Validation of Types816 and 817. Type817 is a version of Type816 that computes the flow rate that would be required in order to obtain a specified collector outlet temperature. The models are separate because Type817 requires additional parameters. Please note that the validation tests were carried out for the “WAVE” model. However, since the other models follow the same mathematical format and differ only in their parameter values, the results below hold for the “SPRING” collector and for both the insulated and uninsulated versions of both.

Test 1: When there is no flow through the collector, the temperature at the collector outlet should be equal to the collector ambient temperature. If the model accounts for thermal capacitance of the collector, the collector outlet temperature should decay to the ambient. Types 816 and 817 do not account for thermal capacitance and the collector outlet temperature is verified to be equal to ambient temperature under no-flow conditions.

Test 2: Under stagnation conditions (1000 W/m2 solar radiation but no liquid flow) the collector outlet temperature rises to 64.5C. This temperature is reasonable for unglazed solar collectors but would be low for glazed solar collectors whose stagnation temperatures typically reach 150-200C. Under stagnation conditions the power generated by the PV is 200W indicating an electrical efficiency of 20%, which is reasonable for a PV panel.

Test 3: When there is a very high liquid flow rate through the collector and solar radiation the collector outlet temperature should be equal to the inlet temperature. It is confirmed to be so. Under this high-flow condition the PV should generate the maximum power of all the tested cases. It does so. The power generated is 250W.

Test 4: With a very low flow rate, the collector outlet temperature should be between the stagnation temperature and the inlet temperature. In the case of both Types 816 and 817 a flow rate of ~8.25L/h and 1000W/m2 is needed in order for the outlet temperature to be below the stagnation temperature. With a flow rate of 0.1L/h and 1000W/m2 the collector outlet temperature is 106C.

Test 4a: The electric power generated by the PV shows a similar behavior. With a liquid flow rate of 0.1L/h, the panel produces 157.8W and should produce 200W (assuming that the stagnation temperature of 64.5C from test 2 is correct).

Test 5: With 1000 W/m2 solar radiation and “rated” liquid flow (37.5L/h) the collector has a thermal efficiency of 40% and an electrical efficiency of 14.5%.

Test 6: When two collectors are placed in series, the second should show an efficiency lower than that of the first. Under this case, the thermal efficiency of the first collector is 40% and the efficiency of the second is 25%. The electrical efficiency of the first collector is 14.5% and the efficiency of the second is 13.8%.

Test 7: The plot of thermal efficiency vs (Tinlet – Tambient)/Gt should be either linear or slightly quadratic depending on the algorithm used to account for incidence angle modification. It is linear in the case of Types 816 and 817.

Test 8: The plot of thermal efficiency as a function of liquid flow rate has the same shape as the plot for the standard TRNSYS collector model (Type1).

Other points for consideration:

The variable FLCONV in the Type816 and 817 code assumes that the liquid density is 1kg/L. If the collector is always used with water as its working fluid then this is not a problem. It is recommended that the working fluid liquid density be taken as a parameter as in the case of the working fluid specific heat.

Conclusions:

Type817 gives credible thermal and electrical energy production results over the whole range of reasonable ambient temperature, inlet temperature, and solar radiation. Care should be taken in analyzing results for low flow rate (less than 8.5L/h per panel) situations as outlet temperatures will be higher electrical production will be lower than at stagnation conditions.

The above tests indicate that the model respects basic thermodynamic laws and shows the behavior that one would expect. In order to state that the model results match performance that could be measured in the field it would be necessary to have a data set of recorded measurements. A data set of 15 minute measurements for a period of at least one week would be required in order to determine categorically that Types 816 and 817 accurately model both steady state and transient behavior.

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