

**Course Name: Bioclimatic Architecture: Futureproofing with Simple and Advanced Passive Strategies**

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**Lecture 04**

Solar air collectors

Hello, dear students. So, we had seen some passive technology last class, and as a continuation, we will see another advanced solar passive technology, and today we will see solar air collectors. So, in today's class, we will see an advanced passive technique, which is solar air collectors. And today's class we will have an introduction to thermal collectors. We will look at the types of thermal collectors. Then we will look at the body solar air collectors.

We will look at the components and types. We will go through case studies. and we will go through the case studies. Now, what is a solar collector? A solar collector is essentially a flat box, and it is made up of three major components or parts.

It has a transparent cover, tubes that deliver coolant, and an insulated rear plate. The solar collector operates on the greenhouse effect concept, where solar energy impacting the transparent surface of the solar collector is transferred through this surface. The interior of the solar collector is normally evacuated, and the energy held inside it is effectively trapped, heating the coolant contained within the tubes. The tubes are often composed of copper with the back plate coated black in order to enable the absorption of solar radiation. The solar collectors are usually insulated to prevent heat loss.

What is the basic principle of a solar thermal collector? So the solar thermal collectors operate by bringing in fresh outside air and making it pass through a maze of black metal with a specific selective coating. This collects far more heat than it produces. This warm air is then blasted into the house by a solar-powered fan. Where can we use this? So, this is very commonly used in cold climates and in areas where solar energy is abundant and could probably be harnessed and used to improve the energy efficiency of buildings. These contraptions perform very well when they are placed on a south-facing wall.

A southern roof also works, but it must be ducted into the home through an optimal benefit

of a stack effect. If you see how it works, the solar walls work best on well-insulated buildings. So, the buildings must have good insulation. And the passive solar wall uses a natural convection of air to transfer heat from the collector to the building. So when sunlight strikes the collector, the dark metal is an absorber, and it gets heated.

This absorber transfers the heat to the air cavity. between the absorber and the glazing material. So it transfers the heat in this zone. The warm air rises and flows into the building through a small aperture, which is about 200 mm. And this is opened near the ceiling because warm air rises, and therefore it is best to have an aperture near the ceiling.

So cool air from the building that is heavy is drawn inside because of the vacuum effect, and this cool air further gets warmed up with the absorber here. This cool air gets warmed up with the absorber, and this cycle continues. So, the passive solar wall is self-regulating. When the sun is lowest in the sky in the winter, maximum solar energy is collected. Let us now look at the types of solar collectors.

So, there are primarily two types of solar collectors. One is a stationary collector; another is a concentrating collector. The stationary comprises the flat plate collector, the evacuated tube collector, the solar air collector, and the unglazed collector. Whereas the concentrating one has a parabolic trough collector, parabolic dish reflector, fresnel collectors, and heliostat field collector. So let us look at what flat plate collectors are.

Now, this is the most popular type of solar collector and is called the flat plate collector. This has an absorber, a transparent cover, and insulation. This method is most commonly used, especially in residential structures where hot water is in great demand and a lot of money is spent on generating hot water. The next one is the evacuated tube collector. Now this is a vacuum collector, and the absorber strip is enclosed in an evacuated and pressure-proof glass tube.

The heat transfer fluid goes straight from the absorber to a U-tube or a tube in a tube system. The third type is the parabolic trough, and this particular type of solar collector is very commonly used in solar power facilities. This method uses a trough-shaped parabolic reflector to focus sunlight on an insulated tube or heat pipe located in the focal point. The heat that is produced is transmitted to the power station boilers. So, this is a flat plate collector.

Now, let us look at the power tower. The power tower is a large tower surrounded with tracking mirrors known as heliostats. Now these orient themselves to follow the sunlight, gather the sunlight, and transport it to the top of the tower where the receiver is located. The heat obtained is then transferred to a power plant, which is placed below. As compared

to standard solar cells, the power tower allows for the cheaper coverage of a considerably broader area using relatively affordable mirrors.

Next, we have the solar collector cells. The collectors require ideal meteorological conditions, which are difficult to find in many parts of the world. So, solar cells and panels, on the other hand, are a very good choice for anybody to create their own environmentally friendly energy. Next, we will see flat plate collectors and their working principles, along with the applications. Now, flat plate collectors comprise a dark flat plate absorber; then there is a transparent cover that reduces heat losses, a heat-insulating backing, a flow passage, and an enclosure.

So, you can see that a dark flat plate absorber is present. So, this is the absorber on which incident radiation strikes. Solar incident radiation strikes on the absorber. So, here you can see there is a heat-absorbing back plate. which has insulation here, and there is a sealed heat enclosure.

So this whole thing is enclosed, and there is a glazing sheet here that absorbs the heat. Let us look at the evacuated tube collectors. Evacuated tube solar collectors are the most common and simple types of solar technology. The operating process of an evacuated tube solar collector is similar to leaving a jar exposed to radiation and allowing its liquid contents to heat up. But the evacuated tube solar collector operates in a more sophisticated and efficient manner than the analogy that is stated.

There are three different types of evacuated tube collectors. First is the U-pipe evacuated tube. Second are thermosiphons, and third is the heat pipe. While evacuated tube technology obviously outperforms flat panels in almost every water heating application, the benefits are absolutely important when utilized for solar air conditioning, heating, or commercial purposes. Let us look at the parabolic trough.

A parabolic trough solar plant collects solar energy and directs it to a linear heat absorber through a long trough-shaped solar concentrator. These reflectors follow the sun across the sky to maximize its efficiency. Closely similar is the Fresnel collecting system. which uses long flat mirrors to simulate the parabolic trough and follow the sun. Both methods pump heat-collecting fluid via the heat receiver.

The heat gathered is often utilized either directly or indirectly to generate steam and power a steam turbine generator. Parabolic trough reflectors may reach concentration ratios of even up to 100. Some parabolic trough plants have thermal energy storage, which is built-in. This allows them to function for extended periods of time every day. Due to its established technology, a majority of commercially built CSP projects use parabolic

troughs.

Due to its established technology, many projects use parabolic troughs. Let us look at the power tower in brief. In power towers, there is a concentration of solar power systems. A large number of flat sun-tracking mirrors known as heliostats, which we have already seen earlier, direct the sunlight to a receiver at the top of a tall tower. A heat transfer fluid is heated in the receiver, and that is used to heat a working fluid, which is then utilized in a typical turbine generator to generate electricity.

Some power towers employ water or steam as a heat transfer fluid. Other sophisticated designs are experimented with with high-temperature molten salts or sand-like particles to boost the power cycle temperature. A solar electric generating system, which is the biggest concentrated solar thermal plant in the United States, is located in California's Mojave Desert, and this is capable of producing about 392 megawatts of power by utilizing 1,73,500 heliostats, each with two mirrors that concentrate the sunlight. Let us now look at solar collectors. So what is a solar collector? A solar air collector is made up of an absorber material, which may have a selective surface that captures solar radiation and transmits it to air by conduction heat transfer.

What exactly is it used for? So, solar thermal air collectors prepare fresh air for heating, drying, and maintaining a minimum temperature throughout the winter. Unlike water collectors, air collectors have the benefit of not freezing, and they have a lesser environmental effect. Now, why are they important? They are important because they provide a sustainable and cost-effective alternative to fossil fuels for space heating and other purposes. Their benefits include a reduced energy bill, and the other benefits include that their carbon footprint gets lowered because better indoor air quality and enhanced thermal comfort are assured. Let us look at the components of a solar air collector.

So, a solar air collector has an absorber plate. This absorber plate This absorber plate is a dark-colored plate that absorbs the solar radiation from the sun's heat. It is often constructed of metal with a selective coating that effectively absorbs solar light while limiting heat loss. then we will see what are collectors. So, some collectors use a translucent cover like this, which is made up of either glass or plastic.

So, this can be this could be made up of glass or plastic. This helps to retain the heat and reduce convective losses. So, unglazed collectors, on the other hand, are based on direct contact between the absorber and the air passage. Then there is insulation here.

You can see this is the insulation. The collector's back and sides are insulated to prevent heat loss to the environment. Then there is a series of ductwork that transfers this warm air

from the collector to the intended destination. Let us now look at the types of solar air collectors. First we will look at the unglazed type. So the unglazed type: these are simple and less expensive, but they are less effective in cold areas.

They are commonly used to warm ventilation, air, or dry agricultural products. These non-insulated collectors are ideal for applications requiring temperatures below 30 degrees Celsius. Unglazed solar collectors are often composed of black plastic treated to withstand ultraviolet rays. Because these collectors have no glass, a large portion of the solar air is absorbed. However, because these collectors are not insulated, a considerable portion of the collected heat is lost when exposed to windy and cold weather.

So, you can see here that there is this glazing that we saw in the section, and then you have the absorber plate. This is the absorber plate. This is the glazing, which actually induces a lot of heat to be transferred to the absorber plate. And then there is a series of flow passages, or tubes, and then below the absorber plate is the insulation layer.

So, this is the insulation layer. So, the heat transfer medium is these tubes. Inlet air, which is cool, is absorbed inside the tube, and because of the heat from the glazing and the absorber plate, the outlet air becomes warm. And this entire thing is placed in a casing, and this looks like this when placed on a roof. Multiple of these look like this. As we already saw, there are air collectors and solar air collectors that are glazed.

So, these collectors feature a translucent cover that absorbs heat and increases efficiency, particularly in cold weather. They are ideal for space heating applications. Then we have the transpired ones. These collectors are built into building elements like roofs and walls. They have a more attractive look and may be utilized for both space heating and ventilation.

They use perforated galvanized steel or aluminum panels. Next, we will see the applications of solar air heating systems. The solar air heating system consists of two parts. Next, we will see the applications.

The first is the solar air heating system. The solar air heating system consists of two parts. A solar collector mounted on the side of the building facing the equator and a fan and air distribution system installed inside the building. Large quantities of outdoor air are used for processing air heating applications. The second application is drying of agricultural products. This is a good application for solar energy, as the required temperature rise must be kept relatively low to prevent damage.

For solar energy in a SAH system, this is used for heating. There are likely to be times when energy is collected but cannot be used to offset heating loads. Only energy that can

contribute to reducing the heating load can be considered usable. Next, we will see the solar air heating background. So, Conservable Engineering's Solar Air Heating, or SAH, system has been demonstrated to be effective for heating or preheating air in a variety of applications.

The device, sometimes known as a solar wall, is most typically used in heat ventilation and air in buildings, but it has also been employed in operations like crop drying when warm air is required. So, this figure depicts the world's largest solar air heating system, which was installed at Bombardier's Canadair Division manufacturing site in Montreal, Canada. This industrial building project includes 10,000 meters of solar air heating collectors. To summarize all that we studied, solar air collectors are a very effective way to provide supplemental natural ventilation. A solar air collector thermoelectric hybrid system may be designed and manufactured.

The hybrid system's thermal efficiency improves as the air mass flow rate increases. To summarize, in today's class, we saw a system of heating air that can be used to either warm up the indoors or it can be used for any purpose where heat is needed for drying, and one of the applications is agricultural drying of products wherever it is required. This system can be made very compact, or this system can be very elaborate and space-consuming. The more space, the more collectors, the more heat can be generated, and that is where heliostats come into play. This system can be used on a smaller scale to heat residential areas in very cold climates. This can be used for heating residential areas. The heat produced can also be stored if a proper contraption is devised in order to keep the indoors warm throughout the day. So, today we saw a system of heating air with a solar collector, which comprises an absorber and a contraption to facilitate absorption of heat by means of either a metal plate or a glass, and from the absorber the warm air is carried through the tubes. There is an inlet that allows cool air to enter through the tubes, and because of the heat from the absorber plate, the air becomes warm, and the outlet gives warm air. Wherever necessary, this warm air can be thrown, whether it is inside a room or over a particular product.

To me, the analogy is similar to that of a hair dryer with a heater coil inside. Only thing is we use electricity to heat the coil, but here we can have a, in this case, we can have an absorber plate that absorbs heat and transmits it outside as warm air. So, today we saw yet another advanced passive system that has an application in cold climates or it has an application in warm climates where hot air is needed for certain purposes. With this, we stop today's class, and we will meet in the next class with yet another topic.