MATHEMATICAL MODEL

(Case Study Of Steam Power Plant/Pltu Karimun Planning)

by:

Mubarak[1)],**Puji Harsanto**[2)]and **Musrifin Galib**[1)]

[1)]Lecturer of Marine Science Department University of Riau [2)]Lecturer of Wijayakusuma University Purwokerto

Abstract

In this study the applicability of the hydrodynamics two-dimensional depth-averaged models is investigated. The simulations consists of two-dimensional, vertically averaged finite element hydrodynamics (RMA2), pollutant transport/water quality (RMA4). A constant and same value of Manning's coefficient is specified throughout the whole domain for all models. Channel outlet PLTU dimension is 510 m in distance from coastal, and 5 m in width, which bed elevation -1 m and the discharge release 1.566 m^3/s. Temperature of PLTU outlet is 34 °C and water temperature of coastal area is around 27 °C. The results from simulation describe that water temperature propagation produces the rising temperature at the area conservation, 0.89 °C at north side and 0.90 °C at South side of channel.

Key words: two-dimensional depth-averaged, pollutantconcentrate distribution

1. INTRODUCTION

Development of mathematical models to study the impact of human activities on land and at sea quite rapidly, one of which is a study of the waste stream and salinity were carried out in R'ıo de la Plata (Fossati and I. Piedra-Cueva, 2008).

In the planning of coastal structures for disposal of waste heat in coastal areas or coastal planning requires attention to the environmental impacts that may occur. Disposal of the lack of proper distribution of heat will cause environmental damage to water, such as the destruction of coral reefs and other marine biota. Thus, in planning and building waste heat must consider heat distribution possible. Heat distribution is such that the distribution of the resulting heat is not on the beach or a protected area does not damage the environment as a whole.

The distribution of the resulting heat will be affected by the process of diffusion and dispersion of ocean currents. Prediction of the heat distribution can be done with a mathematical model has been developed. In this study the heat distribution will be analyzed with a two-dimensional mathematical model of average depth.

2. METHODOLOGY

2.1 Equation Model

Hydrodynamics simulations of flow and heat distribution using the model RMA2 and RMA4. Hydrodynamic model is a model with two-dimensional finite element method with a mean horizontal depth. With these numerical models can predict flow patterns, water surface elevation and horizontal velocity components in both permanent flow conditions (steady flow) and no permanent flow (unsteady flow) as well as the distribution of the resulting heat.

To simulate the flow hydrodynamics simulations of sediment needed first. The simulation results are used as an input stream to simulate heat distribution. Simulation scheme can be presented in a flow chart as shown in Figure 1.

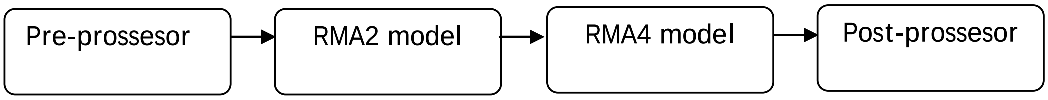


Figure 1. Schematic overall simulation

RMA two mathematical models are used to predict the hydrodynamic flow is based on two basic equations, the equation of mass conservation (continuity equation) and momentum equations, as presented below:

$$\frac{\partial h}{\partial t}+h\left(\frac{\partial u}{\partial x}+\frac{\partial u}{\partial x}\right)+u\frac{\partial u}{\partial x}+v\frac{\partial v}{\partial y}=0 \qquad (1)$$

Momentum equation for two-dimensional flow in the direction of x and y can be written in the form of the following equation:

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+g\left(\frac{\partial h}{\partial x}+\frac{\partial a_o}{\partial x}\right)-\frac{\varepsilon_{xx}}{\rho}\frac{\partial^2 u}{\partial x^2}-\frac{\varepsilon_{xy}}{\rho}\frac{\partial^2 u}{\partial y^2}+\frac{gu}{C^2 h}\sqrt{u^2+v^2}=0 \qquad (2)$$

$$\frac{\partial u}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+g\left(\frac{\partial h}{\partial y}+\frac{\partial a_o}{\partial y}\right)-\frac{\varepsilon_{xx}}{\rho}\frac{\partial^2 v}{\partial x^2}-\frac{\varepsilon_{yy}}{\rho}\frac{\partial^2 v}{\partial y^2}+\frac{gv}{C^2 h}\sqrt{u^2+v^2}=0 \qquad (3)$$

where:

u = horizontal velocity x-direction flow,
v = horizontal velocity y-direction,
t = function of time,
g = acceleration due to gravity,
h = water depth,
a_o = elevation of the base profile,
ρ = density,
ε_{xx} = turbulence exchange coefficient normal direction-x,
ε_{xy} = turbulence exchange coefficient tangential direction-x,
ε_{yx} = turbulence exchange coefficient tangential direction-y,
ε_{yy} = turbulence exchange coefficientnormal direction -y
C = Chezy roughness coefficient (or koef. Manning, n = 1 / C h1 / 6)

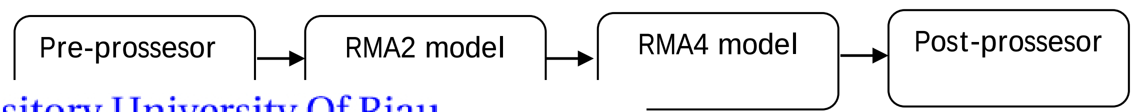
Formula of the model is two-dimensional system with an average depth where the concentration is assumed uniform vertical direction. RMA4 basic equation that expressed the two-dimensional transport equation is as follow:

$$\left(\frac{\partial c}{\partial t}+u\frac{\partial c}{\partial x}+v\frac{\partial c}{\partial y}\right)=\left(\frac{\partial}{\partial x}D_x\frac{\partial c}{\partial x}+\frac{\partial}{\partial y}D_y\frac{\partial c}{\partial y}+\sigma\right) \qquad (4)$$

where c is the concentration of water quality; t is time; u and v is the velocity in the direction of x and y; D_x and D_y are the model dispersion coefficients in direction x and y; x and y, respectively; D_x and D_y are the model dispersion coefficients in the direction of x and y, and σ is the source sink.

2.2 Data Model

Some basic data is needed in the study of bathymetric data and tides on locations to explore. Bathymetry data are data on the depth of the sea around the work site. Bathymetric



data can include primary data and secondary data. In this study bathymetric data used are primary data. Tidal data used in the model is the data simulated tidal strait of Malacca as a whole. The ups and downs that occur around the Cape Sebatak used as data models tidal. Tidal observations as shown in Figure 2.

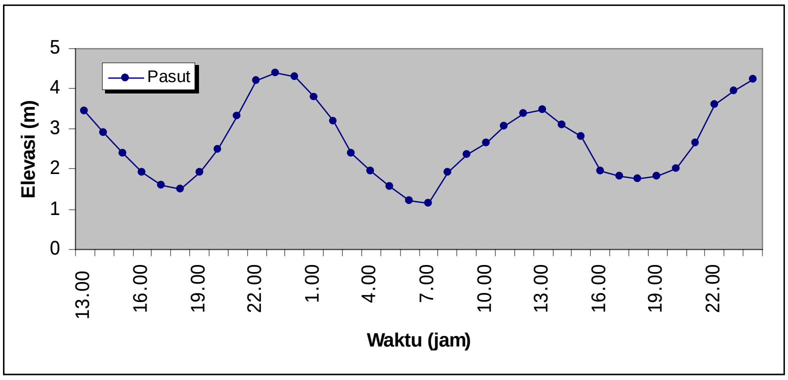


Figure 2. The ups and downs in the Cape Sebatak for 36 hours

The first step in the simulation is the determination of the domain model, i.e. waters planned waste heat, which will be simulated flow patterns. Domain model is a limit of the area to be modeled and used as model input placement and boundary conditions. Domain boundary is the sea and coastline borders the land. Domain boundary is larger than the area to be analyzed. This is to avoid boundary effects that occur in a matter of numerical hydrodynamic flow. Domain models are represented in the element mesh (mesh) discrete. Study area as shown in Figure 3.

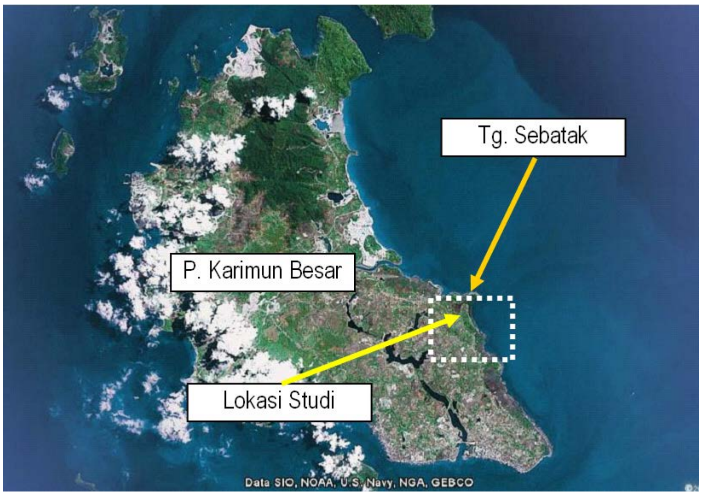


Figure 3. Study area

2.3 Model Parameters

Model parameters are hydraulic parameters, consisting of basic roughness coefficient (Manning coefficient, n), viscosity turbulence (eddy viscosity, diffusion coefficient, ϵ) stream. As an initial basis determining the manning roughness using secondary data (the result of previous studies) or based on existing regulations. Value of the model parameters are highly dependent on the nature of the flow. Range of values for n and ϵ recommended for different types of flow are presented in Table 1 and Table 2.

Table 1. Range manning coefficient, *n*

Flow	Manning coefficient, n

Shallow river without a hitch	0.025 – 0.035
Deep river	0.018 – 0.025
Shallow estuary without plants	0.020 – 0.030
Deep estuary	0.015 – 0.025
Dense vegetation in damp soil	0.050 – 0.100

Sources: BOSS SMS User's Manual, 2003

Table 2. Diffusion coefficient range of flow, ϵ

Flow	N.d/m2
Steady flow through the shallow river	240 – 1,200
Rapid flow through the shallow river	1,200 – 2,400
Deep estuary	2,400 – 4,800
Shallow estuary	9,500 – 14,400
Wet soil with the tides	4,800 – 9,500
The flow around the building	50 - 240

Sources: BOSS SMS User's Manual, 2003

3. RESULTS AND DISCUSSION

3.1 Simulation Scenario

Module apply to the case of power plant construction plan Krimun. Plan for power plant located in the southern headland Karimun sebatak. For the purpose of cooling the plant is planned taking water from the ocean through the open channel. While the waste heat from the power plant water flowed into the sea with an open channel or closed to the sea at a distance ranging from 510 m discharge end of the shoreline. Wastewater temperature data is estimated at around 34 °C, whereas the sea water temperature ranges from 27 °C. Hot effluent discharge is 0.778 m3. For the purposes of development or security, (e.g. cooling water discharge is increased) then the effluent discharge simulation used twice so used 1,556 m^3 effluent discharge. Scenario simulations in this work are as follows:

- simulated conditions of the plan with west monsoon
- simulated conditions of the plan with the east wind

Element mesh around the outlet of waste heat disposal plan as presented in Figure 4. While Figure 5 is the result of tidal calibration surrounding heat waste disposal plan.

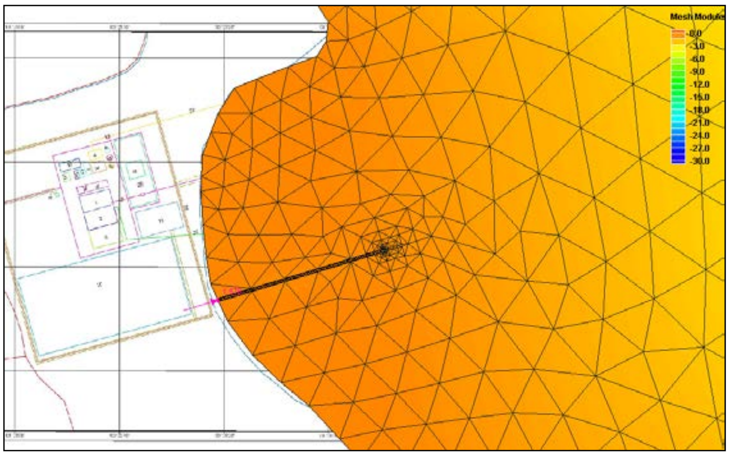


Figure 4. Detail element mesh for the plan condition outlet (with duct exhaust waste heat) around the power plant plan

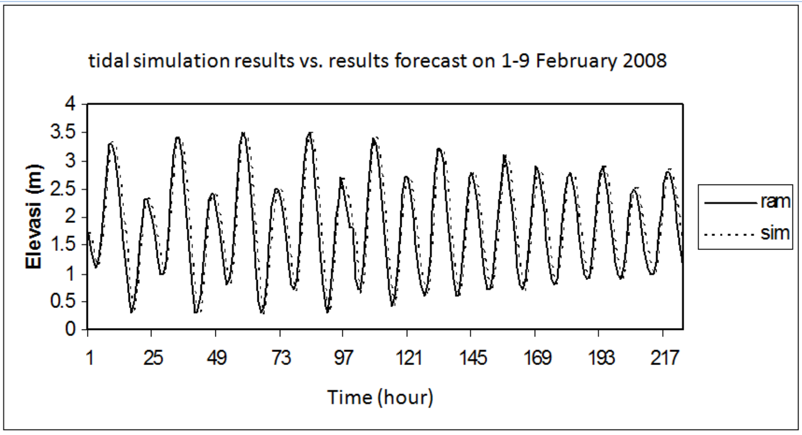


Figure 5 Results tidal calibration

3.2 Heat Distribution

To determine the gradation heat distribution from the mouth to the coastal reef made cut lines that follow the direction of the heat distribution pattern as shown in Figure 6 to the east, while to the west gradation graph heat distribution is presented in Figure 7. From the figure it can be seen that there is a significant decrease from the mouth of the outlet up to a distance of about 100 m. Changes in the heat of the outlet until the end of the reef is about 6.1 °C. Seawater temperature in the boundary of protected areas increased from 27 °C to 27.9 °C.

As in the east, in the west also made changes in heat trace gradation of mouth outlet to protected area boundaries. The results of the trace gradations indicate that protected areas south of the discharge channel in the west is an area which is affected by the distribution of waste heat. Graph gradation heat distribution is presented in Figure 9. The temperature difference between the outlet temperature in the range from 6 to 11 °C protected areas. Seawater temperature in the boundary of protected areas rose Dair 27 °C to 27.89 °C. By seeing that the temperature increase in the area of protected areas ranged 0.89 °C the dimension is secure.

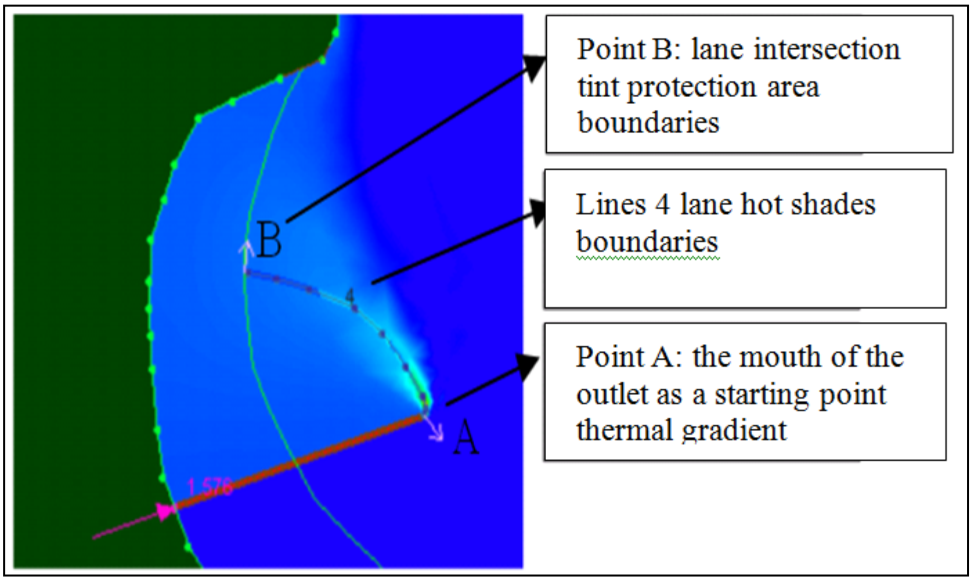


Figure 6. Line gradation lines cut heat distribution while the east

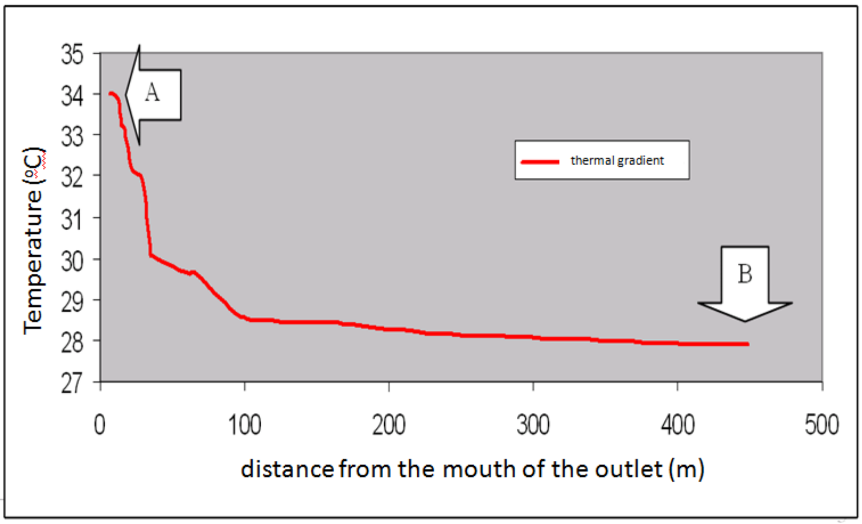


Figure 7. Gradient distribution of heat from the mouth of the outlet until the end of the reef (the east)

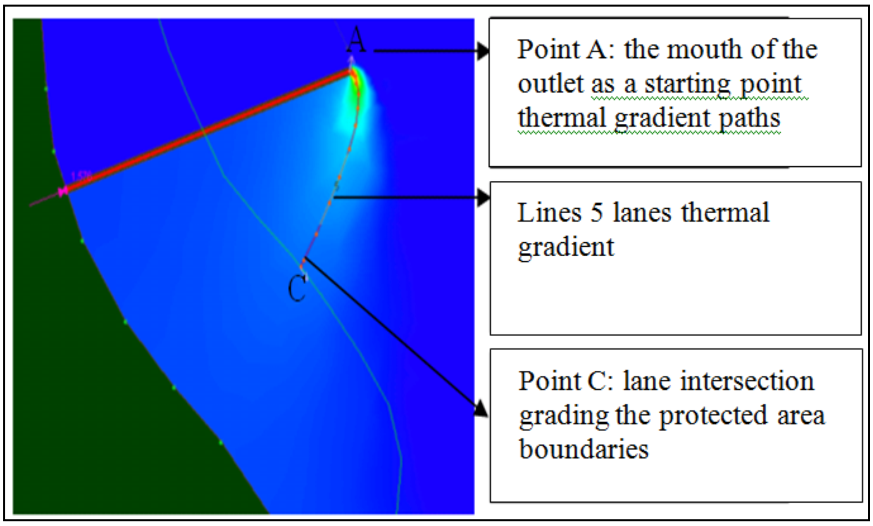


Figure 8. Line gradation lines cut heat distribution while the west

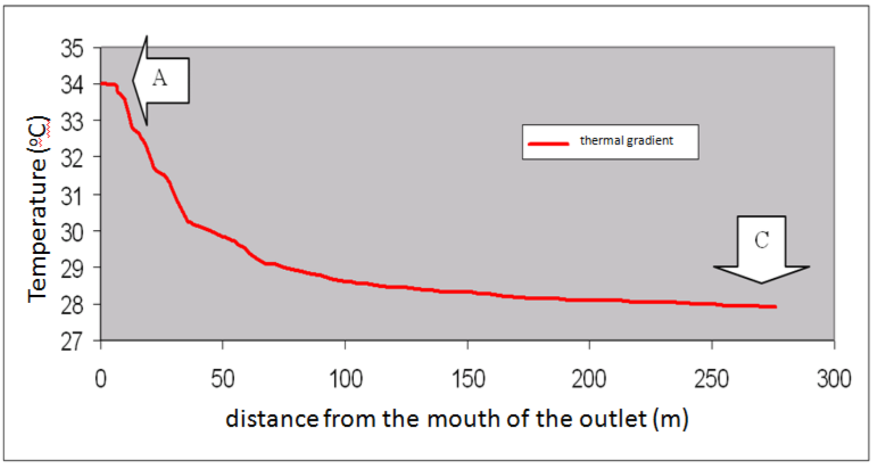


Figure 9. Gradation heat distribution from the mouth of the outlet until the end of the reef (the west)distance from the mouth of the outlet

4. CONCLUSION

From the results, the mathematical model simulations obtained some conclusions as follows:

• The condition of the simulation is as follows: sewage heat in the form of an open channel with a length of 510 m, width 5 m and a depth of -1 and heat discharge 1,566 m^3. Temperature waste heat temperature of 34 °C and 27 °C seawater.

• Distribution of heat in the west and the east have an impact on the increase in protected areas.

• Temperature changes the area of protected areas in the north channel of waste heat of 0.89 °C. While in the south channel heat waste by 0.9 °C.

• The use of mathematical models are useful in predicting the distribution of heat in coastal areas.

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