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CONCEPT OF SWIMMING FLAT-BOTTOMED EVACUATION PLATFORM

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Abstract

This article presents the concept of rescue airboat with the elements of a laboratory stand. The boat consist of a hull made of composites, reinforced by replaceable, 30 mm thick, polyethylene boards. The boards will protect the boat hull and will provide low value of friction parameter and protection against effects of fire exposure and dangerous liquids. The final optimal shape of the boat's hull will be achieved by numerical simulations. The boat will be equipped with electronic steering, communication and lighting systems as well as sophisticated navigation system (GPS and a module for checking depth of the water). Due to special catches on board, it will be possible to install folding seats for passengers as well as platforms for transportation of goods.

Our evacuation boat should present higher parameters of safety and more functionalities than standard evacuation boats providing possibility to move even over short segments of roads and terrain out of the water.

The propulsion system will be mounted above the board and will consist of pushing engine with power of 600 KM and three blades propeller. The airflow will be directed properly by two or three moveable surfaces.

The research element of the project will be constructing special equipment to measure linear and angular speed and acceleration parameters, as well as position of boat and depth of water below.

Keywords: *transport, rescue, evacuation boat*

1. Introduction

This article describes the concept of a prototype floating platform, which will allow moving around backwater and shallow water fords, and also to recognize and effectively coordinate the evacuation from in terrain. The proposed floating vehicle (sliding on the water surface) will belong to unconventional objects intended to perform tasks by the fire brigade, police, border guards and military. The project, in which the demonstrator of evacuation floating platform will be developed, is being implemented by a consortium of research centers and industrial entrepreneurs, led by Automotive Industry Institute. The elaboration of demonstrator will include following steps:

- technical design as well technological and design calculations,
- technical documentation,
- preparation of the technical basis for the realization of the prototype,
- conducting tests in compliance with production specifications,
- preparation of documentation for the codification of the product,
- analysis on the requirements for range of the certification research to in order to obtain a safety certificate.

Under the research it is planned to determine requirements as well as to analyze the technical and operating parameters, elaboration of operating and utility assumption of watercraft, which overcome water obstacles. In the field of overcoming these obstacles, it is necessary to perform analysis and examination on properties and parameters of stability, to choose masses and their spatial distribution in different states of exploitation, to determine location of centre of mass and metacentre and perform calculations of stability of vehicle during movement on the water surface. The next steps of research will include assessment of the possibility to use existing power sources in regard of the manoeuvring characteristics during overcoming water obstacles, modelling research, strength calculations and elaborations of the driving characteristics. Afterwards layouts, which provide buoyancy and waterproofness of platform, will be evaluated, including the size and location of the holes in technology in the hull. The final stage of the analysis will be numerical simulation of the water flowing around hull platform in various movement conditions.

As part of development work, an elaboration of a floating platform design is planned, performing the preliminary design a system for controlling platform's drive, elaboration of the concept and preliminary technical documentation, and also realization of a prototype platform. Then the research on resistance driving and movement from various modifications of the hull and driving of platform will be carried out to obtain assumed movement parameters, including:

- research on process of transporting and launching platform into the water,
- resistance and propulsion tests of modified version of the platform,
- tests on manoeuvrability of platform,
- research on platform's stability in different states of exploitation,
- researches to optimize location of the centre of gravity, including the determination of stability,
- stability test under real conditions,
- tests on platform's prototype drive system.

The research will carried out with the use of simulation modeling studies and research in real conditions.

One of the concepts of mobile evacuation floating platform is presented in Fig. 1.

2. Requirements for a floating evacuation platform

The platform will be driven by a pusher engine with a three blades propeller. It is expected to use an engine of 600 KM power. It will allow moving the platform in the aquatic environment, as well as in land environment, even in stony areas. The engine will be encased in a tubular protective structure, however vector control will be in progress by using the control surfaces (vertical, but horizontal are possible as well). They will direct the air flow from behind propeller in the desired side. Another important aspect will be selection of appropriate engine's power in relation to planned weight of boat and used polyethylene protective plates of hull, which are characterized by a low coefficient of friction, even in the land conditions. These plates will be the cover of the boat hull against mechanical damage and expenditure due to friction with the ground. In case of damage or expenditure, quick-change plates with new ones will be possible.

The key definitions associated with the floating unit are unsinkability, buoyancy and stability. Unsinkability of ship means the ability to keep on the water surface after the launching into it.

Fig. 1. One of the concepts of swimming flat-bottomed evacuation platform (Own develop of Automotive Industry Institute)

Keeping on the surface means remain buoyancy in such a state of equilibrium, which allows even to perform basic functions, despite operating heeling moments. In case of evacuation platform, keeping unsinkability has a special importance. Much more dangerous occurrence for platform is losing stability, which is a sudden process, and as a result overturning the platform and suddenly sink. Stability is concept in the field of ship theory and concerns the ability of floating unit to resist external forces that could cause to tip it over. Distinguished by longitudinal and lateral stability, which can be defined as the ability of returning the floating unit, after the disorder of starting position by external forces, to the state of equilibrium established in the design phase of floating unit. An important concept in the range of ship stability is metacentre. It is conventional point on the vertical line, perpendicular to the level of water and passing through the point of the buoyancy force, in the place of intersection with geometrical axis of the ship. When the metacentric height is positive (metacentre is above the centre of gravity), buoyancy and gravity forces, come the ship down to the vertical, when it's negative (metacenter is below the center of gravity) – the ship may tilt and sink.

It is assumed that the platform will be characterized by high stability. This will be achieved thanks to flat bottom of platform, at a relatively low draft of the hull, and favourable proportion of the width to the depth of the hull immersed in the water.

In order to introduce the product for the first time on the market of the European Union, it is necessary to subject it to the so-called conformity assessment procedures to the extent required by the relevant legislation for this product of the European Union (directives). Organization dedicated to conformity assessment in Poland is the Polish Register of Shipping (PRS). It should be noted that a large number of rules concerns seagoing ships, and therefore big floating units. Some rules also applies to inland waterways. The evacuation floating platform, which was developed in the framework of the research project, is the special unit, which will be used in emergency situations, usually in water bodies with low depth. Thus, most of rules for ships as such, does not apply in the case of the platform. It should be taken into account that the platform will be used to transport people. Accordingly, it should ensure the safety for the crew and passengers.

In the fourth part of the requirements developed by the PRS, titled "Rules for classification and construction of seagoing ships", there are the requirements for unsinkability and stability of floating units. The annex 2 to the above-mentioned document presents a simplified methods for calculating ships stability, whose capacity above the water part of hull is such a spread out that when it is tilted there is no much dipping of the ship, so that we can use the following simplifications:

– the angles of ship flooding can be calculated without including of equal capacity waterline (waterline – the line of water, like a sideway view of water line on the hull of ship), according to the formula:

$$\varphi_z \cong \frac{60 \cdot (z - T)}{y} \ [°], \tag{1}$$

where z, y are the coordinates of ship flooding point [m], and T is the current dipping [m],
– angle of flooding deck φ_{zp} is given by the formula:

$$\varphi_{zp} \cong \frac{120 \cdot (H - T)}{B} \ [°], \tag{2}$$

where H is a side height of ship [m], and B is a breadth of ship [m],
– metacentric height for ships with simplified shapes can be calculated using the following formula:

$$GM = 0.08 \cdot \frac{B^2}{T} + \frac{T}{2} - KG \ [\mathrm{m}], \tag{3}$$

where KG is the center of mass height of ship in a given loading condition [m],
– the center of mass of the loaded unit can be calculated using the following formula:

$$KG = 0.75 \cdot H \quad [\mathrm{m}], \tag{4}$$

– the center of mass of the loaded unit can be calculated using the following formula:

$$Z_{gl} = H + \frac{1}{2} h \ [\mathrm{m}], \tag{5}$$

where h is the maximum load height above deck in meters,
– for ships with simplified shapes, center of buoyancy can be adopted according to the formula:

$$Z_F \cong \frac{T}{2} [\mathrm{m}], \tag{6}$$

where T is the average dipping for loading condition in meters,
– static tilt angle to the value of 12° from load by external torque can be calculated using the following formula:

$$\varphi_s \cong \frac{6 \cdot M}{D \cdot GM} [°], \tag{7}$$

where:
M – tilting torque, in particular, from the wind pressure, M_w [kNm],
D – ship buoyancy [t],
φ_s – static tilt angle [°],
GM_0 – initial metacentric height [m].

The angle of dynamic tilting from M, φ_0 torque load can be calculated using the following formula:

$$\varphi_0 = 2 \cdot \varphi_s = \frac{12 \cdot M}{D \cdot GM} \ [°]. \tag{8}$$

It is planned to equip platform with mounting points for on-board equipment. They will enable rapid assembly and disassembly of equipment such as seats - in the case of people evacuation. Seats are going to be made of durable plastic, so they are lightweight and resistant to influence of water. It is also projected to install metal baskets to carriage flood sleeves which are filled with water. After transport to the place of rescue, these sleeves are filled with water and form a protective barrier similar to a shaft formed from sandbags. For the filling water from the water supply or even directly water, causing the flood can be used. On the board of platform pallets for transportation of materials and equipment to remove flood effects, such as fire engines will be assembled as well.

Main drive in floating platform will generate noise of considerable intensity. The platform will be also use to save people and animals. Thus, one of the requirements for the platform is the ability to carry out this type of action as quietly as possible. For this reason, during the design phase, it is planned to apply electric outboard engines of low power to enable very silent work and precise control of the boat when it reaches the place of the rescue operation. This will be particularly important during the rescue of animals that can be scared by a combustion engine's noise. The current solution in construction of floating platforms allows reducing the intensity of noise by using multi-scapular propellers made of carbon fiber.

3. Navigation panel

The platform will be equipped with a control panel for controlling on board devices integrated with navigation panel. The control panel will consist of steering wheel, twist grip throttle, a set of indicators and switches including the main switch. Devices will indicate fuel level, engine cooling liquid temperature, condition of equipment via the platform (positional lighting and area lighting, etc.). The navigation panel will work with the receiver satellite navigation system, it shows current geographical location, speed and course boats. At this stage, the possibility of using sonar to measure depth of water at the bottom of the boat is being considerate. However, due to the possibility of damaging the measuring knob, when the boat will be moving in the environment other than water, its application will be much more difficult. Data of evacuation platform position will be presented on display LCD. It must provide waterproofness and must be able to withstand mechanicals damage.

The main purpose of the platform will be evacuation in the floodplain but it may also be necessary to evacuate during flooding in the city. In order to facilitate navigation, as well as information about possibility of encountering the obstacles on the surface of the water the ability to use in navigation panel terrain map, in which will marked shape of area and terrain and the underwater obstacles, is considered.

It is planned to equip the platform with navigation panel, which features designation on the map marking the position of starting point of the rescue mission and current position so that the panel will facilitate navigation to the selected destination.

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