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FACULTY OF ENGINEERING
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Investigation of air movement in confined spaces

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PREFACE

This dissertation is submitted to Ain Shams University for the degree of Degree of Doctor of Philosophy in Mechanical Power Engineering.

The work included in this thesis was carried out by the author at the Department of Mechanical Power Engineering, Faculty of Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

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Dedication

To my mother Soul God's mercy be upon her (Allah yerhamha)

And

my father

And

To my **son**

ABSTRACT

Research on indoor environments has received more attention recently because requirements of thermal comfort, reports of symptoms and other health complaints have been increasing. Heating, ventilating, and air-conditioning (HVAC) systems are used to control the indoor environment. Therefore, it is necessary to provide a good thermal comfort levels and a good ventilation system that can provide good indoor environment.

To improve thermal comfort levels and indoor environment, the study of airflow with the assistance of the distribution of several significant parameters on indoor environment was done in this study.

In this research numerical simulations through computational-fluid-dynamics (CFD) was used. The majority of the CFD is based on the solution of Navier-Stokes equations, the energy equation, the mass and conservation equations as well as the transport equations for turbulent velocity and its scale. Commercial program of ANSYS- CFX as a solution tool is used to perform the analysis at steady state condition and three-dimensional. The program, used in this research, was validated.

By using the validated program, numerical simulations of several different cases of wall supply air grilles and the floor-supply system were conducted to evaluate the design and the performance of the system. Temperature and Velocity distributions over various virtual planes for all the cases studied were analyzed and the evaluation criterion is thermal comfort; temperature difference and velocity are calculated to get the optimum air conditioning systems to achieving the maximum comfort for the occupants.

The results are reported in terms of thermal comfort, which indicate that the occupants will experience most comfort if the air conditioning system is placed on the position, which the wall diffusers located on the same side of the exits, where diffusers and exits are 2.44 [m] and 1.9 [m] above the floor respectively.

Also the study includes a floor-supply displacement ventilation system that can provide fresh air directly to the occupied zone. However, the existing floor-supply displacement ventilation systems have some problems. Hence, the objectives of this research were to improve the disadvantage of this system, and to develop a new design for the floor-supply displacement ventilation system with floor diffusers. The results show that the impacts of several parameters, such as the air change rate, number

of air supply diffusers, the air supply location, air supply temperature, air supply velocity, number of exhaust grills and exhaust location on the indoor environment were investigated based on the thermal comfort level. From the results, the parameters were ranked in the order of their impact.

Also this thesis focuses on effect of office dimensions and people number on displacement ventilation. Multiple Plumes and Wall Heat Transfer Three-Node Displacement Ventilation Room Air Model (Energy Plus program) was used to estimate previous factors on displacement ventilation. Multiple Plumes and Wall Heat Transfer models are used to estimate main subzones temperature. The study shows that, those are affected by office dimensions and people number. So that displacement ventilation is suitable for higher no. of people, more height of walls, longer distance between inlet and outlet. It is recommended to use displacement ventilation in zones, which having high walls, long distance between inlet and outlet and big number of people like big offices, theaters, cinemas ….and so on.

This result can be used for more specific case studies of each building design and also can be extended to a more complex air conditioning system like those in industries, hospitals as well as the gigantic shopping malls and also to study the indoor Quality.

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