A Hybrid Refrigeration and Power Cycle with Ammonia-Water Mixture

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Abstract:

Cogeneration systems typically use waste heat from power cycles such as gas turbines for steam or hot water production. We developed a unique cogeneration plant to explore cascading energy use, which we call an Advanced Co-Generation System (ACGS). The ACGS is a so-called polygeneration plant capable of generating electricity, steam, hot water, and chilled water concurrently. It offers three stages of power cycles: a gas turbine as Brayton cycle at topping, a steam turbine as Rankine cycle at middle and an ammonia-water mixture turbine as Kalina cycle at bottoming stage. At the bottoming stage, a Kalina cycle and an ammonia-absorption chiller are linked with pipes to share the ammonia-water mixture, the "natural" working fluid. This represents a novel hybrid cycle for generating power and heat to meet both electricity and chilling needs. Due to the mismatch between demand patterns and nominal plant performance at rating, seasonal changes in demand can result in low efficiency with conventional cogeneration systems over the course of the year, especially in periods of low heating/cooling demand. The ACGS makes it possible to compensate for low heat demand by combining the three stages of power cycles to increase electrical production.

The overall system configurations and some experimental results of the steady state are shown. The effectiveness of the bottoming stage that employs an ammonia-water mixture as the working fluid is confirmed by experimental investigation. The experimental investigation shows that the AWM bottoming power-refrigeration cycles contributes to a higher bottoming efficiency, which is about 7.0 % in electric power. Otherwise, the efficiency at the middle stage in conventional combined gas and steam turbine power plants is 4.6 %. The cogeneration efficiency at the bottoming reached about 26.5% which is the heat and power ratio to the heat input from the heat recovery steam generator.

Keywords:

Kalina Cycle, Cogeneration, CHP, Absorption, Ammonia-Water mixture