CASCADED ORGANIC RANKINE CYCLE SYSTEM

BACKGROUND

The present disclosure relates generally to Organic Rankine Cycle (ORC) systems and, more particularly, to a cascaded organic Rankine cycle.

The Organic Rankine Cycle (ORC) is a vapor power cycle with an organic fluid refrigerant instead of water/steam as the working fluid. The working fluid is heated in an "evaporator/boiler" by a source of waste or low quality heat. The fluid starts as a liquid and ends up as a vapor. The high-pressure refrigerant vapor expands in the turbine to produce power. The low-pressure vapor exhausted from the turbine is condensed then sent back to the pump to restart the cycle.

The simple rankine cycle used for power generation follows the process order: 1) Adiabatic pressure rise through a pump; 2) Isobaric heat addition in a preheater, evaporator and superheater; 3) Adiabatic expansion in a turbine; and 4) Isobaric heat rejection in a condenser, although other cycle modifications are possible such as the addition of a vapor-to-liquid recuperator.

A main thermodynamic irreversibility in organic Rankine cycles is caused by the large temperature difference in the evaporator between the temperature of the waste heat stream and the boiling refrigerant. The higher the waste heat stream temperature the greater this irreversibility becomes. One way to reduce this loss is to cascade two thermodynamic cycles together where a cycle operating at higher temperatures rejects heat to a cycle operating at lower temperatures.

SUMMARY

A cascaded Organic Rankine Cycle (ORC) system according to an exemplary aspect of the present disclosure includes a bottoming cycle in thermal communication with a topping cycle through a condenser/evaporator in which a bottoming cycle working fluid is first evaporated and then superheated and a topping cycle working fluid is first desuperheated and then condensed such that a percentage of total heat transfer from the topping cycle fluid that occurs during a saturated condensation is equal to or less than a percentage of total heat transfer to the bottoming cycle fluid that occurs during a saturated evaporation.

CLAIMS

What is claimed is:

1. A cascaded Organic Rankine Cycle (ORC) system comprising:

a topping cycle; and

a bottoming cycle in thermal communication with said topping cycle through a condenser/evaporator in which a bottoming cycle working fluid is first evaporated and then superheated and a topping cycle working fluid is first desuperheated and then condensed such that a percentage of total heat transfer from said topping cycle fluid that occurs during a saturated condensation is equal to or less than a percentage of total heat transfer to said bottoming cycle fluid that occurs during a saturated evaporation.

2. The system as recited in claim 1, wherein said working fluid for said topping cycle is Siloxane MM.

3. The system as recited in claim 1, wherein said working fluid for said bottoming cycle is R245fa.

4. The system as recited in claim 1, wherein said bottoming cycle includes a recuperator.

5. The system as recited in claim 1, wherein both said bottoming cycle fluid and said topping cycle fluid in the condenser/evaporator are saturated over approximately 40% of said total heat transfer.

6. The system as recited in claim 1, further comprising a hot oil circuit in thermal communication with said topping cycle through an evaporator.

7. The system as recited in claim 1, further comprising a cooling circuit in thermal communication with said bottoming cycle through a condenser.

8. A method of operating a cascaded Organic Rankine Cycle (ORC) system in which a bottoming cycle is in thermal communication with a topping cycle comprising:

maintaining a percent saturation for a working fluid in the topping cycle at less than a percent saturation for a working fluid in the bottoming cycle.

9. The method as recited in claim 8, further comprising:

utilizing Siloxane MM as the working fluid in the topping cycle; and

utilizing R245fa as the working fluid in the bottoming cycle.

10. The method as recited in claim 8, further comprising:

utilizing a condenser/evaporator as the thermal interface between the bottoming cycle and the topping cycle.

11. The method as recited in claim 8, further comprising:

operating a condenser/evaporator as a condenser for the topping cycle and as an evaporator for the bottoming cycle.

12. The method as recited in claim 8, wherein a "knee" of the working fluid in the topping cycle flowing right to left lies to the left of the "knee" of the working fluid of the bottoming cycle flowing left to right in a normalized enthalpy plot.

13. The method as recited in claim 8, wherein the working fluid in the topping cycle is at less than a 40% saturation for the working fluid in the bottoming cycle.