



AIN SHAMS UNIVERSITY  
FACULTY OF ENGINEERING  
MECHANICAL POWER ENGINEERING DEPARTMENT

# **Experimental and Numerical Investigation of Various Cooling Techniques for Enhancing Solar Cells Efficiency**

A thesis submitted in partial fulfillment of the requirements of  
the Doctor of Philosophy degree in Mechanical Power  
Engineering

Submitted by:

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M.Sc. in Mechanical Engineering (Mechatronics), Ain Shams  
University, June 2014

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**Cairo, 2017**



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## **EXAMINERS COMMITTEE**

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# STATEMENT

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

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

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

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# ABSTRACT

One of the important challenges in utilizing the photovoltaic (PV) system is the decrease in the energy conversion efficiency of PV cells during the working period. This is due to increase in the cells temperature above a certain amount. To enhance the output power of PV systems one way is cooling them during the operation period that can be achieved via heat absorption by a cooling medium, which can in turn be utilized in other applications.

This thesis investigates the output power of photovoltaic module. It includes two parts, the first is comparing two previous shapes of cooling fluid pipes (serpentine shape, parallel shape) with a new structure (serpentine-parallel shape) that was a combination between these two shapes. At the start water is used as the cooling fluid.

In the second part, two types of nano-fluids ( $\text{TiO}_2$ -water,  $\text{Al}_2\text{O}_3$ -water) as a cooling fluid are used to enhance the PV performance on the best shape of pipes. A comparison between theoretical (Comsol Multiphysics package) and experimental work results for fixed Photovoltaic/ Thermal (PV/T) hybrid system is presented.

An active cooling system is designed and conducted to cool the PV module at which an absorber system consists of copper plate and pipes that are attached in the backside of the PV module to allow water or the other two nano-fluids to flow underneath it.

In addition to the above an electrical analysis for the systems is conducted where I-V, and output power during working hours are presented. Beside that the thermal study for the fixed PV module and the piping system is presented which constitutes the outlet temperatures, the module temperatures, and overall heat transfer. As a result, a significant improvement in the electrical output power is recorded associated with the decrease in the module temperature.

# **ACKNOWLEDGEMENT**

First and foremost, I would like to thank my supervisors Prof. Mahmoud Abdelrasheed Nosier, Prof. Nabil Abdelaziz Mahmoud, Prof. Osama Ezzat Abdellatif, and Assoc. Prof. Ahmed Saad Khalil for their continuous guidance, encouragement and help. They helped me throughout the Thesis. I learned so many valuable things from them. I would like also to thank them for their patience.

Also, I would like to thank all of other Ain Shams University, Faculty of Engineering members whom I took classes with. Special thanks to Centre of Renewable Energy (CEST), Faculty of science at El Fayoum University. Many thanks go to my colleagues and friends for their support and help during my thesis. Those especially deserving of a mention include Prof. Wagdy Anis, Prof. Khaled Kirah, Prof. Ayman Bahaa, Dr. Sameh Osama Abdellatif, Eng. Anwar Magdy, Eng. Ibrahim Gouda, Eng. Andrew Seif, Eng. Nabeel Negm, Eng. Abanoub Refat. I have learned a great deal from all of them.

Last but not least, I would like to thank my family for their patience, care, and love during the course of this thesis.

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