STUDENT'S DECLARATION

I hereby certify that the work which is being presented in the major project entitled **"Modelling and Thermal Performance Analysis of Evaporative Cooling Systems"** in partial fulfilment of the requirements for the award of the degree of Master of Engineering in Thermal Engineering, submitted to the Department of Mechanical Engineering, is an authentic record of my own work carried under the supervision of **Dr. R.S. Mishra, Professor** of Mechanical Engineering Department, Faculty of Technology, University of Delhi, Delhi.

I have not submitted the matter embodied in this major project as whole or in part, for the award of any other degree.

Naresh

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Date: ____________

This is to certify that the dissertation entitled **“Modelling and Thermal Performance Analysis of Evaporative Cooling Systems”** submitted by **Mr. Naresh (**09/THR/09), (University Roll. No.8579) in partial fulfilment for the award of the Degree of Master of Engineering in Thermal Engineering of University of Delhi, is an authentic record of student’s own work carried out by him under my guidance and supervision.

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Nomenclature

$A_s = Surface\ area\ of\ pad\ module (m^2)$

$A_c = Cross\ section\ area\ of\ air\ passage (m^2)$

$C_{pa} = \ Specific\ heat\ of\ dry\ air \left(\frac{kJ}{kgK}\right)$

$C_{pv} = \ Specific\ heat\ of\ water\ vapours \left(\frac{kJ}{kgK}\right)$

$C_{pma} = specific\ heatof\ moist\ air \left(\frac{kJ}{kgk}\right)$

$d = diffusion\ coefficient$

$ex = Total\ exergy\ of\ air \left(\frac{kJ}{kg}\right)$

$exth = Thermal\ exergy\ of\ air \left(\frac{kJ}{kg}\right)$

$exme = Mechanical\ exergy\ of\ air \left(\frac{kJ}{kg}\right)$

$exch = Chemical\ exergy\ of\ air \left(\frac{kJ}{kg}\right)$

$h_c = Heat\ transfer\ coefficient \left(\frac{w}{m^2 k}\right)$

$h_m = mass\ transfer\ coefficient \left(\frac{kg}{m^2 s}\right)$

$h_{fg} = latent\ heat\ of\ vaporizaton\ of\ water\left(\frac{kJ}{kg}\right)$

$h_{a,in} = Specific\ enthalpy\ of\ inlet\ air\left(\frac{kJ}{kg}\right)$

$h_{w,in} = Specific\ enthalpy\ of\ inlet\ water\left(\frac{kJ}{kg}\right)$

$h_{a,out} = Specific\ enthalpy\ of\ outlet\ air\left(\frac{kJ}{kg}\right)$

$h_{w,out} = Specific\ enthalpy\ of\ outlet\ water\left(\frac{kJ}{kg}\right)$

$h_{w,wb} = Specific\ enthalpy\ at\ of\ water\ wet\ bulb\ temperature\left(\frac{kJ}{kg}\right)$

$k = Thermal\ conductivity\left(\frac{w}{mk}\right)$

$l_e = Characteristic\ dimension\ of\ pad\ module(m)$

$l = length\ of\ one\ pass\ of\ pad\ module(m)$

$m_a = mass\ flow\ rate\ of\ air\left(\frac{kg}{s}\right)$

$m_{a,in} = Inlet\ mass\ flow\ rate\ of\ air\left(\frac{kg}{s}\right)$

$m_{w,in} = Inlet\ mass\ flow\ rate\ of\ water\left(\frac{kg}{s}\right)$

$m_{a,out} = Outlet\ mass\ flow\ rate\ of\ air\left(\frac{kg}{s}\right)$

$m_{w,out} = Outlet\ mass\ flow\ rate\ of\ water \left(\frac{kg}{s}\right)$

$m_w = mass\ flow\ rate\ of\ water \left(\frac{kg}{s}\right)$

$p_0 =\ atmospheric\ pressure\ of\ air (kPa)$

$p =\ pressure\ of\ air\ at\ anyh\ condition (kPa)$

$R_a = Characteristic\ gas\ constant \left(\frac{kJ}{kgK}\right)$

$\rho = Density \left(\frac{kg}{m^3}\right)$

$t_s = surface\ temperature\ of\ pad\ module (℃)$

$t_{wb} = air\ wet\ bulb\ temperature (℃)$

$t_{wf} = water\ film\ temperature (℃)$

$t_{in} = Air\ inlet\ temperature (℃)$

$t_{out} = Air\ outlet\ temperature (℃)$

$T_0 =\ Absolute\ atmospheric\ temperature (K)$

$T =\ Absolute\ temperaure\ of\ air\ at\ any\ condition (K)$

µ=*Kinematic viscosity (kg.m/s)*

$V = Velocity\ of\ flow \left(\frac{m}{s}\right)$

$w_{out} = Air\ outlet\ specific\ humidity\left(\frac{kg}{kg}\right)$

$w_{in} = Air\ inlet\ specific\ humidity\left(\frac{kg}{kg}\right)$

$w_s = \ Specific\ humidity\ of\ air\ at\ saturation\left(\frac{kg}{kg}\right)$

$w_0 = \ Specific\ humidity\ of\ air\ at\ atmospheric\ condition\left(\frac{kg}{kg}\right)$

$w = \ Specific\ humidity\ of\ air\ at\ any\ condition\left(\frac{kg}{kg}\right)$

$N_u = Nusselt\ Number$

$Re = Reynolds\ Number$

$Pr = Prandtl\ Number$

$Sh = Sherwood\ Number$

$Sc = Schmid\ Number$

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Abstract

Evaporative cooling is a passive method which can save the fossil fuel reserves or contribute to prevent the use of gas CFC in refrigeration, which contribute to global warming. Evaporative cooling is an environment friendly technology and can be used as an alternative to mechanical refrigeration systems. It is a cost effective technology for preserving food and vegetables, therefore this is an eco-friendly alternative to mechanical refrigeration systems.

In this project we have developed thermal model for evaporative cooling for (i) Normal water temperature (ii) Elevated water temperature (iii) Chilled water temperature. The results were compared with experimental results found out through experiments conducted on the experimental test setup for several days. It was observed that theoretical results well matches with experimental measurements, therefore the model can be used for analyzing performance of any type of evaporative cooling system.

Mathematical expressions between various parameters have been developed based upon the experimental data. These expressions have been developed for individual water temperature as well as for combined data for all water temperatures.