Advanced Heat Recovery

Piecing Together An Effective Cogeneration System

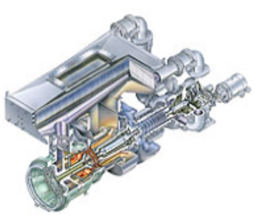
The most basic thermodynamic cycle for power generation involving a gas turbine is the simple Brayton cycle, which involves the compression of air, the introduction and combustion of fuel into the compressed air, and the expansion of the combustion exhaust through a set of turbine blades. Cogeneration systems utilize the hot exhaust gasses to perform useful work and produce steam for heating and cooling applications. The efficiency of these cycles depends largely on the amount of heat that can be recovered.

There exists a broad range of cycle improvements and modifications that can be made to a standard cogeneration system to improve its thermal efficiency and power output. Three specific modifications – reheat, recuperation, and intercooling – are given the largest focus in academic research because they are effective and firmly established ideas that have been tested in industrial applications.

Reheat:

Reheat involves processing the exhaust of a first-stage turbine in a second-stage turbine for additional power extraction. Between the two turbines, exhaust temperature is raised by injecting and combusting supplemental natural gas (or another fuel type if it is available). The effectiveness of this modification depends on the pressure and oxygen content of the first-stage turbine exhaust stream. Reheat creates an increase in power output and usually a small gain in cycle efficiency.

Recuperation:



Recuperation, also commonly referred to as regeneration, involves heating the compressed air before it is combusted by passing it through a heat exchanger with the turbine exhaust gases. Raising the initial air temperature decreases the amount of fuel necessary to bring the gases up to the turbine operating temperature, thereby decreasing the running costs and total emissions. The Solar Mercury 50 (click on thumbnail to the left) is perhaps the only turbine of its size on the market to feature a recuperator.

Intercooling:

Thermal efficiency can also be increased by decreasing the required work of compression through a process known as intercooling. Such a process usually involves two stages of compression. The air is water-cooled after the first stage to decrease its volume and thus decrease the work required to compress it further in the second stage. Intercooling also increases the density of the inlet stream, consequently increasing the mass flow rate of the process and thus the power output.

Any combination of these three cycle improvements can be employed in the design of a more efficient cogeneration system. It is possible that several modifications could also work in concert to produce higher gains in efficiency. If, for example, a turbine is recuperated, it requires less fuel to bring the air to a desired operating temperature. Decreasing the amount of fuel combusted increases the amount of oxygen in the exhaust stream, potentially enhancing the effectiveness of reheat, which relies on combusting that oxygen.