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STUDY ON OIL SORBENTS EFFECTIVENESS

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Abstract

The paper presents search for objective and quantitative method of determination usefulness of various loose sorbents destined for cleaning surfaces polluted with oil. The motivation to take up the topic is that oil pollution emergence in marine areas remains still as the environmental problem. During the ship exploitation there is possibility of appearing of the fuel oil, lubricating oil, hydraulic oil or even transformer oil leaks on the board which might be erased by washing or using sorbent powders and granules or mates. In the case of disposing the washing liquids, the large volume of oil-in-water emulsion is forming which is gathered in a tank and further transported to the vessel cleaning system. In the case when sorbents are applied in an early phase of oil leakage, the vessel cleaning system is less overloaded which reduce the probability of failure.

We report analyses of effectiveness of mineral and organic sorbents. The time-period of incepting of defined amount of oil by define amount of sorbent is applied as the sorption effectiveness parameter. Time plots of oil sorption as well as visualizations of this process are presented. Method to characterize the efficiency of sorbents in relation to used lubricating oil is proposed which will stand as the base for further works directed towards elaborating optimal sorbent-set which can be rapidly used for combat spillages and leaks of oils and even other liquid dangerous payloads carried by ships.

Keywords*: fuels, lubricant oil, maritime engineering, environmental protection*

1. Introduction

Various aspects of oil pollution in the sea have been studied for decades, among other: detection, source identification, impact on natural environment, prevention, spillages combating, responsibility for the perpetration of spills and insurance issues. The question of combating oil spills has numerous aspects. The greatest number of research reports and descriptions of accidents and oil spill combat actions are included in the proceedings of the International Oil Spill Conference (over 3,000 papers) [5] and in the monograph by Fingas [4]. With regard to oil spills on sea the largest number of reports refers to the frequency of spill, source of oil pollution, physical and chemical properties of oil after contact with water, remote sensing of oil spills, equipment for oil-pollution classification, behaviour of oil spills, evaporation modelling, formation of oil-in-water and water-in-oil emulsions, physical spill countermeasures on water (skimmers, booms, pumps, oil-water separators), treating agents (dispersants, surface washing agents, emulsion breakers and inhibitors, sinking agents, biodegradation agents, solidifiers), in-situ burning, automated assessment of amount of spilled oil, effects of oil on the environment, detection of spills, source of spill identification, contingency planning, specific case studies. Some reports relate to the use of sorbents to combat or prevent spills. Sorbents are material that incept oil through either absorption or adsorption and can be of natural or synthetic origin.

In the case of spill accident various types of sorbents were tested and observable data were reported [1-3, 6] but there are not enough number of effective laboratory methods for prediction of usefulness to define sorbent in oil spills combating actions. To remove oil from hard substrates and from the surface of water a lot of materials have been tried, for example synthetic: polyester, polyethylene, polypropylene, polyuretane; natural organic: peat moss, straw, vegetable fibre, bird, feathers, bark or wood fibre; natural inorganic: clay (kitty litter), expanded pearylite, expanded vermiculite.

In this paper we report introductory laboratory tests on sorptivity of mineral and natural sorbents, performed in the Student Scientific Society „Nautica" (at Faculty of Marine Engineering of Gdynia Maritime University).

2. Material and methods

Sorbent named "Densorb" was used as the mineral one while as organic sorbent the peat moss was used. The used lubricate oil "Marinol" represented oil substances. The experiment consisted of tracking oil absorption by the sorbent lying on the surface of oil which Fig. 1 shows.

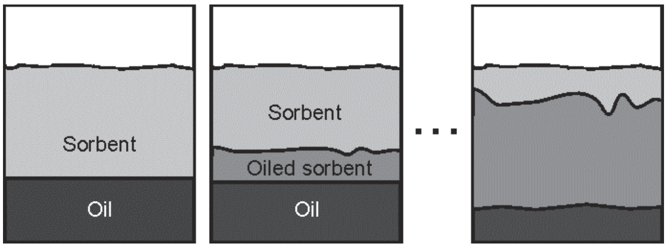

Fig. 1. Principle of the experiment

In described tests 20 ml of oil and 40 ml of sorbent were applied. Volume of oiled sorbent is represented by the size of the plot visible on the photograph as the sorbent with changed colour. After placing the sorbent on the oil surface the photo was made every 10 seconds for 3 minutes. The sizes of the oiled area were measured by the planimeter. All experiments were carried out in the room temperature (20-22ºC).

3. Results

Photographs for chosen seconds in Fig. 2 are showed. Changes of the oiled area were relatively rapid at the beginning whereas have become slower after several dozens of seconds. Fig. 3 presents a graph showing increasing of oiled area of the sorbent.

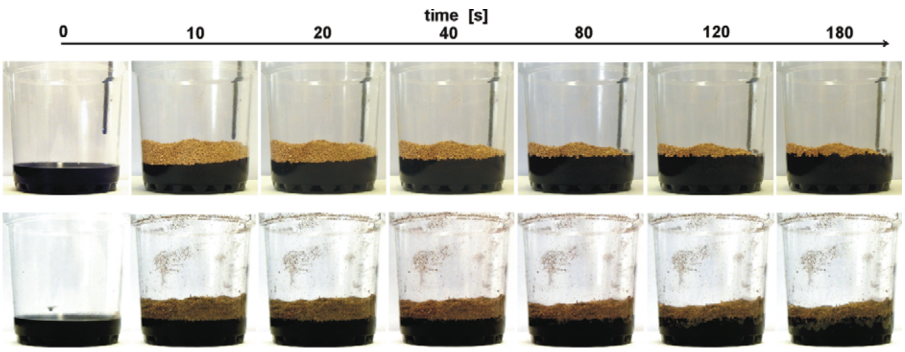

Fig. 2. The exemplary photographs showing increasing of an oiled area of the sorbent. The upper row – mineral sorbent "Densorb", the lower one – organic sorbent (peat)

There were algebraic models chosen for obtained results in the form expressed by relation (1):

$$V = V_{max}(1 - e^{-pt}), \qquad (1)$$

where:
V – volume of the sorbent oiled,

V_{max} – estimated volume when oiled area is stabilized,
p – sorption parameter,
t – time of sorption.

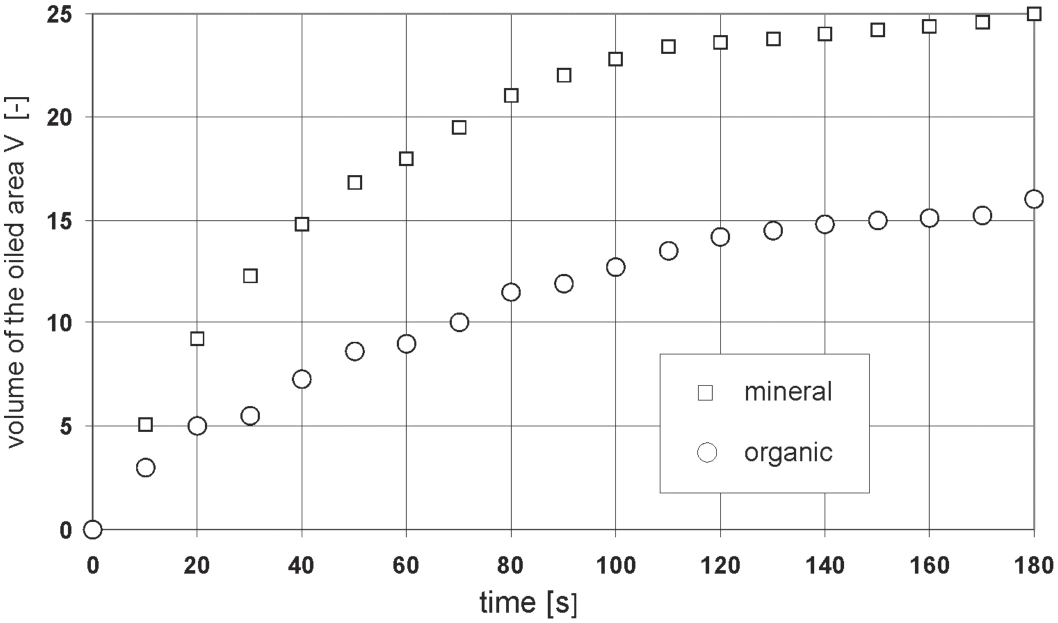

Fig. 3. Oiled area as the time dependence

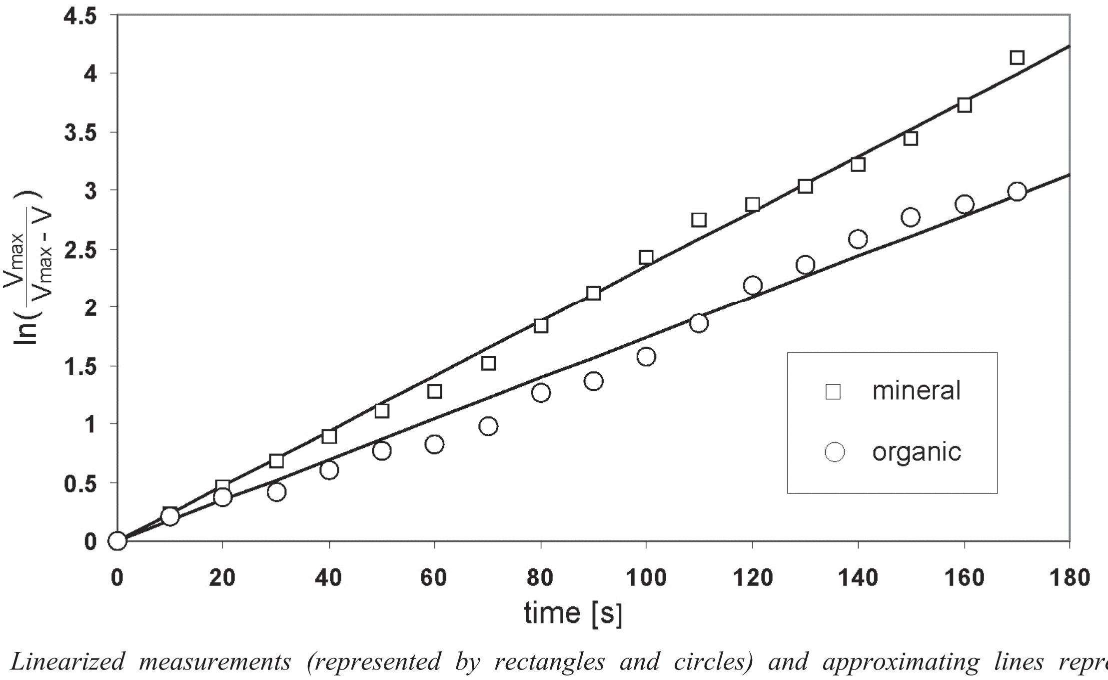

Fig. 4. Linearized measurements (represented by rectangles and circles) and approximating lines representing $\ln(V_{max}/(V_{max}-V))$ *in the function of time*

Relation (1) can be linearized to the following form:

$$\ln\left(\frac{V_{max}}{V_{max}-V}\right)=p\,t\,. \tag{2}$$

Dependence of $\ln(V_{max}/(V_{max}-V))$ on the time of contact with oil t in Figure 4 is plotted. In the same chart linear functions obtained by parameterisation by the method of least squares are shown.

The slope *p* of those functions is regarded as the absorption parameter indicating the activity of the sorbent. For the tested two types of sorbent following results were taken: for mineral sorbent $p = 0.025\ s^{-1}$, for biological sorbent $p = 0.017\ s^{-1}$.

4. Conclusions

In the above analyzed method of evaluation of sorbent single numerical parameter characterizes sorptivity of define type of loose sorbent. This parameter is independent on amount of material (oil and sorbent) used in testing. However, the measurement precision is higher with greater amounts of material. The method is promising for the future in case when oil absorption rate is desirable, but the main merit is that it gives possibility to rank objectively different types of materials in terms of their usefulness for the removal of a particular type of oil from the solid substrate.

However, some issues remain unsolved, for example how various types of sorbent will behave in various temperatures and in contact with other kinds of oil than applied here (the used lubricate ship oil). The solution of this problem, based on proposed method is easy – research can be carried out according to current needs. It is much more difficult to develop methods for testing the feasibility of particular sorbent when the mixture of oil and water is contacted or with oil floating on the water surface. In this situation the game between oleofility and hydrophobicity of the sorbent begins. It is expected that results presented in this paper give the methodical base for elaborating objective method of testing the sorbents for not only solid substrate but for aquatic areas also.

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