STUDY ON A FLAT PLATE SOLAR COLLECTOR

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ABSTRACT

Solar energy is become an alternative for the limited fossil fuel resources. One of the simplest and most direct applications of this energy is the conversion of solar radiation into heat, which can be used in water heating systems. A commonly used solar collector is the flat-plate. Flat Plate Collector (FPC) is widely used for domestic hot-water, space heating/drying and for applications requiring fluid temperature less than 100oC. Three main components associated with FPC namely, absorber plate, top covers and heating pipes. The absorber plate is selective coated to have high absorptive. It receive heat by solar radiation and by conduction; heat is transferred to the flowing liquid through the heating pipes. The fluid flow through the collector pipes is by natural or by forced circulation (pump flow). For small water heating systems natural circulation is used for fluid flow. Conventionally, absorbers of all flat plate collectors are straight copper/aluminum sheets however, which limits on the heat collection surface transfer area.The performance of any solar collector is largely affected by various parameters such as Glazing (single glazing and double glazing), Absorber plate, Top covers and Heating pipes. The absorber plate of the FPC transfers solar energy to liquid flowing in the tubes. The collector efficiency is dependent on the temperature of the plate which in turn is dependent on the nature of flow of fluid inside the tube, solar insulation, ambient temperature, top loss coefficient, the emissivity of the plate and glass cover, slope, etc.

Keywords - Flat plate collector, efficiency of collector, solar water heating, solar energy.

I. INTRODUCTION

1.1 Solar Collectors

Solar collectors are the major component of active solar-heating system. They collect and store the sun's energy, transform its radiation into heat, and then transfer that heat to a fluid (usually water or air). The solar thermal energy can be used in solar water-heating systems, solar pool heaters.[1] Solar energy is the most essential and economical of all energy forms. Renewable sources of energy from sun are fairly non-polluting and considered clean. Solar energy as the green and environmental friendly energy has produced energy for billions of years. Solar energy that reaches the earth is around 4x1015 MW and it is 200 times as large as the global utilization. [2] There are a large number of solar collector designs that have are functional.

These designs are classified in two general types of solar collectors:-

1) Flat-plate collectors – The absorbing surface is approximately as large as the overall collector area that intercepts the sun's rays.

2) Concentrating collectors – Large areas of mirrors or lenses focus the sunlight onto a smaller absorber.[3]

1.2 Heat collectors

Solar collectors are either non-concentrating or concentrating. In the non-concentrating type, the collector area (i.e., the area that intercepts the solar radiation) is the same as the absorber area (i.e., the area absorbing the radiation). In these types the whole solar panel absorbs light. Concentrating collectors have a bigger interceptor than absorber. Flat-plate and evacuated-tube solar collectors are used to collect heat for space heating, domestic hot water or cooling with an absorption .[4]

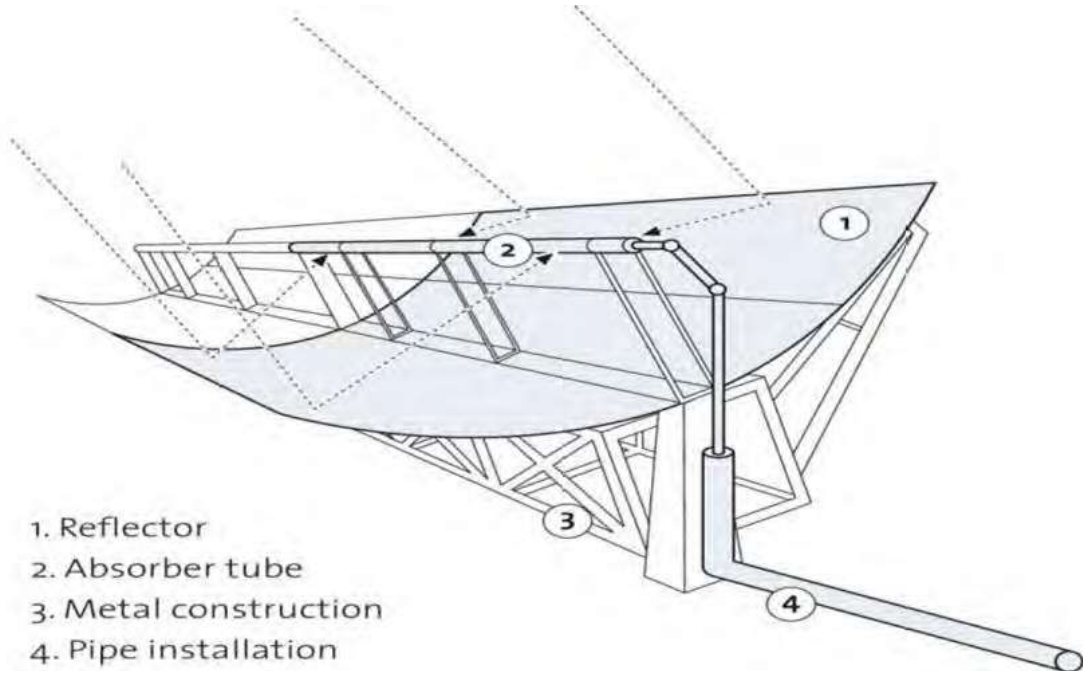

Figure 1. Schematic of a Concentrating Solar Collector[5]

II. FLAT PLATE COLLECTOR

A typical flat-plate collector made up of an absorber which is in an insulated box together with transparent cover sheets (Glazing). The absorber is usually made up of a metal sheet of high thermal conductivity such as copper or aluminium, with integrated or attached tubes. Its surface is coated with a special selective material to maximize radiant energy absorption while minimizing radiant energy emission. The insulated box reduces heat losses from the back and sides of the collector. These collectors are used to heat a liquid or air to temperatures

less than 680°C.[7] Flat plate collectors: in which absorbing surface is approximately as large as the overall collector are that intercepts the sun's rays. Concentrating collectors in which large areas of mirrors or lenses focus the Sun light onto a smaller absorber.[8]

Fig2. Flat plate thermal system for water heating deployed on a flat roof.[6]

Flat-plate collectors consist of

(1) a dark flat-plate absorber,

(2) a transparent cover that reduces heat losses,

(3) a heat-transport fluid (air, antifreeze or water) to remove heat from the absorber, and

(4) a heat insulating backing.[9]

Flat-plate collectors are in wide use for domestic household hot-water heating and for space heating, where the demand temperature is low. Many excellent models of flat-plate collectors are available commercially to the solar designer.[10] Solar flat plate collectors are used for water heating applications and the efficiency of these systems are around 70% which is very high as compared to solar direct energy conversion systems having efficiency around 17% [11].

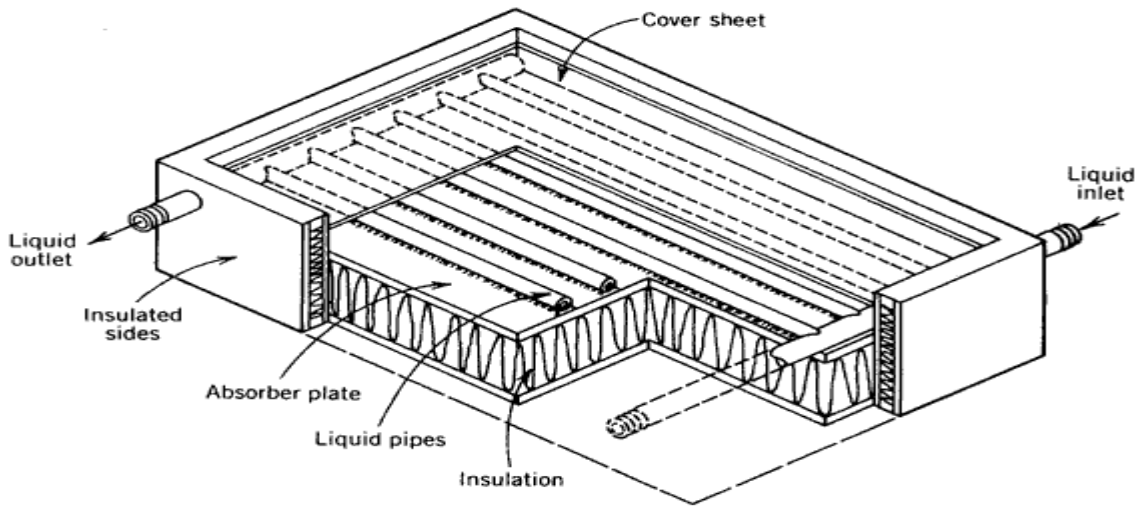

Figure 3: Cross-section of a typical liquid flat plate collector[12]

III THE MATHEMATICAL MODEL DEVELOPMENT OF A FLAT–PLATE SOLAR COLLECTOR SYSTEM

This section presents a mathematical model describing the flat-plate solar collector system the flat-plate solar collector contains one tube that is divided into five nodes (glass cover, air gap, absorber, fluid and the insulation) perpendicular to the liquid flow direction, figure4.[13]

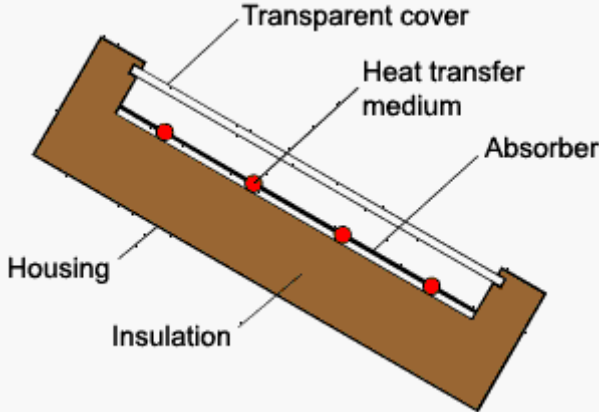

Figure4: Sketch of the five nodes analyzed in the flat-plate solar collector model[14]

IV. PERFORMANCE

The performance of the solar thermal flat plate collector depends on the amount of solar insulations absorbed by the plate. The emissivity of the selective coated plate is Usually around 0.1 and that of glass cover lies between 0.85 - 0.88.[15] The major heat loss in the collector is from the top through the glass cover compared to bottom and side losses. The top loss coefficient from the collector is evaluated by considering both convection and radiation from the absorber plate to ambient. the collector efficiency under different conditions such as the absence of cover, with single and double glazing under different ambient conditions, tilt angles, wind speeds, emissivity of both glass cover and absorber plate.[16]

V. CONCLUSION

Theoretical and experimental analysis is performed on a flat plate collector with a single glass cover. It can be concluded that the emissivity of the absorber plate has a significant impact on the top loss coefficient and consequently on the efficiency of the Flat plate collector. The efficiency of FPC is found to increase with increasing ambient temperature. Using the solar fuel with in solar collector application have enormous potential in the future and is under global focus to attain clean and green energy. A detailed mathematical derivation for the flat-plate solar collector cross sections (cover, air gap, absorber, working fluid, and insulation) was presented. A way to describe the thermal performance of a Flat Plate Solar collector has been shown. The most important measure is the collector efficiency. A more precise and detailed analysis should include the fact, that the overall heat loss coefficient

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