]od wysokości wody w przedziale. Wyniki przeprowadzonych obliczeń wstępnych współczynnika mogą być podstawą do opracowania zasad walki z uszkodzeniami poszycia kadłuba okrętowego.

1. INTRUDUCTION

Even highly organized fleets struggle with accidents and technical breakdowns which cannot be completely eliminated. The breakdowns can be classified based on their causes. The basic causes of the breakdowns are: warfare, defects of materials and defects within the

[1]Akademia Marynarki Wojennej, Wydział Nawigacji i Uzbrojenia Okrętowego, Katedra Eksploatacji Jednostki Pływającej, Gdynia 81-103; Śmidowicza 69. Telefon: +48 58 626-27-31, E-mail: w.mironiuk@amw.gdynia.pl
[2]Zachodniopomorski Uniwersytet Techmologiczny, w Szczecinie, Wydział Techniki Morskiej, Al. Piastów 41 Tel. 600 275 871, E-mail: HORN.losiewicz@wp.pl

production process, constructional defects, technological defects in the process of renovation, material's wear and tear, not meeting the requirements in operating and servicing an equipment, not taking security measures while storing dangerous cargoes, e.g. explosive materials, petroleum products and other chemical components of serious fire hazard [5].

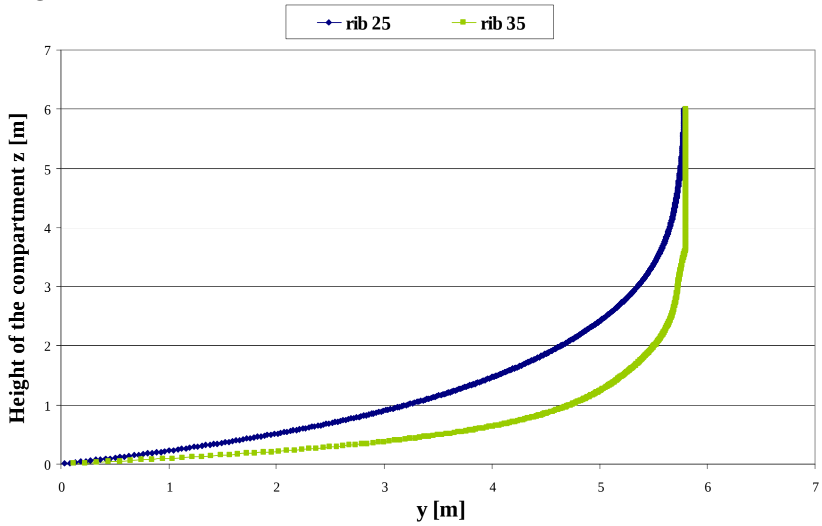
A partial or total loss in functionality of mechanisms and installations can occur both during warfare and during daily operating a ship.

Failures caused by navigational mistakes or wrong maneuverability represent a group of ship accidents and breakdowns which can lead to dangerous lost of floating of a ship due to flooding its compartments.

The most important thing in such a situation is to make a correct assessment of the ship's state after damage, which enables us to carry out a proper action of damage control.

2. COMPUTING THE VOLUME OF DAMAGED COMPARTMENT

The volume of a damaged compartment is necessary to assess the ship's state. The auxiliary power plant and engine room warship type 888 were chosen to the research. The lines plan of the ship's hull is used to compute the theoretical volume. Moreover, the plan was also used to have sections extracted at the place of ribs number 25, 35, 40, 45, 50, where we can find the damaged compartment. The sections of an auxiliary power plant are shown in Figure 1 [4].



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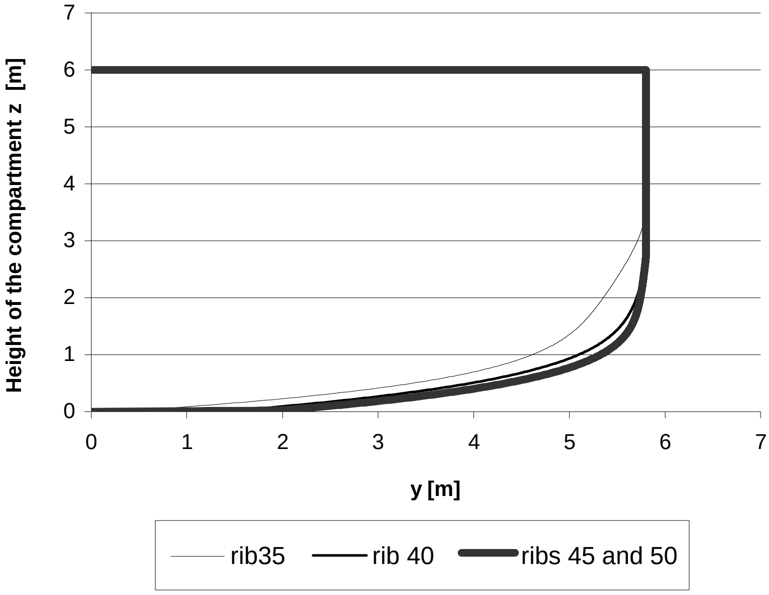

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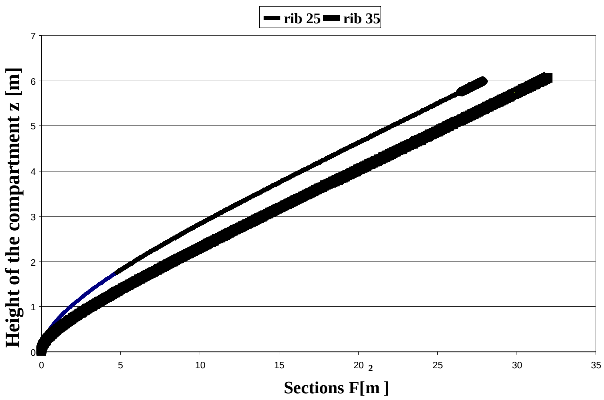
Figure 1. Sections of the:
a) auxiliary power plant room; b) main engine room

The area of the sections was calculated to estimate the accurate volume of the damaged compartment. Integral curves of sectional areas, obtained in this way, are presented in graphic form as a multinomial degree 7 in Figure 2.



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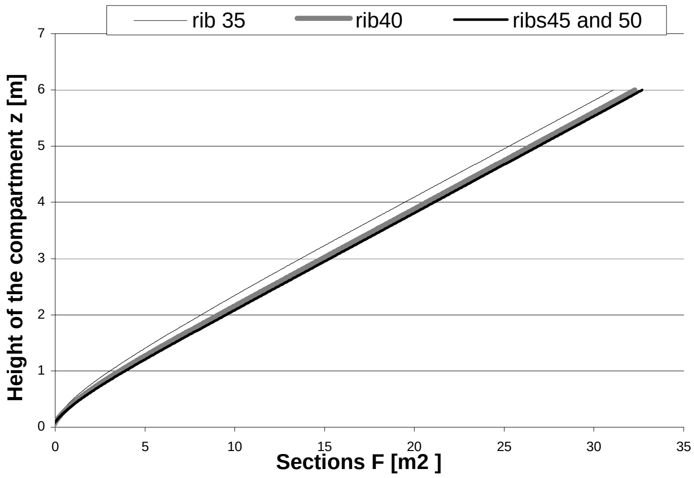

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Figure 2. Integral curve of the : a)auxiliary power plant room sectional areas; b)main engine room sectional areas

Using section areas and a distance between them, the theoretical compartment volume can be calculated, by the formula [1,2]:

$$v_t = \sum \frac{(F_i + F_{i+1}) \cdot l_w}{2} \tag{1}$$

Where: l_w = the distance between sectional areas,

F_i, F_{i+1} = section areas.

During the research the main dimensions and position of mechanisms and devices inside the auxiliary power plant and main engine room were determined. After that their volume was calculated.

The simulation model of the auxiliary power plant and main engine room, equipped with all main mechanisms and devices, were made in the next part of the research. The view of the compartments being flooded is shown in Figure 3 [4].

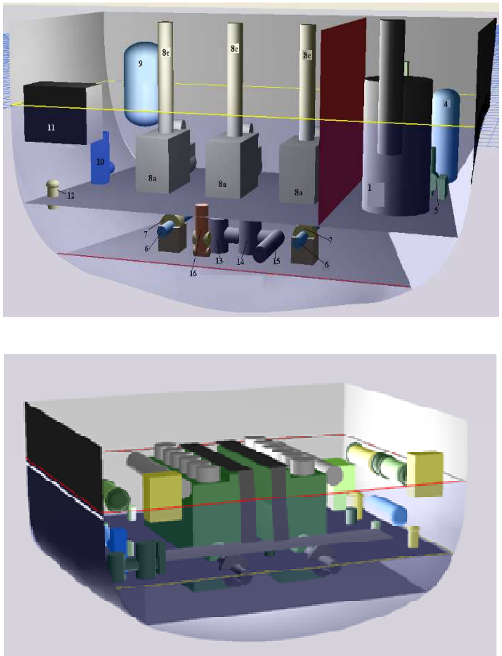

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Figure 3. Compartments: a) auxiliary power plant room; b) main engine room

3. PERMEABLILITY CALCULATION

The volume of the empty compartment was calculated with the aid of the computer program. The real quantity of the water, flooding the compartment, is less than the theoretical volume of the compartment due to the volume of all mechanisms and devices inside the compartment. Usually, to calculate a real quantity of the water, the permeability of flooding compartment μ is used. Permeability is used in ship survivability and damaged stability calculations. In this case, the permeability of a space is a coefficient from 0 to 1. The permeability of a space is the percentage of volume of the space which may be occupied by seawater if the space is flooded. The remaining volume (not filled with seawater) being occupied by machinery, cargo, accommodation spaces, etc.
The values of permeability for compartment is calculated by the formula [1]:

$$\mu = \frac{\mathrm{v}}{\mathrm{v_t}} \tag{2}$$

where v_t = theoretical compartment volume,

v = real quantity of the water inside the compartment.

The numerical value of the permeability depends on both, a kind and destination of damaged compartment. The permeability of the compartment μ, which is announced in the SOLAS Convention, is usually used to calculate the real volume of the compartment. Typical values from the SOLAS Convention are:
-0.95 for voids (empty spaces), tanks, and living spaces;

-0.85 for machinery spaces;
-0.60 for spaces allocated to stores.

This implies that for damaged stability calculation purposes, machinery spaces are only 15% full with machinery by volume (100% - 85% = 15%). In preliminary research presented in the paper, permeability of the auxiliary power plant room was estimated.

To determine the permeability the surface of main mechanisms and devices inside the auxiliary power plant room on the different height was determined.

The surface of liquid flooding the compartment, for growing level of water in the compartment, we will mark subtracting sum of surface of sections all devices being on this level from surface of flotation on suitable height.

The sections of the compartment on the different heights was introduced in the Figure 4 for auxiliary power plant room and the Figure5 for the main engine room.

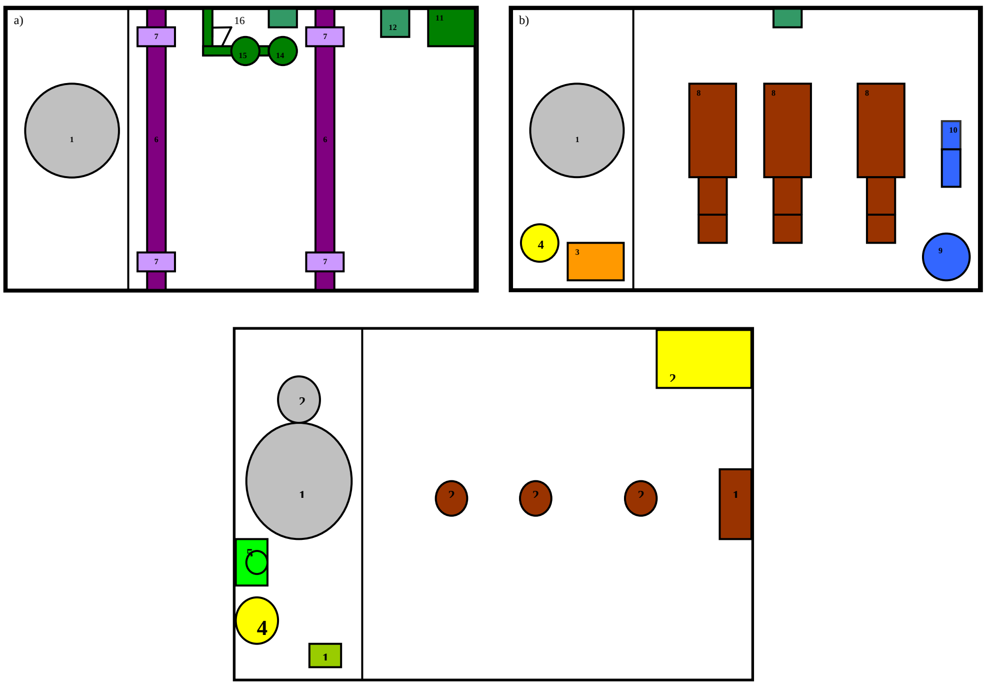


Figure 4. The position of devices inside the auxiliary power plant room on different heights
a) z=1,0 m,
b) z=2,2 m,
c) z=3,7 m
1.Boiler; 2. exhaust manifold of boiler; 3. thermal chest; 4. Oil separator; 5. bilge pump of oil separator; 6. propeller shaft; 7. slide bearing; 8a. generating set; 8b. generator; 8c. exhaust manifold of generation set; 9. compressed air tank; 10. Compressor; 11. oil used tank; 12. equalizing water cooling tank; 13.oil centrifuge;14. kingston; 15. sea water filter; 16. kingston main; 17. bilge pump; 18. Transformer; 19. drip clarifier; 20. oil tank.

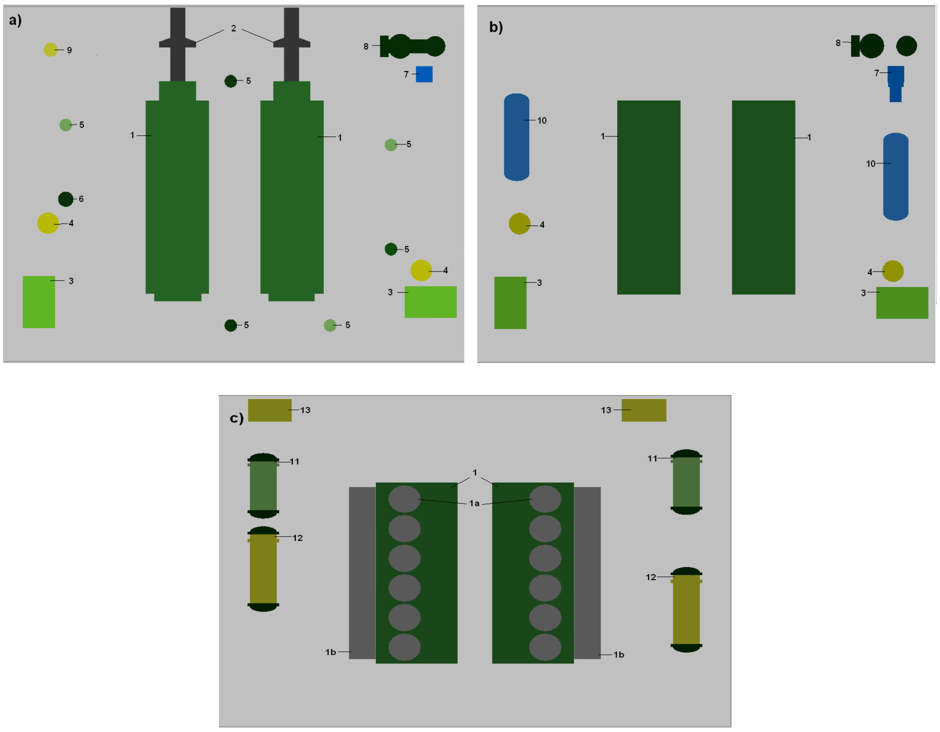


Figure 5. The position of devices inside the main engine room on different heights
a) z=2,1 m,
b) z=2,7 m,
c) z=4,2 m

1. Main engines; 1b.Cylinders; 1a.exhaust manifold; 2. Propeller and clutch; 3. Fresh water generation; 4. Oil filter; 5. Water pomps; 6. Fire pomp; 7. Compressor ; 8. The valve of sea water; 9. Oil centrifuge; 10. Air pressure tank; 11. sea water cooler; 12. Oil cooler; 13. Oil tank

Knowing the surface of water inside the flooded compartment and the flotation we can determine the permeability of the surface [1]:

$$\mu_f = \frac{F}{F_{WOp}} \tag{3}$$

Where: F- surface of devices and mechanisms,
F_{WOp} - flotation of damaged compartment.

The permeability surface value is necessary to determine the second moment of the free surface. Knowing curves of the section areas damaged compartments presented in Figure 1 the second moment of the flotation section is calculated according to the formula[1,2]:

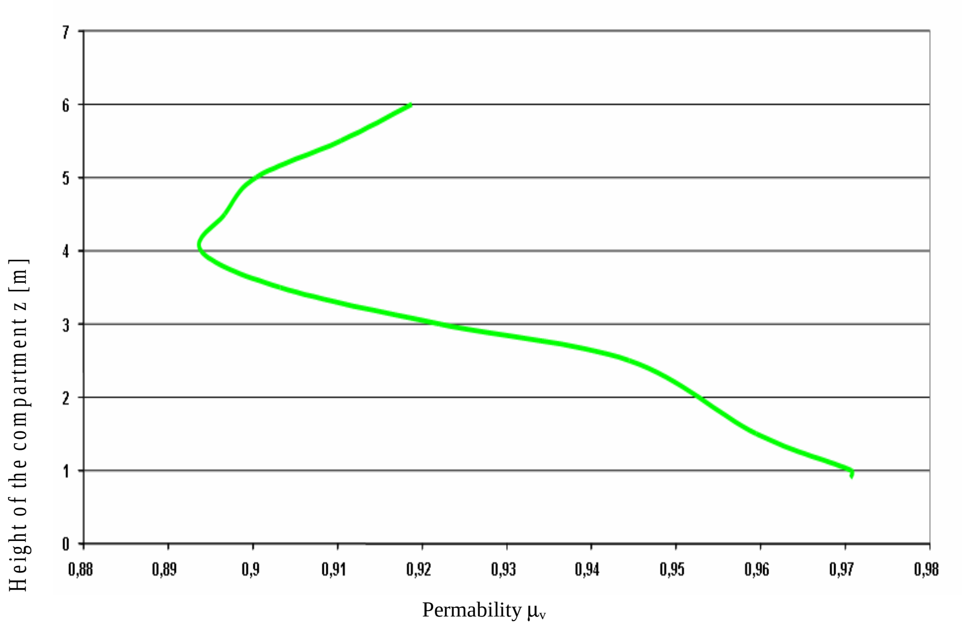
$$i_{bt} = \frac{l \cdot b^3}{12} = \frac{l \cdot (2y)^3}{12} \tag{4}$$

Where: l – length of the compartment,
b- breadth of the compartment.

The value of the real second moment of the flotation section is calculated from the mathematical formula[1,2]:

$$i_b = i_{bt} \cdot \mu_f \tag{5}$$

The results of second moments obtained in this way are used in the computer program to calculate damage compartments permeabilities.
The value of the permeability depends on the height of the water inside the compartment. The graph of the permeability is shown in Figure 6 [4].



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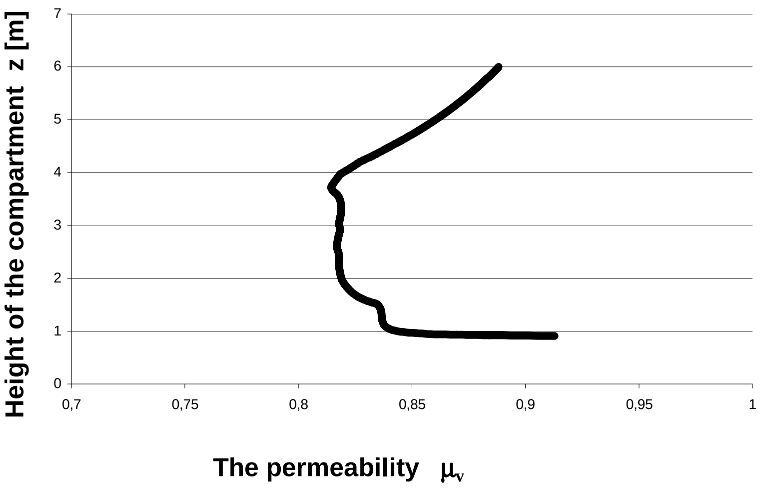

b)

Figure 6. Graph of permeability μv:a) auxiliary power plant room; b)main engine room

The average value of the permeability for chosen compartments, obtained as a result of experiment, is comparable with the value of the SOLAS Convention and equals 0,84.

4. SUMMARY

The worked out method presents the permeability value depended on the water level inside damaged compartments. Due to this, we can estimate more accurate quantity of the water in compartments and finally more accurate, for example, the flooding time damaged compartments. The aim of presented method is providing experimental validation.

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