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DIPLOMA PROJECT

THERMAL PERFORMANCE TESTING AND CLASSIFICATION OF FLAT-PLATE SOLAR COLLECTORS

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Summary
The objectives of this project are :

1) To study the Cyprus Standard concerning the Performance characteristics of flat-plate solar collectors.

2) To identify the parameters affecting the thermal performance of flat-plate solar collectors

3) To carry out experimental test and investigate the performance characteristics of different types of flat-plate solar collectors, using the methods described in the Cyprus Standard.

4) To classify the tested collectors according to their performance.

The tests were conducted at the Applied Energy Research Centre of the Ministry of Commerce, Industry & Tourism.

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Nomenclature

Symbol	Meaning	Units
Aa	Aperture area of collector	m^2
Ag	Gross area of collector	m^2
c_f	Specific heat capacity of heat transfer fluid	J/kg K
F	Collector heat removal factor	-
G	Solar radiation	W/m^2
Q	Useful power extracted form the collector	W
T	Absolute temperature	K
Ta	Ambient air temperature	°C
Ti	Collector inlet temperature	°C
Tm	Mean temperature of heat transfer fluid	°C
U	Measured overall heat loss coefficient	W/m^2K
τ	Absorber plate transmitance	
α	Absorber plate absorbtance	

1. Introduction

1.1 About flat-plate collectors

The collector is in a way the "furnace" of a solar heating system. The collector receives the solar radiation from the sun and converts it into a reliable heat source for homes, business and industry.

There are two basic types of solar collectors, the *concentrating* and the *flat-plate* collector.

Concentrating collectors are focusing the direct radiant energy on a small absorber area to collect heat energy and produce high temperatures.

Flat plate collectors are termed as low temperature collectors and will function at various levels of efficiency. They absorb both, direct and diffuse radiation. A flat-plate collector receives the solar energy from the sun and converts it into heat. This is achieved by absorbing the solar radiation in a thin black metal surface and then this heat is conducted in a fluid medium which is then stored into an other part of the heating system.

Flat-plate collectors can also be classified into three groups according to their main applications as follows :

(a) Applications with a very small rise in temperature, such as in swimming pools where a high flow rate is maintained to limit the temperature rise to less than 2°C.

(b) Domestic heating and other applications where the maximum temperature required is not greater than 60°C.

(c) Applications such as process heating which temperatures considerably above 60°C are necessary. Here a more sophisticated design is required to reduce the heat losses from the collector to the environment.

From the great variety of collectors the flat-plate collector appears to be a comparatively straightforward piece of equipment.

A flat-plate collector consists of five main components:

1. Absorber plate. The absorber plate is the component of the collector that converts the light into heat energy and transfers this energy into the flowing liquid. The absorber plate is a vital element of a collector. The absorber plate must absorb as much as possible of the radiation and loose as little heat as possible. Absorbers are usually made of copper, aluminum or steel. Factors that determine the absorber material are its thermal conductivity, its durability and ease of handling. Also in

order to increase the fraction of available solar radiation absorbed by the plate, a surface coating is usually given to the absorber plate.

2.Tubes or fins. These are used in order to direct the heat transfer fluid from the inlet to the outlet. The collector design must provide a uniform flow for the heat transfer fluid through the collector. There are a number of tube designs being used in collector plates. A very serious problem in liquid type collectors is corrosion. The best way to prevent corrosion is to use copper pipes, although even copper is not trouble free but is by far the safest material to use.

3.Glazing. One or more transparent covers may be used on a collector. Transparent covers reduce the heat loss from the collector in two ways. Firstly a transparent cover has the ability to admit sunlight to leave the collector but reduces the radiative heat loss. Secondly it keeps wind and natural convection from robbing heat from the absorber plate. Main materials used for glazing are glass and plastic because they have many of the same characteristics of heat and light transmission.

4. Insulation. The insulation of a collector prevents heat from escaping through the frame and protects the absorber plate and the tubes from the cool outside environment. The insulating material should have low thermal conductivity , low bulk density and high melting point, it should also be resistant to rot, weather, insects and rodents. Materials most widely used as insulation in solar collectors is various types of fiberglass and polyurethane foam.

5. Casing. This contains all the components that form a solar collector. The casing must be waterproof and airtight in order to protect its contents from the weather conditions. It must expand and contract with the rise or fall of the external and internal temperatures in order to support the internal components and also to maintain the airtight seals between the components.