Collector level overheating protection for Honeycomb solar thermal collectors

The problem

System overheating can degrade heat transfer fluids, accelerate scaling, cause premature component failure, and reduce system performance. Solar-thermal systems incorporate safety devices in the thermal loop in order to avoid these hazards. Such devices are normally are system-level temperature limiting sub-systems that add to the cost and design complexity of solar thermal systems.

The overheating problem is especially critical in systems incorporating high performance collectors. As a result of its high efficiency, TIGI's honeycomb collector can reach internal temperatures over 250 C under such circumstances.

TIGI introduces **collector-level** overheating prevention (OPD) which enables retention of the collector's high efficiency under normal working conditions but quickly transitions to fast excess thermal energy release to the atmosphere when a pre-set temperature is reached.

This is illustrated in figure 1 where collector efficiency is plotted versus collector interior temperature for a typical high end flat plate collector, honeycomb collector and honeycomb collector with an integrated overheat protection device.

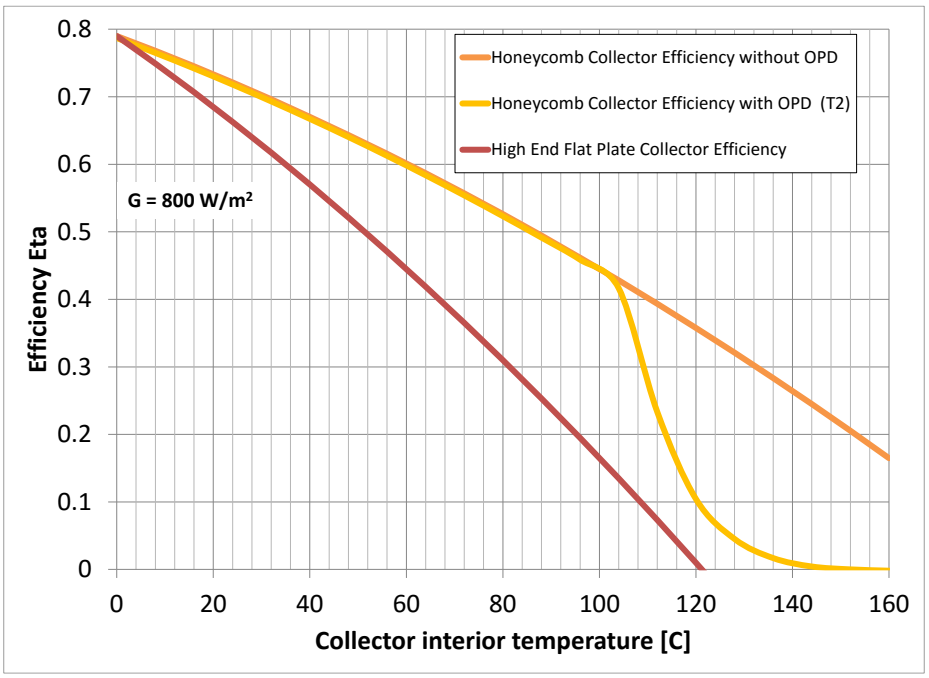

Figure 1: Collector efficiency dependence on collector interior temperature for high end flat plate collector, honeycomb collector and honeycomb collector with Overheat Prevention Device.

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The engineering principles

For maintenance-free extended product life, the engineering aim was to design a passive OPD with no moving mechanical elements such as valves, and no need for electrical elements. TIGI opted for closed loop heat-pipe technology for its ability to transfer large amounts of thermal energy by minimal mass transfer utilizing latent heat under phase change conditions. Unlike normal closed loop heat-pipes, in this case kick-in is designed to only start above a pre-selected temperature. The solution is based on a closed loop heat pipe which contains a dual fluid composition in contrast to conventional heat pipes which typically comprise single fluid in vacuum. The OPD shows fast transition between thermal isolation and thermal coupling between collector interior and external environment. It is based on a fluid loop which is independent of the primary heat transfer loop. The proprietary solution is protected by multiple patents.

The solution

The TIGI OPD includes the following elements:

- An internal evaporator thermally coupled to the absorber plate.
- A condenser, external to the collector's case, to dissipate heat to the atmosphere.
- A closed loop pipe connecting the evaporator and the condenser.
- The evaporator is filled with ethylene glycol/water up to about 90% of its volume.
- The system is neither pressurized nor evacuated.

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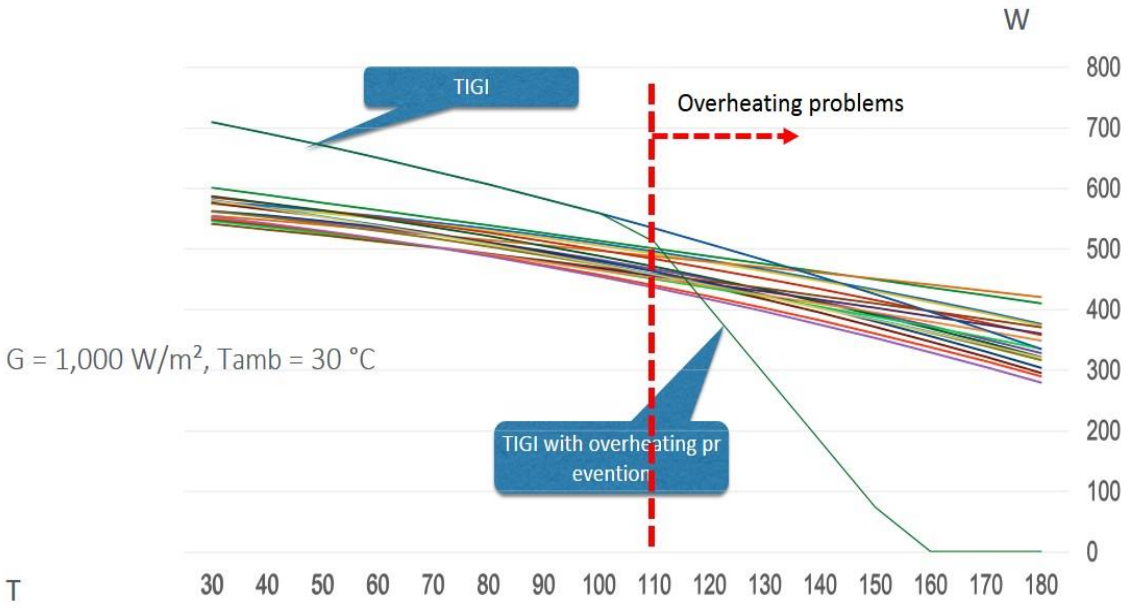
Testing and test results

Accelerated life tests were carried out at SPF for over 12 months of the OPD. It included among other dry stagnation test of 12 months on a solar tracker after which the performance was tested and showed no measurable decline in performance. The test results show that the OPD functions flawlessly according to specifications, kicks in and out as required and has very low parasitic heat losses.



Status

TIGI's HC1 includes an overheating prevention device that:

1. Is at the collector level
2. Has no losses until a pre-determined temperature (currently slightly above atmospheric pressure boiling point of water) and then transitions to very fast heat dissipation. Dry stagnation temperature < 130°C
3. Most efficient collector does not reach glycol cracking temperatures - reduces maintenance costs
4. Eliminates the cost related to system-level overheating protection
5. Simplifies design complexity related to system level overheating prevention
6. Solar Keymark certified and has undergone multiple robustness tests
7. Patent protected

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