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CAI 335 : SOLAR AND WIND ENERGY SYSTEMS

UNIT 1

SOLAR ENERGY RADIATION AND SOLAR THERMAL COLLECTORS

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In solar thermal energy systems, the absorber plate is a key component responsible for absorbing sunlight and converting it into heat. This heat is then transferred to a working fluid (usually water or air), which can be used for various applications like space heating, water heating, or even electricity generation. The heat balance of an absorber plate is the process of determining how much energy is absorbed, lost, and converted into usable heat.

Heat Balance of an Absorber Plate

The heat balance of an absorber plate involves several processes:

1. Solar Radiation Absorption: The absorber plate receives solar radiation (direct and diffuse sunlight). The amount of radiation absorbed depends on the material properties of the plate, including its surface color, texture, and absorptivity (how efficiently it absorbs sunlight).

2. Heat Conversion: Once the solar radiation is absorbed by the plate, it is converted into thermal energy. The efficiency of this conversion depends on the material's ability to absorb and retain heat.

3. Heat Loss: There are various mechanisms through which heat is lost from the absorber plate:

- Convective Losses: Heat can be lost through convection to the surrounding air. This occurs when the air in contact with the plate is heated and carried away by the wind or natural air movement.

- Radiative Losses: The absorber plate also emits some of its heat back to the surroundings in the form of infrared radiation. The rate of radiative heat loss depends on the temperature of the plate and its emissivity (the ability to radiate heat).

- Conductive Losses: Heat can also be conducted to the mounting structure of the solar collector, which can then dissipate it into the environment.

3. Heat Transfer to Fluid: The working fluid (water, air, or another medium) in the collector absorbs heat from the absorber plate. The efficiency of this heat transfer depends on the fluid's flow rate, temperature difference, and the thermal conductivity of the materials involved.

The goal of a solar collector design is to maximize the absorption of solar radiation and minimize heat losses. A well-designed absorber plate balances these processes, ensuring that as much of the captured energy as possible is converted into usable heat.

Types of Absorber Plates

There are several types of absorber plates used in solar thermal systems, each designed to optimize heat absorption and minimize losses.

1. Flat Plate Absorber: The most common type, consisting of a flat metal sheet (often copper or aluminum) coated with a selective coating that improves its ability to absorb sunlight while minimizing heat loss through radiation. The plate is usually black to maximize absorption. The fluid flows through tubes attached to the back of the plate, transferring the absorbed heat.

2. Evacuated Tube Absorber: This type uses glass tubes to encase the absorber plate. The tubes are evacuated of air, creating a vacuum that reduces heat loss through convection and conduction. The absorber plate inside the tube is usually coated with a selective material. These systems are more efficient at higher temperatures compared to flat-plate collectors.

3. Compound Parabolic Collector (CPC): In this design, the absorber plate is curved to reflect and focus sunlight onto a receiver. This type is often used in applications where space is limited or where a higher concentration of sunlight is needed. CPCs can collect solar radiation at different angles throughout the day.

4. Grooved or Structured Absorber Plates: Some absorber plates have grooves or structured surfaces that enhance heat transfer. These features improve the contact between the fluid and the absorber surface, increasing the rate of heat transfer to the working fluid.

5. Solar Parabolic Troughs: This design uses a long, curved reflector that concentrates sunlight onto an absorber tube. The absorber tube is heated by the concentrated sunlight and transfers the heat to the working fluid. Parabolic trough collectors are often used in large-scale solar thermal power plants.

Each type of absorber plate has its advantages and disadvantages, and the choice of which to use depends on factors such as climate, intended application, and system size.