COMPARATIVE ANALYSIS OF HEATED WATER DISPERSION IN STILLWATER BODY USING SOFTWARE CORMIX 1, PHOENICS AND PLUMAC2.2

ANTONIO CARLOS DA FONSECA BRAGANÇA PINHEIRO
Professor of the School of Engineering - Mackenzie University

Rua Itambé n. 45, Prédio 6 – Higienópolis – São Paulo
CEP: 01239-902 – SP – Brazil
Tel.: 55 11 236-8552 - fax.: 55 11 236-8553 - e.mail.: antonio.dee@mackenzie.br

JAYME PINTO ORTIZ
Professor of Polytechnic School - University of São Paulo

Rua Prof. Mello Moraes n. 2231 - USP - São Paulo
CEP:05508-900 - SP - Brazil
Tel.: 55 11 818-5335 - fax.: 55 11 813-1886 - e.mail.: jportiz@usp.br
Invited Professor of Mackenzie University
and Mauá Institute of Technology

ABSTRACT

The man in the current stage of technological development has been improving the prognostic methods that facilitate the analysis of environmental impact assessment using new techniques of applying numerical and physical modelling. This work compares the use of some expert systems to give the prognostic of temperature profiles when warm water effluents are released in stillwater reservoirs through single port submerged horizontal conduits. The results are presented through some non-dimensional graphics obtained by using CORMIX 1 and PLUMAC 2.2 expert systems and software PHOENICS.

Keywords: Environment, Dispersion, Warm Effluents, Cormix, Software, Expert Systems

INTRODUCTION

The release of warm effluents can cause damages to the environment. The aquatic fauna usually do not support temperature variations in its habitat. Water temperature variations above 3 ºC can affect the metabolisms of certain species, even causing the death of these species. When warm water need to be released in stillwater, we should have effective mechanisms that can predict the field of temperatures in the water environment. The prognostic of the temperature field can be made through physical models simulation, that are more expensive, or through the use of numeric modelling. The main difficulties in using these models are related with the correct simulation of the existing boundary conditions [8],[9] and [10].

SOURCES OF WARM EFFLUENTS

The main sources of warm effluents arise from cooling systems that operate in open systems. We can have those effluents in several industries, but the main source is originated from Thermal Plants Cooling Systems. Thermals Plants temperature effluents commonly are about 10 to 15 ºC over environmental water reservoir. Then we should foresee the dimensions of the cooling pond, where, the temperature of the effluent should not surpass those specified by the environmental legislation.

MATHEMATICAL MODELS

The existing mathematical models have an intrinsic complexity for the resolution of all the equations related with the involved phenomena. In this work we will make a comparison of the results obtained among some software: CORMIX 1, Plumac2.2 and Phoenics [7].

EXPERT SYSTEMS

Are inherent to the expert systems development a series of considerations that drive to simplifications of the conservation equations and involved transport equations. In the other side, are there general software that give solutions which are closer to the prototype reality and the real boundaries, but that consume longer computer timing processing of information requesting the use of supercomputers or, at least, workstation. In most of the practical cases it is possible to obtain reliable results using methods that simplified the mathematical equations, and whose answers are enough for the determination of the main involved parameters. [1].

CORMIX 1 EXPERT SYSTEM

This expert system, developed by Environmental Protection Agency of United States - EPA/USA, nowadays, is accepted internationally as a good tool to provide information in the prognostic of water field temperature, when warm effluents are released in the water bodies. This program uses the integral method in its development [4], [5] and [6].

PLUMAC 2.2 EXPERT SYSTEM

This expert system was developed by the author, using integral technique and using experimental parameters as the entrainment, a = 0.082, and the relationship of lateral spread among the profiles of speed and of specific mass, l = 1.16 [1],[2],[4].

PHOENICS

Phoenics is a software distributed by CHAM Limited - England. An academic version of turbulent model was used, and the option was for the application of $k-e$ turbulent model [3].

MAIN INVOLVED PARAMETERS

The main involved parameters used to study the dispersion process of warm water released in stillwater reservoir are the effluent inflow conditions [diameter of the conduit (D), discharge (Q0), temperature (T0)] and the conditions of the receiving body [temperature of the water body (Ta), submerged level]. The main non-dimensional parameter involved is the densimetric Froude Number:

$$Fdo = \frac{U_0^{\ 2}}{\sqrt{\frac{\Delta r}{r} g\ D}}$$

Where:

U0 ....effluent discharge velocity
D ....diameter of the conduit
g.......................acceleration of the gravity
r_0....................density of the effluent in the discharge
$\Delta r = ra - r_0$ ....density variation between the density environment and the density of the effluent

EXPERIMENTAL ANALYSIS

The comparison among the use of expert systems is showed through the comparative graphics presented in this paper for densimetric Froude Number equal to 6, 11 and 20. In the case of the Phoenics application a spaced mesh of 0.10 m was adopted simulating an experimental tank with 2.0m x 2.0m of area with 1.50m of depth. The data time processing was sensibly larger when Phoenics is used.

The non-dimensional comparative graphics presented, show the path of the thermal plume axis [x/D x y/D], the temperature concentration through the thermal plume axis [x/D x Concentration = T - Ta] and the thermal dispersion through the thermal plume axis [y/D x Dispersion = (To–Ta) / (T–Ta)].

CONCLUSIONS

Figures 1, 2 and 3 show that graphics (x/D x y/D) results obtained by using CORMIX 1 and PLUMAC 2.2 expert systems are close in terms of the thermal plume path. However the Phoenics application shows a greater dispersion of graphic points.

Figures 4, 5 and 6 show that graphics (x/D x Concentration) results have a reasonable convergence between the curves of CORMIX 1 and Plumac2.2, as well as a better adjustment for the curve of Phoenics, compared with the previous graphics.

Figures 7,8 and 9 show that graphics (y/D x Dispersion) results compared well for the application of CORMIX 1 and PLUMAC 2.2, but there is a great dispersion when the PHOENICS is used. This dispersion is probably related with the fact of, when using PHOENICS, it is simulating a larger time, for which exists a radiation process and convection, not simulated when it is used the expert systems. Some researches are being doing in experimental facilities, in the sense of allowing a better conclusion on the subject.

REFERENCES

[1] Adams, E.E.; Harleman, D.R.F.; Jirka, C.H. et. al: Heat Disposal in the Water Environment. Cambridge, Massachusetts: Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, Massachusetts Institute of Technology. (1981).

[2] Anwar, H. O.- Behavior of Buoyant Jet in Calm Fluid Journal of the Hydraulics Division. Proceedings of the American Society of Civil Engineers, July, 1969, pp. 1289-1303.

[3] CHAM Report TR200 – PHOENICS Reference Manual –CHAM Concentration, Heat & Momentum Limited, London, May 1989. 305p.

[4] Doneker, R.L.; Jirka, G.H.: Expert Systems for Mixing-Zone Analysis and Design of Pollutant Discharges. Journal of Water Resources Planning and Management, Vol. 117, No.6. November/December 1991. pp. 679-697.

[5] United States Environmental Protection Agency (Ed.): EPA-Users Manual for CORMIX 2.10. Athens, Georgia: October 1993. 80p.

[6] Jirka, G.H.; Doneker, R.L.: Hydrodynamic Classification of Submerged Single-Port Discharges. Journal of Hydraulic Engineering, Vol. 117, No.9. September, 1991. pp. 1095-1112.

[7] Orlob, G.T.: Mathematical Modeling of Water Quality: Streams, Lakes, and Reservoirs. New York: John Wiley & Sons. (1980). pp. 227-335.

[8] Ortiz, J. P.; Pinheiro, A.C. da F.B.: Horizontal Water Buoyant Jet Discharge in Stagnant Water Reservoir. International Symposium held at The University of Porto, Porto, 1996, Paper 22.

[9] Pinheiro, A.C.F.B.: The State of the Art of Physical Modeling of Jets and Thermal Plumes in Lakes and Great Reservoirs. Master Dissertation. São Paulo: Polytechnic School of Engineering of the University of São Paulo. (1993). 168p.

[10] United States Environmental Agency (Ed.): The Lake and Reservoir Restoration Guidance Manual. First Edition, EPA 44015-88-002. February 1988. 200p.

FIGURES

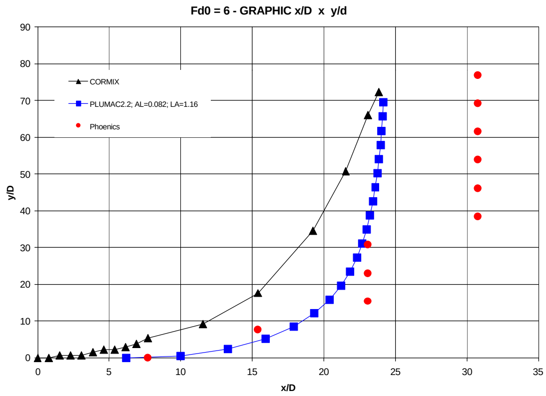

Figure 1 – Fdo = 6 – Graphic
[x/D x y/D]

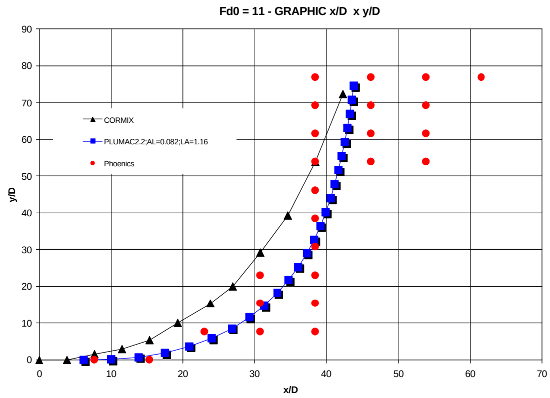

Figure 2 – Fdo = 11 – Graphic
[x/D x y/D]

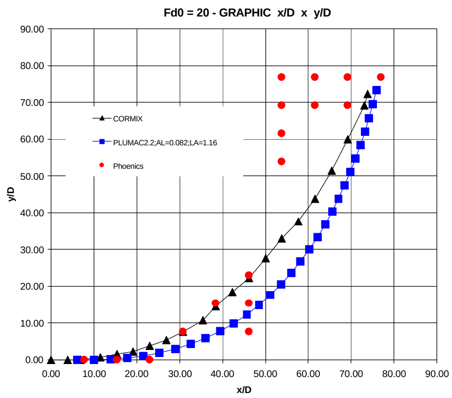

Figure 3 – Fdo = 20 – Graphic
[x/D x y/D]

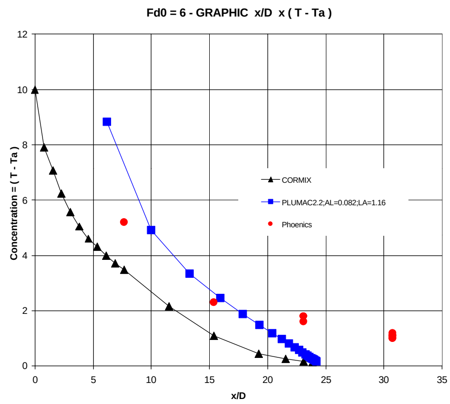

Figure 4 – Fdo = 6 – Graphic
[x/D x Concentration(T–Ta)]

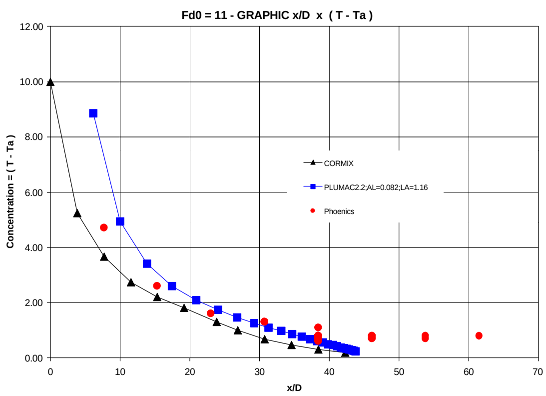

Figure 5 – Fdo = 11 – Graphic
[x/D x Concentration (T – Ta)]

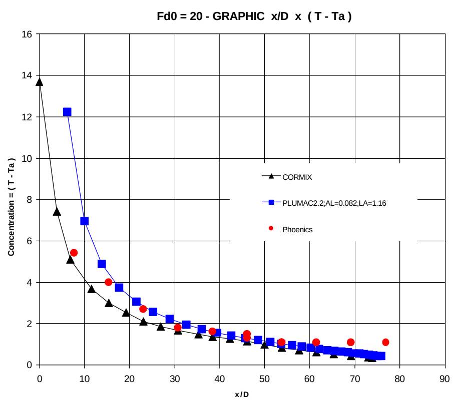

Figure 6 – Fdo = 20 - Graphic
[x/D x Concentration (T – Ta)]

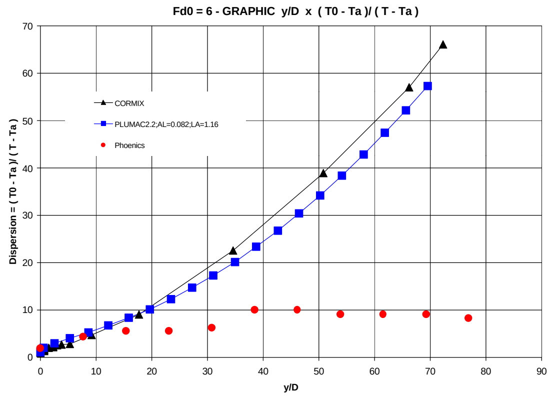

Figure 7 – Fdo = 6 - Graphic [x/D x Dispersion (T0 – Ta)/(T – Ta)]

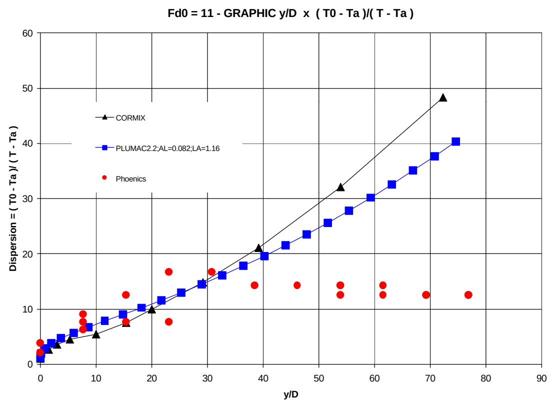

Figure 8 – Fdo = 11 - Graphic [x/D x Dispersion (T0 – Ta)/(T – Ta)]

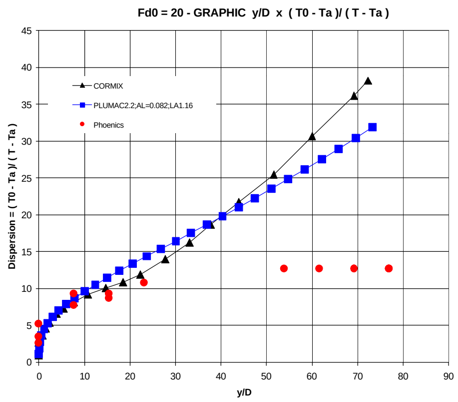

Figure 9 – Fdo = 20 - Graphic [x/D x Dispersion (T0 – Ta)/(T – Ta)]