Chapter I

Introduction

Transportation of crude oil in the Gulf of Thailand has increased because of the industry development. Crude oil is generally used for electricity production to support industrial development and urbanization. Although Thailand have a number of crude oil sources such as Petch crude oil source at Lankrabu district in Kampangpetch province, crude oil still not enough for all activities. The solution for the lack of crude oil is that Thailand has to import crude oil from other countries.

Crude oil is imported from many sources, such as, Middle Asia, South East Asia, and East Asia to Crong Toey or Laem Chabang Port in the Gulf of Thailand. Thus, there are a lot of tankers in shipping routes. Moreover, in areas near ports or oil refineries in the Upper Gulf, not only crude tankers but also other ships have increased rapidly, so the opportunity of oil spill by ship accident will be larger.

Crude oil in the sea can severely damage the living and non-living marine resources. Organisms will be destroyed by poison and their habitat will be damaged by crude oil covering. For human, if a great amount of crude oil is spilled near important areas such as beaches for tourism or aquacultural area , it will damage scenery and economy of these areas and a whole country. So spilled crude oil will have to be cleaned up and eradicated very rapidly before it spreads widely and destroys environmental resources. Oil spill models, used to predict trajectory at different timeof crude oil after spilling in the sea, is necessary for planning and managing to collect crude oil in the sea.

Generally, there are two factors to be considered for reliable result of prediction of oil slick movement by a model. One is quality of the model and another is the quality of input data used in model. Although there are a number of oil spill models that have been developed and used in Thailand, lacking of available input data such as current system and wind is still a problem. Therefore, to find or synthesize reliable current data, used in oil spill model, is one of several ways to solve this problem.

In this study, the oil spill trajectory model for the South China Sea developed by Hang, Evensen, and Martinsen (1989) that was one of the model that can be categorized as a simplified model, will be tested by using measured wind data, residual and computed tidal current as input. To get the tidal current data, computation by hydrodynamic model is selected. A time-dependent, normal mode hydrodynamic model developed by Banpapong, Reid, and Whitaker (1985) will be revised to fit the computational domain for the Gulf of Thailand. The hydrodynamic model will be tested, and verified by comparing the computed to the recorded current data from oceanographic buoys deployed in the Gulf. Then, available current data from hydrodynamic model will be used to compute oil slick movement, and results will be compared with those in the field experiment.

Objectives

To apply a hydrodynamic model for computing current in the Gulf of Thailand, and the the results of this computing will be used as input in the oil spill trajectory model for more accuracy in prediction of oil spill movement in the Gulf of Thailand.

Scope of Study

1. Hydrodynamic model, used for investigating Hurricane-Induced Forerunner Surge in The Gulf of Mexico, will be applied to compute current in the Gulf of Thailand.

2. The oil spill trajectory model will be tested by using measured wind and computed current from applied hydrodynamic model as input.

The Circulation Models in the Gulf of Thailand.

For a few decades, the circulation in the Gulf of Thailand has been studied. Some researches considered a whole Gulf, but some did only in the Upper Gulf. However, the causes of water motion and methods in computation were different in each study.

Vongvisessomjai, Arbhabhirama, and Fuh (1978) developed hydrodynamic model in the Upper Gulf of Thailand using finite difference technique. The governing momentum equations consisted of Coriolis, pressure gradient, and bottom stress terms. Fresh water flow discharge from the Maeklong, the Tha Chin, the Chao Praya, and the Bang Pakong river were included in computation. Water elevation at open boundary were computed from input which consisted of the tidal harmonic constants at boundary stations at Sattahip and Hua Hin. The result of this study showed that the current in the Upper Gulf of Thailand was under the influences of tide, fresh water discharge from rivers, and wind. As the water discharge into the Gulf was small compared with the value of water in the Gulf, thus the current component contributed by fresh water is small. Wind driven current was also small because the Upper Gulf was located in weak wind zone. Thus, the main instantaneous flow was due to the tidal fluctuation. However, the combined magnitudes of fresh water current and wind driven current were the same order of magnitude as the resultant current which was obtained by summing the instantaneous tidal current for a period of one or several tidal cycle.

Liengcharernsit (1979) developed two-dimensional mathematical model for hydrodynamic circulation in the Upper Gulf of Thailand by using finite element technique. The governing momentum equations included convective-inertia, pressure gradient, atmospheric pressure, Criolis, wind stress, and bottom stress terms. The vertically averaged form of these equations neglecting the variation in water density were used. Fresh water discharge from four major rivers and water elevation at open boundary were included in hydrodynamic computation. At the ocean boundary, water elevation was a straight line jointing between Hua Hin and Sattahip. For the river boundary, values of flow velocities were computed from the average river discharge. The result of this study showed that the maximum flow velocity was about 0.50 m/s at nodal points on the ocean boundary during the most flood and ebb periods. The values gradaully decreased to about 0.20 m/s near the northern coast of the Upper Gulf due to bottom friction. The highest water level elevation was in northern coast about 1.45 m. above the mean water level, while the lowest value was about 0.60 m. below the mean level. The author concluded from this result that the dominant currents and tides in the Upper Gulf have a period of one day, i.e. diurnal components are predominant.

Nelasri (1981) developed three-dimensional hydrodynamic model applied to the Gulf of Thailand which was modeled as a rectangular semi-enclosed basin of constant depth with a uniform wind blowing over the region. The computational grid area didn't include the Upper Gulf because the author considered a whole Gulf as a simple rectangular basin. The momentum governing equations consisted of Coriolis, pressure gradient, and wind stress term. The mass-transport stream function and water elevation were computed numerically using a finite difference scheme. The author concluded that the flows in the Upper half of the Gulf were directly influenced by the density gradient and wind stress. The density forcing became an important effect in the case of a uniform wind field.

Sojisuporn (1984) developed a computer simulation three-dimensional model of wind driven current applied to the Upper Gulf of Thailand. The model is based on the assumption that the current was produced by wind stress, slope of water surface, and Coriolis effects. Explicit method of finite difference technique was used in computation. At open boundary, the velocity that perpendicular to boundary was setted as zero. The real depth was used in this study. The result showed that there was no horizontal circulation in the Upper Gulf of Thailand. The author discussed that, because of the problem of lacking of viscosity constant (μ) used in surface wind stress term (assumed data was used), thus the results of computation could not be compared with the measured data.

Sripanyawitchya (1988) developed a three-dimensional computer model of wind driven circulation in the gulf of Thailand by using explicit method in finite difference technique. The effects of wind and water discharge from major rivers were included, but not for tidal effect. The result showed that the circulation was in the form of vertical circulation of surface and bottom water mass. During the southwest monsoon, the surface current follows the wind direction into the Gulf, while during the northeast monsoon, the surface current flow out of the Gulf.

Charuskumchornkul (1988) developed a depth-average two-dimensional model of oceanographycal circulation by using Alternating Direction Implicit (ADI) finite difference technique. The model was applied to Upper Gulf of Thailand, the Chao Praya river mouth, and Learm Chabang Port. For model of the Upper Gulf, discharge from the Maeklong, the Tha Chin, the Chao Phraya, and the Bang Pakong river were included in computation. At the open boundary, in case of the Upper Gulf, water surface elevation used in model was computed from harmonic analysis of tide at Sattahip and Hua Hin, but in the case of the Chao Praya river mouth and Laem Chabang Port, velocity at the corresponding grid points computed from the first case were used as condition at open boundary. The calibration of model to the current system was performed and showed the satisfactory comparison between the computed values and theoretical values of tide level obtained by harmonic analysis. The computed velocities were verified to the measured current data of Hydrographic Department, presenting good result. The conclusion was that both ebbing and flooding currents in the Upper Gulf were found to be affected strongly by the contribution of river flow effects as well as the restriction of coastline configuration by the shoreline boundary, where the contribution of topographic features and the bottom friction effects were found to be smaller.

Chokechalermwat (1990) developed a depth-average two dimensional finite element model to analyse the tidal current pattern in the Upper Gulf of Thailand. The analysis was considered the monthly current and water fluctuation basis under the consideration of tide, wind and river discharges. As the result of the study, the main harmonic constituents of tide in the Gulf were M2, S2, O1, and K1. The currents in the Gulf flew mainly in the north-south direction except at the edge of the gulf where the flow direction trends to be perpendicular to shoreline with small elliptical circulation. The maximum and averaged velocities in the Gulf were in the order of 0.2-0.8 m/s and 0.06-0.23 m/s respectively. The minimum velocity area was found to be at the south of Bangkok Bar and the maximum velocity area is at the mouth of the Gulf near Sattahip.

Azamy, Isoda and Yanaki (1991) developed two-dimensional hydrodynamic model to investigate the effect of wind on day-to-day and monthly mean sea level variations over the South China Sea including the Gulf of Thailand area. The observed wind data at 130 kilometers offshore Kuala Terengganu and one in the Malacca Strait was used as the main force for computation. The homogenous wind field was divided into two areas, on the western and eastern of Joha Baru. However, the water elevation along the open boundary was set as zero. The results showed both sea level variation and ocean current vector field in the same charts separately for each case. Daily mean sea level variation result agreed to the observed data, while monthly mean sea level variation didn't show good comparison. The authors mentioned that the causing of unsatisfactory result could be due to the open boundary condition. The monthly mean current field showed that there was a counter-clockwise gyre in the central Gulf of Thailand during northeastern monsoon, while a clockwise gyre occurred during southwestern monsoon. The Monsoon winds were the main driving force affecting the sea level variation around West Malaysia was the conclusion of this study.

Archevarahuprok and Wongwises (1994) investigated the monthly mean sea current and sea level elevation in the Gulf of Thailand by using two-dimensional numerical model. The model used the energy conserving time-space finite difference scheme and adopted the splitting method as a technique for computation, and the monthly mean climatological wind was used as input. The monthly mean vector fields of ocean current and simulated sea surface elevation for every month were both presented in the study. The resulted showed that the permanent coastal current was anticyclonic (clockwise) circulation along coastline in summer (May to September), and there was cyclonic (counter-clockwise) circulation with small mesoscale circulation nearby the seashore of the southwestern coast of Thailand in winter (October to April). One of the conclusions from this study was that the seasonal variation of sea current and sea level elevations were influenced by the atmospheric circulation and the coastline boundary.

Sojisuporn (1994) again used a three-dimension hydrodynamic model to study the characteristic of density-driven and wind driven current in the upper Gulf of Thailand. This study was very interesting because the author try to simulate the circulation in the upper Gulf by using the available salinity and temperature data taken from Hydrographic Department, and Royal Thai Navy during March 1993. The homogeneous northeast wind with speed of 5 m/s was used in this circulation model, while tidal forcing was neglected. The governing equations of tree-dimensional model included the momentum equations, the continuity equation, and the conservation of temperature and salinity equations. The momentum equations retained the temporal changes, field accelerations, Coriolis effects, pressure gradient terms, and horizontal and eddy viscosity terms. In this study, the vector field results of the density current and wind-driven current were compared. In the density current results, the water at surface layer flowed southward and westward, while the flow in wind-driven results were stronger and directed more westward due to the Coriolis effect. The flow distribution in the middle layer showed a small clockwise eddy in the upper right and counter-clockwise in the upper region. However, in both models, the flow fields in the bottom layer direct northward to replenish the outflow into the surface layer.

Snidvongs and Sojisuporn (1997) used three-dimensional hydrodynamic model to investigate the net circulation in the Gulf of Thailand under different monsoon regimes. The governing equations were the same as those in the study of Sojisuporn (1994). The net circulation in three layer, 0-10 m, 10-40 m, and >40m, were simulated using tri-monthly averaged of observed temperature, salinity, depth, and wind. The sources of temperature and salinity data were come from SEAFDEC, NODC, and JODC. The constants of homogenous wind were used in computation divided for four tri-month periods. The values of wind velocity were 5(NE), 2(NE), 5(SW), and 5(SW) in m/s for Dec-Feb, Mar-May, Jun-Aug, and Sep-Nov respectively. The results showed that the water in the upper 10 m flew from the South China Sea during the northeast monsoon, and opposite during the southwest monsoon. The water near surface layer in all simulation was replenished mainly by the opposite flow in the mid-depth layer and slightly from the deep water below 40 m.