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An Advanced Numerical Solution for the Hydraulic Cooling Systems in Power Plants

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A THESIS

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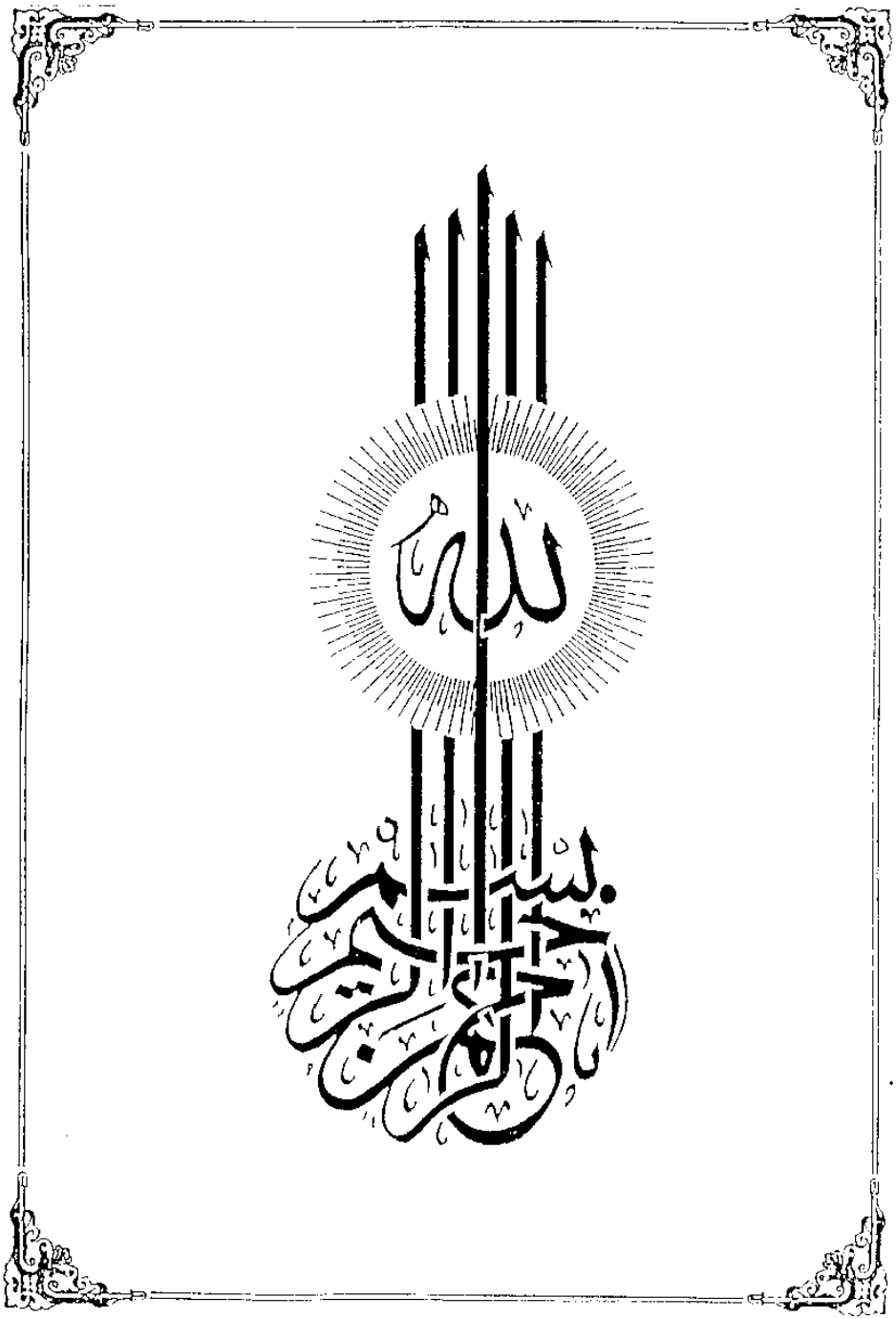

Abstract

This work aims to achieve better understanding of the heat exchange phenomena in water courses. This phenomena is increasing now a days as a result of the growing demand on thermal power plants. These plants take water from the open channels to use it in their cooling systems, then the hot water is returned to the open channels which results in heat pollution. The Ministry of Public Works & Water Resources has set the specifications which should be met when disposing hot water in the Nile River or in the open channels. Law No. 48-year 1982 presents the details of these specifications.

This M.Sc. studied the different parts of this phenomena. In the third chapter, a one-dimensional hydrodynamic model was built to study the unsteady flow in open channels. The theory as well as the detailed description of the model is given in this chapter.

In the fourth chapter, the heat-exchange between hot water and the environment was elaborated. The theoretical approach for this phenomena includes the following five points:

1- The short wave solar radiation.
2- The long wave solar radiation.
3- The long wave radiation from the water surface.
4- The evaporative heat flux.
5- The conduction heat flux.

A detailed literature review was carried out to achieve the best equations that describes these terms.
These equations were implemented in the partial equations that presents the heat balance between hot water and the environment. This partial differential equation forms the base of the heat exchange numerical model.

The fifth chapter gives a description of Expert Systems. These systems present a new application of computer science, where the human experience can be encapsulated in a numerical form, which can be used by others. The produced tool has the advantage of being user friendly as it has a graphical interface to deal with the user. The produced tool is the result of joining the produced three numerical models under the shell of the Expert Systems.

Two case studies were carried out to acquire the needed experience. In the sixth chapter, North Cairo and Damietta power plants were studied. The produced tool together with the physical scale models were used to carry out these studies.
The results of these studies are compatible with the measurements that were obtained during the hydrographic survey, which ensures the accuracy of the study.

One of the results of this study is that the numerical and physical scale models should be integrated to achieve an overall and sound solution of the heat exchange problem in open channels.

Thanks God for the completion of this work

Vita

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Statement

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Civil Engineering.

The work in this thesis was carried out by the author in the Hydraulics Research Institute from Jan. 1992 until Oct. 1994.

No part of this work has been submitted for a degree or qualification at any other university or institute.

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As my first M.Sc was dedicated to my family, this study is also dedicated to them.

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The following symbols are used inthis thesis:

A	is the cross sectional area.
B	is the channel top width.
b_s	is the storage width.
C_p	is the water specific heat.
C	is the Chezy resistance coefficient.
D	is the Diffusion coefficient.
E	is the mass flux (mass/area/time).
e_s	is the saturated vapor pressure at 2 m height.
e_2	is the vapor pressure at 2 m height.
$f(W_z)$	is the wind speed function for mass flux.
g	is the gravitational acceleration.
H_{an}	is the long wave net atmospheric radiation.
H_{bl}	is the long wave radiation from water surface.
H_{con}	is the heat lost by conduction.
H_{eva}	is the heat lost due to evaporation.
H_{sn}	is the short wave net solar radiation.
H_{tot}	is the total heat flux through.
h	is the water depth.
I_b	is the bottom slope.
L_v	is the latent heat of vaporization.
M	is the molecular weight of water vapor.
P	is the wetted perimeter.
Q	is the discharge.
R_a	is the gas constant.
R	is the hydraulic radius (A/P).
T_{sw}	is the water surface temperature.
T_a	is the mean absolute air temperature.
T	is the water temperature.
T^*	is the air temperature.
T_{aw}	is the ambient temperature.
U	is the cross-sec. average velocity.
W_z	is the wind speed at height z.
	air.
W_2	is the wind speed at 2 m height.
W_2	is the wind speed 2 m above the water surface in
α	is the molecular kinematic heat conductivity.
β	is the coefficient of thermal expansion of air.
ν	is the kinematic viscosity of air s/m^2.
ρ	is the water density.
σ	is a constant.
ϵ	is the average emittance of the atmosphere.

1. INTRODUCTION

1.1 Abstract

Keeping the environment clean is a nobel goal which can be achieved by freezing some human activities. For that reason the impact of the human activities on the environment should be better understood. One of endangers activities is the heat pollution in open channels which is a result of producing electrical energy from thermal power plants. The previous studies, dealt with this problem used to study the near field mixing zone but they paid less interest in the far field heat exchange problem. The far field heat exchange is considered to be of more importance from the environmental point of view as it is the dominant phenomena. This study aims to achieve better understanding of this phenomena and to produce a tool for its simulation.

1.2 General

The continuing increase in the demand for electrical energy and the growing electrical power industry in Egypt as well as in many industrialized countries, have given rise to certain environmental problems related to the setting and design of electrical generation facilities. Once-through (open-cycle) cooling is one of the most efficient methods of condenser cooling. This method is more efficient economically and thermodynamically, than that of closed-cycle techniques. If the cooling water outlet structure is designed properly, then it is also efficient ecologically.

According to the Egyptian Ministry of Public Works & Water Resources' Law No. 48,1982 which deals with the protection of the Nile River and water courses from thermal pollution, the maximum temperature rise in the river is 5 °c above the ambient temperature, with maximum absolute value of 35 °c . Since the water in the Egyptian channels has a maximum natural temperature varies between 28 and 30 °c, and normally the temperature rise along the plant condenser is approximately 10 °c , so a heat pollution problem would be expected. Normally a mixing zone is used to obtain sufficient temperature reduction to meet this standard. Nevertheless, It can happen that during a hot day and when the humidity is high, the mixing zone will be too long to maintain the previously mentioned standard. In that case, an artificial way should be used. There is several artificial cooling devices , the most widely used one is the cooling tower.

It is very important to control the heat pollution as it affects both the physical and chemical properties of water. It changes its density, vapour pressure, viscosity, surface tension, gas solubility, diffusion and it has an effect on the chemical reactions. Consequently a dramatic effect on the environment of the channels might be produced.