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Measurement of Moisture in Solar Thermal Electricity Plant Heat Transfer Liquid

Background

A new method of power generation is beginning to emerge, using solar energy to indirectly drive turbines, rather than photovoltaic cells.

This works by employing arrays of concave mirrors, which reflect the sun's energy onto a tube centered in the focal point of the mirror array. The tube consists of two layers of glass, a darkened internal tube to absorb the heat, surrounded by a clear glass tube to ensure dispersal of the heat evenly around the entire circumference of the heat-transfer tube.

The central tube is filled with a mixture of biphenyl/diphenyl-oxide. This fluid is similar in viscosity, appearance, heat capacity and other characteristics to water apart from its freezing point, which is around 20°C and, more critical to its intended purpose, a boiling point approaching 300°C. This gives it ideal characteristics to transfer the heat produced by the solar arrays, provided that the fluid is not allowed to freeze on cool nights. As such the fluid is maintained at around 60°C at night.

The arrays of mirrors are arranged in rows, and the transfer fluid flows in a loop around them to a power plant in the centre of the site. Power generation is by conventional steam turbine, the steam produced by heat exchangers, whilst further heat exchangers immersed in salt brine tanks are used to capture excess heat during the daytime in order to continue power generation at night whilst also maintaining the loop temperature above the freezing point of the fluid. Given the close proximity to water at two stages in the process there is considerable potential for moisture ingress into the fluid loop.

The purpose of the moisture measurement is to avoid the risk of pockets of steam appearing in the circulation loop due to high dissolved moisture concentration in the biphenyl/diphenyl-oxide mixture. The reasoning behind this is that if moisture saturation occurs in the fluid at the 60 deg C night time temperatures, then the separated liquid water would vaporize as the temperature rises for daytime operation, creating pressurized steam pockets. The danger is that the occurrence of such stream pockets can cause a significant increase in the pressure within the fluid loop, leading to leakage and permanent damage. During actual plant operations the moisture within the fluid is boiled off as

Field of mirror arrays

it passes through a vapor separator. The resultant steam is transferred to condensers.

However, in order to ensure the efficiency of the vapor separator, and to ensure that the moisture content of the fluid does not reach levels where damage could ensue, it is crucial to continually monitor the moisture content of the heat transfer fluid.


Moisture separation tank and condensers

Measurement Technique

This measurement can be undertaken by use of a Michell Instruments Liquidew system, which is capable of measurements accurate to the equivalent of ±1°Cdp from +20°Cdp to -59.9°Cdp, and ±2Cdp from -60°Cdp to -100°Cdp.

Several modifications are required for the sampling system to cope with the temperatures involved: The design now incorporates a sample cooling coil with more than twice the capacity of the conventional coil, to cool the incoming fluid from 250°C down to <50°C. There is also a thermal cut-out in the system, which immediately shuts off the sample flow to our measurement sensors if the fluid temperature exceeds 50^{o}C. The thermal shut-off automatically resets once the sample temperature cools below that threshold, ensuring minimal interruption to a continual operation.

Reference Users

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