Solar Hot Water Systems – A Simple Guide to How They Work

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A typical modern solar thermal hot water system is an amazing example of robust and practical technology. The main component is the solar collector, a manifold with vacuum tubes. Each tube has a heat pipe. The whole ensemble is connected up to form a closed loop, which circulates an antifreeze mixture, that transfers the heat down to the water tank.

The vacuum tubes absorb solar energy, converting it directly into heat for use in water heating. Each solar vacuum tube consists of two glass tubes made from extremely strong borosilicate glass. The outer tube is transparent allowing light rays to pass through with minimal reflection. The inner one is coated with a special selective coating (Al-N/Al) which features excellent solar radiation absorption and minimal emission/reflection properties. The ends of the tubes are fused together with the space between them being evacuated. The insulation properties of the vacuum are so good that while the inside of the tube may be 175 °C, the outer tube is cold to touch.

Inside each evacuated tube is a heat pipe. This is an extremely efficient conductor of heat (in one direction only). The heat is transferred up to the bulb of the heat pipe, which fits snugly into the manifold, through which the working fluid (the antifreeze mixture) flows. As the working fluid circulates through the top (horizontal) pipe it is heated by the concentrated heat conducted up from each of the vacuum tube/heat pipes.

Heat pipes are very simple and hence very reliable. The heat pipe is hollow with the space inside evacuated, much the same as the solar vacuum tube. In this case insulation is not the goal, but rather to alter the state of the liquid inside. Inside the heat pipe is a small quantity of purified water and some special additives. At sea level water boils at 100 °C, but at lower pressures the boiling temperature will be less than 100 °C. Using this principle, an evacuated heat pipe has a boiling point of only 25 °C. So when the heat pipe is heated above 25 °C this water vaporizes. This vapour rapidly rises to the top of the heat pipe transferring heat. As the heat is lost at the condenser (top), the vapour condenses to form a liquid (water) and returns to the bottom of the heat pipe to once again repeat the process.

This makes heat pipes sound very simple - a hollow copper pipe with a little bit of water inside, and the air sucked out! To some extent this is correct, but in order to achieve this result more than twenty manufacturing procedures are required and all with strict quality control. Material quality and strict cleanliness are extremely important to the creation of a good quality heat pipe. If there are any impurities inside the heat pipe its performance will be adversely affected.

Is this high specification needed? A modern solar thermal water system is capable of converting up to 60% of the incident solar energy into useful heat energy. It can operate in temperatures as cold as -60°C so can contribute to water heating throughout a UK winter with no risk of frost damage. The tubes are even durable enough to withstand hailstones. It is because of this high specification that these solar thermal have an efficient working life of at least 25 years.