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NUMERICAL SIMULATION OF HOW TO ABSORB OIL SPILL IN CUBIC ABSORBENT PERLITE

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ABSTRACT

Oil spills in open water like rivers, oceans and rivers every year, imposes negative impacts on the environment. In the first step, they need to recognize familiar with the effects and check the oil and behavior in the environment. In this paper, in addition to the hydrodynamic behavior of the oil patch in the marine environment and the factors influencing this behavior, how to absorb the stain was modeled by absorbing industrial perlite. For modeling, the rules governing the transfer phenomenon, Navier-Stokes equations and k-ε model was used. It was assumed that the cube structure is absorbent and absorption profile in the liquid film around the oil-absorbing absorbent and adsorbent mass were studied. The results of the model were compared with experimental data and model the absorption kinetics of uptake kinetics was studied closer primarily with the absorbent.

Keywords: oil spill, hydrodynamics, absorbent, perlite

INTRODUCTION

The rise of environmental problems in most countries in the world is of particular importance and sparked public sensitivity and caused the world with a sense of common sympathy in order to solve problems. Today, oil pollution prevention is considered as one of the most important environmental issues. When oil flows to the water influenced by the prevailing winds, temperature and direction of water flow and its chemical and physical properties will be changed. When oil spills into the sea, such as the evaporation of volatile substances [1], liquidation of part of petroleum contaminants occurs in water, oxidation part of compounds by sunlight and Water in oil emulsion. It can be noted of procedures of elimination of oil pollution of the sea including the recycling of fuel using mechanical methods, drop to move the water from the beach and clean up oil spills and polluted beaches the use of chemicals scattering [2]. Mechanical recycling performance depends on the position of the oil spills and release oil spills do not work in the oil ports until the beach freeing them for natural spread in the environment. In contrast, dispersive materials are oil slicks on the water surface shattered and turned it into smaller particles, and these particles penetrate deep into the water, diluted and then by microorganisms used in the water, decomposes and eventually disappears. The environmental- economy damage is prevented. It should be noted that the concentration of these substances must be used and the type is examined and tested. Dispersive materials have their own advantages and disadvantages.

PETROLEUM POLLUTANTS

Loss of oil in the water generally exist in two sustainable and volatile forms. The volatile oil tends to scatter quickly in sea level and sustainable type tend not to be scattered on water surface. Volatile oil are usually in the form of kerosene by a factor of gravity lower than 0/8. Sustainable oils are for fuel oil and gravity factor of 0/8. Upon arrival of oil pollution on the aquatic environment, the chemical and physical changes will be begun. This process includes the following steps: evaporation, expansion, emulsification, disintegration and corruption, exchange of air and sea and sedimentation. The most important processes affecting the oil slick is evaporation after discharge into the environment. Natural dispersion, the amount of oil on the surface to reduce the amount of material lost through evaporation and reduces it. But has no effect on the physical and chemical characteristics of the oil, and they do not change. Practically normal distribution can play an important role in removing crude oil from the sea surface.

Chemical oxidation of petroleum compounds is often carried out with the help of sunlight. Physical and chemical processes, biological process occurs slowly. The most important biological processes can be decomposed by micro-organisms oil into carbon dioxide or organic material in the intermediate phase, oxidation, carrying high levels of water and metabolites by large organisms, storage and unloading point. Knowledge of the effects of winds and local currents, including valuable information to determine the speed of play is an oil slick. The warm waters like the Gulf of Oman and the Persian Gulf because of rising temperatures, the lighter the oil spill in the water evaporate. High oil pollution increases the activity of the heavier oil is degrading bacteria.

Much of the pollution of the seas occur due to coastal refineries, industrial and urban sewage discharge, urban loss and urban outfalls. Hydrocarbon deposits are produced by means of transfer and transport by air and sea, are another source of pollution of the seas. From other sources, oil is discharged from the cars. The amount of material falling into the sea and rivers are urban settlements that is estimated around 1/9 million barrels a year. Natural resources and plankton through biochemical synthesis of hydrocarbons to enter the sea.

Except in the case of a catastrophic event, the volume of oil is relatively high that enters the sea from drilling and extraction (20,000 tonnes per year) and small oil spills in the first place. In addition, another of the oil pollution can be noted that the production of offshore Petroleum vessel is transferred to the ground.

Another telltale sign is the amount of oil to ocean tanker accidents than other sources Petroleum polluted sea resolver relatively low but where vast amounts of oil is entered into the marine environment one place and in one area.

The effects of Petroleum pollutants on coastal waters and sea environment

Oil pollution has many negative effects that some of them are:

- Acute toxic effects for aromatic compounds with low boiling point, which leads to instant death.
- Lethal effects for components with high boiling point which affect the physiological and behavioral processes.
- Changes in the physical and chemical changes in the body that lead to individual organisms, as well as changes in the composition and diversity of these animals are.
- Intervention in the movements of living things that lead to drowning or freezing them.

Oil in marine waters was to say if any bad effects on aquatic organisms, but not as a cover to prevent the gas exchange between the sea and the air and prevents water from entering the life of sunlight the water environment and disrupting the function of the sharp decline of photosynthesis and oxygen, water, life is endangered creatures. Heavy Petroleum deposits on the seabed composition including the effects of oil pollution.

In many cases, the oil spill in the sea can result in irritation and skin disorders or at higher levels is due to cancer in workers who collect these materials from the sea.

Intensification of existing diseases, creating a hazard for pregnant women, neurological disorders and pulmonary diseases are other harmful effects to marine oil spills on humans. Smoke, sulfur dioxide, hydrogen sulfide, nitrogen dioxide, carbon monoxide and aromatic Petroleum compounds are of causes of memory problems in humans.

Aquatic oxygen depletion of dissolved oxygen to the tissues affected by this disharmony and imbalance cause serious damage to associated aquatic and it is also believed that oil pollution occurring in the area, there will be as a legacy of food pollution in the area.

So, in this paper is that the hydrodynamic behavior of the marine environment and factors affecting the oil patch on it, and how to attract the spot by industrial absorbing the cube model. For modeling, the momentum and mass transfer phenomena and laws in k-ε model was used to investigate the disturbance. Then, process modeling and simulation is described.

MODELING

The governing equations of fluid flow

Fluid mathematical equations representing physical laws in terms of survival is that some of these

The rules are:

- The mass of the fluid is constant.
- Rate of change of momentum with the resultant fluid forces acting on the particle is (the second law of thermodynamics)
-Rate of Energy change to the total rate of temperature increase rate system and the work done on the fluid particle is (the first law of thermodynamics).

The fluid should always be considered. Here fluid behavior expressed in terms of macroscopic properties such as speed, pressure, density and temperature and derivatives when and where they studied and described. Most important engineering flows are disturbed, the turbulent flow region is not only important in theory. The main reason for the transition to turbulence created in the flow attributed to disturbances. This linear hydrodynamic stability theory is studied. Transition to turbulence is strongly influenced by factors such as pressure gradient, surface turbulence, rough walls and heat transfer. Navier-Stokes equations of continuity and at the same time a closed set of four equations with four unknown u, v, w, p form. In this paper, in the meantime the equations of motion, the details of the case lies in the volatility of the time has been set aside. As a result, six additional unknowns in the equation, the average time is obtained as the Reynolds stresses. The main task confusion model for the development of general calculation is accurate enough for engineers to predict scalar transmission Reynolds stresses and phrases [3].

The most common turbulence models are classified as follows [4]:

- Couches classic, based on the average time Reynolds equations

  - ✓ zero-equation model - mixing length model
  - ✓ Equation model - model k-ε
  - ✓ Equation model tensions Reynolds
  - ✓ Algebraic stress model

- Simulates great literature, based on uniform model

Now the mix of classic and k-ε model is widely used and valuable. Based on the basic assumption that there is a parallel between the yield stresses and viscous stresses of Reynolds.

Here are just a k-ε model used in this paper is described [5].

K-ε model

The shear layers of thin two-dimensional changes is so slow in the direction of flow that confusion can adjust itself to local conditions. If handling properties ignore the influence of turbulence, the effects of the turmoil can be described on the average in terms of the mixture. If it can be ignored the influence of the movement, such as streams with this rotation, the other a short algebraic relationship is not practical to the mix. K-ε model is focused on practices that affect the kinetic energy.

First, it is necessary to analyze the kinetic energy of the fluid flow and the rate of deformation elements such as instantaneous average flow equations in two average and swinging variables. As a result, the average kinetic energy and swinging kinetic energy is shown in the relations 1-2 and 2-2.

$$\bar{k} = \frac{1}{2}(\overline{u^2} + \overline{v^2} + \overline{w^2}) \qquad (1\text{-}2)$$

$$\bar{\kappa} = \frac{1}{2}(\overline{u'^2} + \overline{v'^2} + \overline{w'^2}) \qquad (2\text{-}2)$$

The turbulent kinetic energy and the deformation rate of 3-2 and 4-2 is expressed as [6]:

$$K = \overline{K} + k \quad (3\text{-}2)$$

$$e_{ij} = E_{ij} + e_{ij}^{'} \quad (4\text{-}2)$$

$$e_{ij}^{'} = \frac{1}{2}(\nabla V^{'} + \nabla V^{''}),\, V^{'} = (u^{'}, v^{'}, w^{'}) \quad (5\text{-}2)$$

$$E_{ij} = \frac{1}{2}(\nabla \overline{V} + \nabla \overline{V}^{'}),\, \overline{V} = (\overline{u}, \overline{v}, \overline{w}) \quad (6\text{-}2)$$

The possibility of developing a similar transport equations for all qualities which include depreciation rate of slimy bulk turmoil. The exact equation contains a large number are unknown and cannot be measured, is ε. K-ε standard model has two equation model. One is built for k- ε and one is built on the best understanding of the processes appropriate for that change of the variables. The standard model is of the form of 7-2 and 8-2 [7].

$$\frac{\partial(\rho k)}{\partial t} + \nabla.(\rho k \overline{V}) = \nabla.\left[\frac{\mu_t}{\sigma_k}\nabla k\right] + 2\mu_i E_{ij} : E_{ij} + \rho\varepsilon^{*} \quad (7\text{-}2)$$

$$\frac{\partial(\rho k)}{\partial t} + \nabla.(\rho k \overline{V}) = \nabla.\left[\frac{\mu_t}{\sigma_k}\nabla k\right] + C_{1\varepsilon}\frac{\varepsilon^{*}}{k}2\mu_i E_{ij} : E_{ij} + C_{2\varepsilon}\rho\frac{\varepsilon^{*2}}{k} \quad (8\text{-}2)$$

In the standard model k-ε, values of $= C_{\mu}$ = 0/09, $C_{1\varepsilon}$ = 1/44, $C_{2\varepsilon}$ ‘= 1/92, σ_e = 1/3, σ_k = 1 and are used as well in a wide range of turbulent flows. To calculate the Reynolds stresses, the equation 9-2 is used with k-ε model [8].

$$-\rho\overline{u^{'}_i u^{'}_j} = 2\mu_t E_{ij} - \frac{2}{3}\rho k \sigma_{ij} \quad (9\text{-}2)$$

The results show that the performance of the model has been good especially for flows where the Reynolds shear stresses is more important [9].

KINETICS UPTAKE

The amount of oil absorbed by the adsorbent was investigated. One way to analyze the reaction of absorption, adsorption kinetics equations is the most used of these models, pseudo-first and pseudo-second is shown in equations 3-2 and 2-4, respectively. In this relationship, x is the density of the oil, k_1 and k_2 first fixed constant pseudo II.

$$-Ln\, x = k_1 t \quad (3\text{-}2)$$

$$\frac{1}{x} = k_2 t \quad (4\text{-}2)$$

CFD simulation

The effort is part of the modeling tool to be examined to help absorb the Petroleum composition in the absorbent one cubic element using CFD simulation. Computational fluid dynamics or CFD is a systems analysis of fluid flow, heat transfer and associated phenomena such as chemical reactions, based on computer simulation.

BASIC ASSUMPTIONS

Initial studies to determine the amount of oil absorption was performed within a cube elements (in the form of two-dimensional). Calculation area is shown in Figure 3-1.

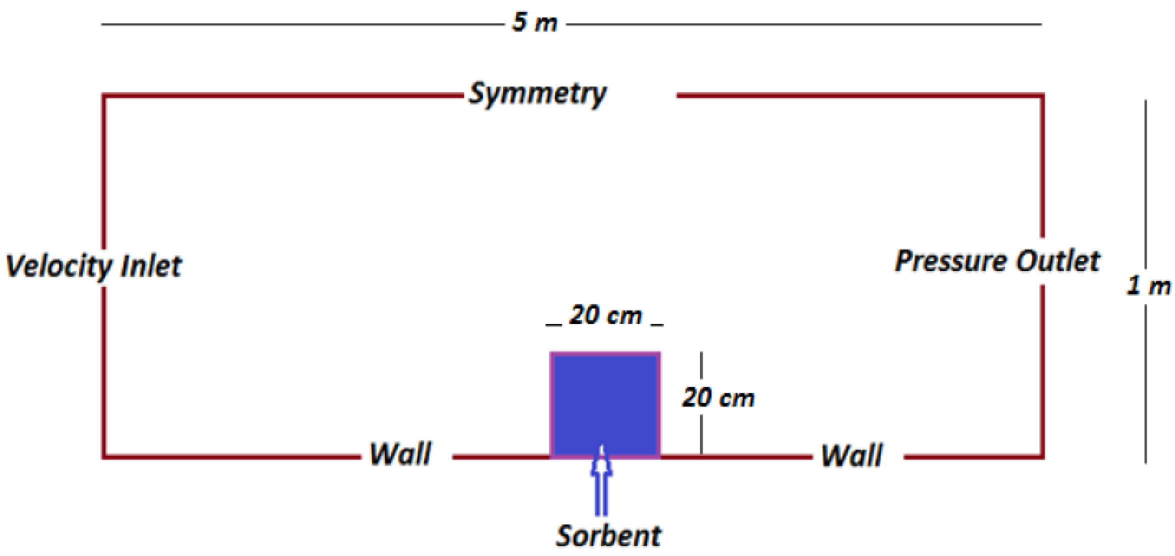

Fig. 3. Schematic of the calculated 1 and boundary conditions

Oil and water mixture with oil mass fraction 0/02 and computational speed of 1 meter per second into the area. The boundary conditions are considered top of the infinite computing range. Walls were used to wall with zero speed and the absorption rate change to obtain experimental values obtained by Ali et al. Assumptions used for the simulation is shown below:

- The changes in the absorption and concentration changes are taken together and is shown in equation 1-3. Although this assumption is true, but only in equilibrium with acceptable accuracy for use in the simulation as well.

$$\frac{\partial C}{\partial t} = -\frac{\partial q}{\partial t} \times \rho = -\frac{\partial q}{\partial t} \times \rho_{solid} \times (1-\varepsilon) \quad (1\text{-}3)$$

In equation 1-3, ε is porous adsorbent and q is the mole absorbed per kilogram of adsorbent.

- To get the changes from the experimental values of q at the same time is used. About 3.2 to estimate this amount was used at any time [10].

$$q = 48.357 \ln(t) - 155.891 \quad (2\text{-}3)$$

RETICULATION

In this paper, the software Gambit is used for the grid geometry. It should be noted that quite regular mesh is used for the simulation. Figure 2-3 has shown the mesh used in the simulation.

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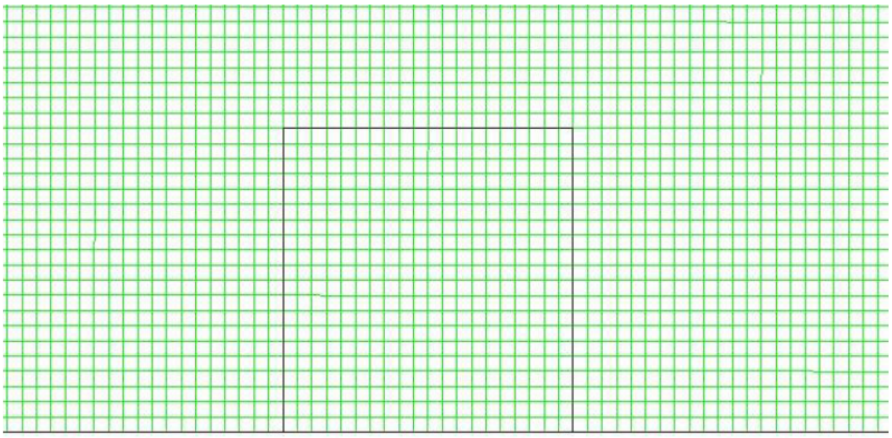

Fig. 2-3. Mesh used in the simulation (from software Gambit)

RESULTS AND DISCUSSION

Field and velocity vector

Figure 1-4 has shown the simulation speed from outside and inside of the cubic absorbent. It is observed that the top absorbent flow rate is higher than elsewhere. This is to reduce the flow cross section at this point. It also observed that the minimum speed is the minimum on absorbent walls. In the absorbent speed due to the influence of oil phase adsorbent is not zero but it is very low compared with the rate in areas outside the absorbent.

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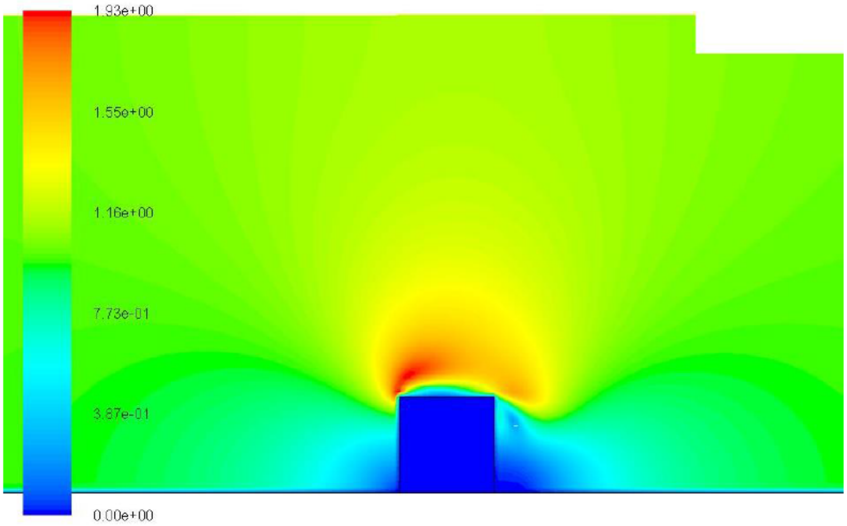

Fig. 1-4. Speed around an absorbent profile

Outside and inside the absorber velocity vectors are shown in Figure 2-4. As you can see, due to the influence of the oil phase to the absorber, the absorber has a rotational velocity vectors within that uniformity is a concentration within the adsorbent.

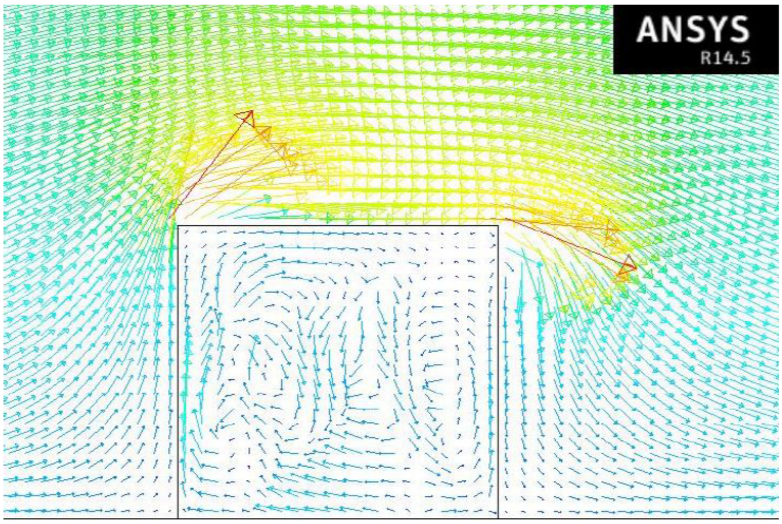

Fig. 2-4. Velocity vectors inside and outside the absorbent

Absorption and concentration variations within the adsorbent

Figure 3-4 has shown the absorption rate of the absorbent. It is observed that the absorption of amounts of absorbent is more from the current chaos, particularly at the rear side of the vortex flow. Changes in the concentration of adsorbent can also be seen in Figure 4-4. As can be seen the concentration around the absorbent is much more than the bulk fluid and the oil absorption is almost completely absorbed.

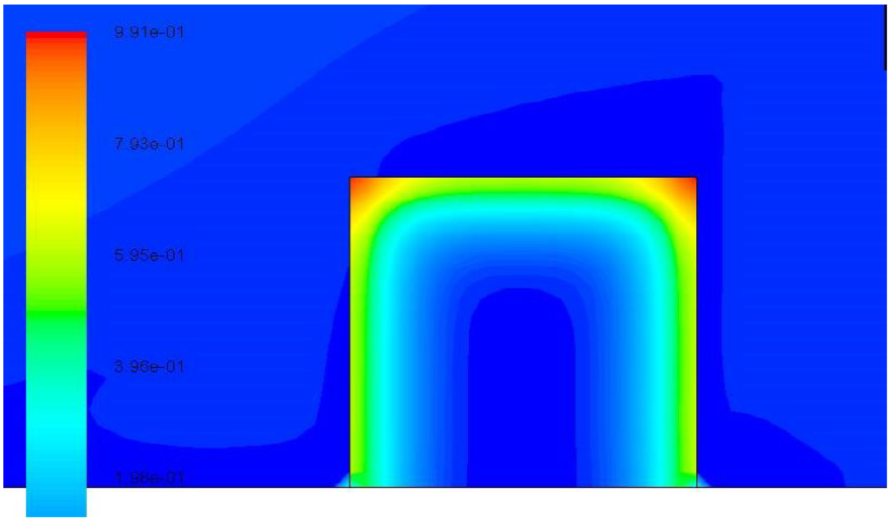

Fig. 3-4. Profile of the oil volume in the adsorbent after 10 seconds

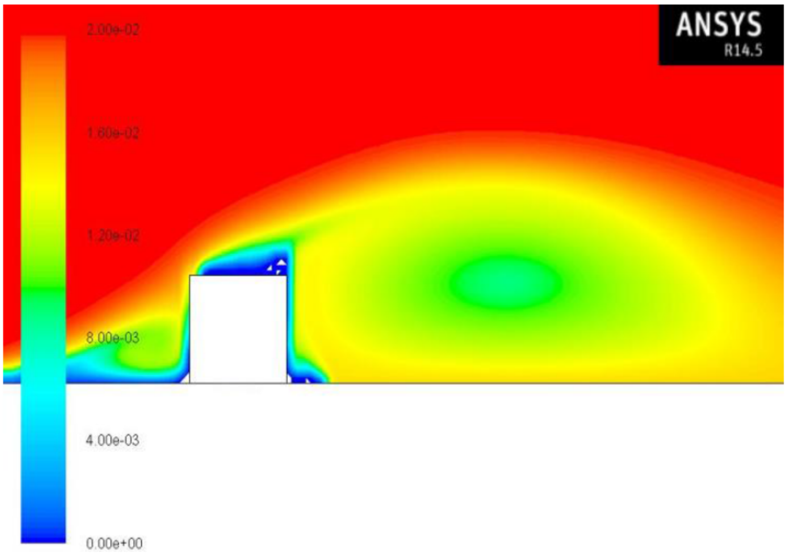

Fig. 4-4. Profile of the oil volume in the adsorbent after 10 seconds

In Figure 5-4 Profiles oil concentration in the liquid film is shown on the axis perpendicular to the adsorbent at three different times. As can be seen, in each of the three times, each part of the liquid film is 1 micron, with different concentrations, which the absorption of the fluid before going to the border, the concentration becomes lower and the zero. It is also clear from the border with advance absorbing the fluid, the viscosity is increased to maximum value. Finally out of the liquid film, the concentration of the mass concentration of the fluid around the solid. At the time, the concentration of the liquid film thickness is less than zero.

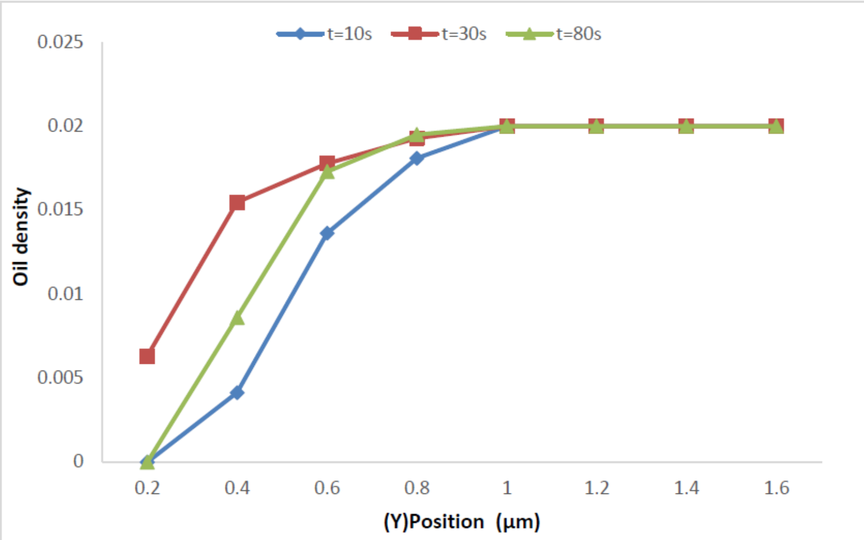

Fig. 5-4. Profiles of oil concentration in the liquid film on the axis perpendicular to the absorbent at three different times

Figure 6-4 shows the profile absorbed, within the adsorbent in the axis perpendicular to the adsorbent at three different times. As can be seen, the greatest concentration of oil absorbed near the surface is absorbent, the amount of the advance to the adsorbent decreases. The difference is that with the time, the amount of oil absorbed from the border is less absorbent, and at the absorbent center will be more.

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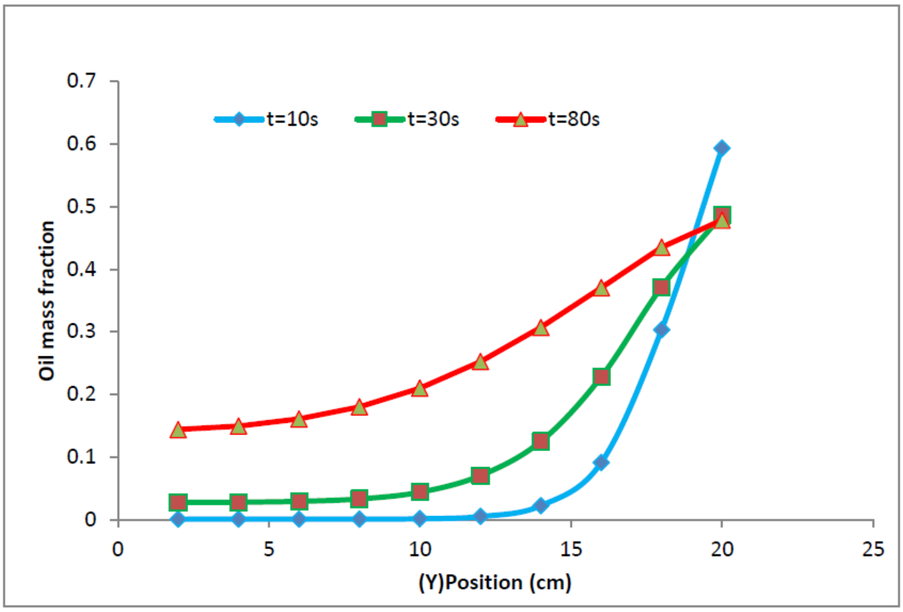


Fig. 6-4. Absorbed profile within the absorbent in the axis perpendicular to the absorbent at three different times

Figure 7-4 shows the profile absorbed into the absorbent with the experimental results in consistent with the time changes. It is observed that the concentration of the oil is absorbed by the experimental results have good accuracy. The maximum difference between experimental and calculated values is equal to 11% of the experimental data shows good accuracy. The results show that the high oil absorption which this absorption is reduced with the passage of time has reached a certain value and tends to an asymptote.

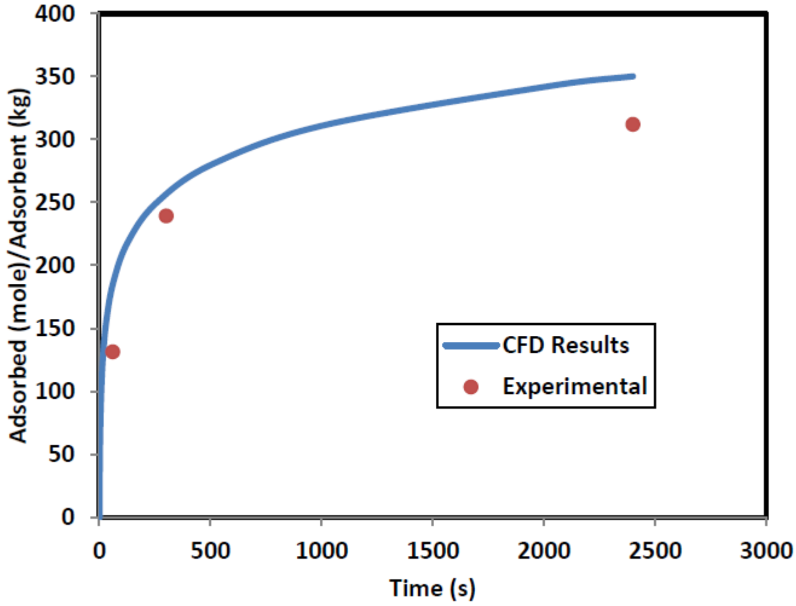
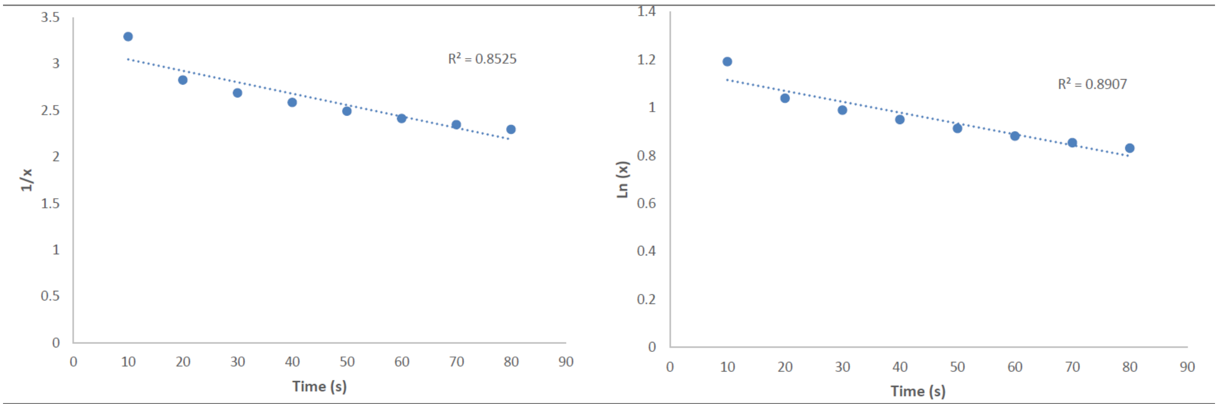


Fig. 7-4. Comparing the amount of oil absorbed in times of simulation with experimental results [35]

Figure 8-4 shows kinetics uptake for absorption cube. Correlation coefficients indicate that the absorption kinetics in a cubic absorbent has more affinity with the first-rate kinetics.



(B) **(A)**

Fig. 8-4 a) kinetics uptake by using primarily oil absorbent and b) kinetics uptake in oil absorbent using the quadratic model

CONCLUSION

In this paper, we tried to provide an appropriate model to simulate the hydrodynamic behavior of the oil spill in the sea. Then, the impact of cubic absorbent on the oil slick was examined. The speed in and out of the absorber, the absorber velocity vector inside and outside, absorption in the absorbent and oil concentration in the liquid film of the parameters was studied in this paper. The results of this earth who primarily kinetics with the kinetics of second grade, more affinity uptake kinetics, but absorbed in the absorbent cubic kinetics does not follow any of these.

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Abbreviation signs

$\bar{k}$ **The middle kinetic energy**

$\overline{\kappa}$ **The swinging kinetic energy**
K turbulent kinetic energy
$\overline{u}$ **The average speed in the x direction**
$\overline{v}$ **The average speed in the y-direction**
$\overline{w}$ **The average speed in the z direction**
$u^{'}$ **Speed oscillating in the x direction**
$v^{'}$ **Speed fluctuation in the y-direction**
$w^{'}$ **Speed oscillating in the z direction**
e_{ij} **Deformation rate**
E_{ij} **The average rate of change**
$e_{ij}^{'}$ **Deformation rate fluctuations**
$V^{'}$ **The relative speed between the oil slick and choppy water level**
$\overline{V}$ **The average relative speed between the oil spill and the water level**
ρ **Density**
μ_t **Viscosity turbulence**
ε^{*} **Depreciation rate per unit mass**
x mass fraction of oil in the absorber
C oil concentration in the adsorbent
k_1 **Sinitic primarily fixed equation**
k_2 **Quadratic equation of fixed Sinitic**
q The mole absorption per unit mass of adsorbent
ε **Porous adsorbent**