Operating Gas Turbines at Maximum Efficiency

High efficiency achieved in partial-load operation Gas-turbine optimum operation system

The installation of gas-turbine power generation facilities is increased worldwide. Requests for high efficiency not only in rated-load operation but also in partial-load operation have been increasing over the past few years. What is IHI's power generation control system that always gives our clients the advantage in a wide range of operations?

General view of LM6000 combined cycle

Inlet-air heating coil using steam

Efficiency of partial-load operation, a key to business feasibility

The need for distributed power supplies has recently been increasing both in Japan and abroad due to various environmental changes, such as mitigation of the risks to energy supply, CO_2 emission reduction requirements, and electricity deregulation. As a way to satisfy these needs the demand for gas-turbine power generation facilities, such as those provided by IHI, is increasing worldwide in applications for medium-sized power generation businesses and private power generation.

Gas-turbine power generation facilities produce combustion gas by combusting fuel, such as natural gas and kerosene, and generate electricity by turning a turbine with the combustion gas. In addition, the introduction of co-generation and a combined cycle allows effective energy use by reusing the hot exhaust gas from a turbine and thereby provides environmental and economical advantages for our clients. In some cases, however, clients are unable to benefit the advantages indicated in an initial plan.

Power generation facilities are generally planned to have a capacity sufficient for the expected maximum demand (rated load). In medium-sized power generation and private power generation, the power-generation load is often changed to suit the fluctuating electricity demand, and operation under a partial load, a load lower than the generation capacity, frequently accounts for a large part of actual operation. Since gas turbines decrease in efficiency during partial-load operation as is the case with other internal-combustion engines, frequent operation in the low-load region will lead to deterioration of a specific fuel combustion, causing the actual advantages to be less than initially planned.

It is generally said that fuel costs account for 60 to 70% of the generating costs, and generating efficiency is the most important index that affects business feasibility. That is why we have received requests for increased efficiency in partial-load operation over the past few years from clients who undergo significant fluctuations in electricity demand depending on the time of use, such as daytime, nighttime, weekdays, and holidays. In some overseas projects, such partial-load operation accounts for 40% or more of the total

operating hours. High performance in partial-load operation sometimes governs business plans.

High efficiency in partial-load operation can be achieved by a method in which the number of operating turbines is changed depending on the load. However, this method is disadvantageous in terms of the space required for the power generation facilities, the increase in the cost of equipment, etc. Thus it is necessary to provide power generation facilities that use one gas turbine to cover operation over a broad range of loads from low-load operation to high-load operation at high efficiency without increasing the number of turbines.

IHI's technologies for maintaining high efficiency

To meet this need, IHI developed the following system and is providing it to its clients. This system controls a gas turbine to perform rated-load operation instead of partial-load operation even under a low power-generation load, thereby maintaining high-efficiency operation in the partial-load region of the power generation facility.

(1) Inlet-air heating system

Gas turbines change their output characteristics depending on the inlet-air temperature; their output increases at low inlet-air temperatures and decreases at high inlet-air temperatures. This characteristic allows a gas turbine to be operated at the rated load even under low electricity demand by increasing the inlet-air temperature instead of operating the gas turbine at partial-load.

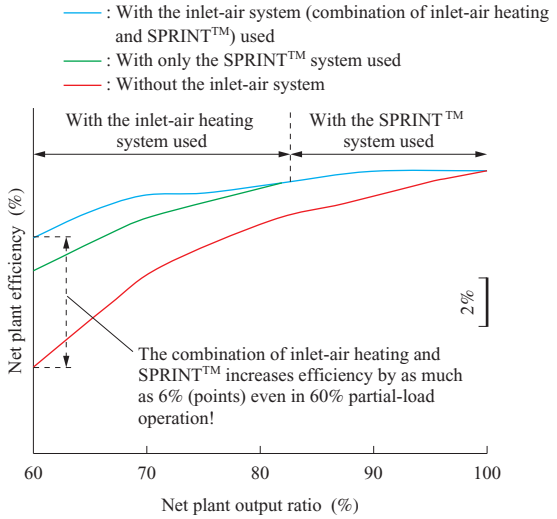
IHI developed a system that increases the inlet-air temperature by directly leading the steam from a heat recovery steam generator, which uses the exhaust heat from a gas turbine, to an inlet-air heating coil. However, the surface temperature of inlet-air heating coils tends to become uneven depending on the flow rate of steam supplied. This tendency causes a technical issue with this heating system. That is, it is difficult to achieve the uniform temperature distribution required for the inlet air when the system is planned to cover a wide range of heating amount for inlet-air heating, or in other words, when the steam flow rate varies significantly. We therefore developed an inlet-air heating coil and a control system that are capable of uniformly heating inlet air even if the heating amount required for the inlet air varies. The inlet-air heating coil and control system use steam to achieve optimum inlet-air heating at various load levels.

Thus, we developed a system that maximizes the advantages of inlet-air heating. This system reduces power requirements and significantly shortens the transition time to the inlet-air heating mode, compared with conventional inlet-air heating systems that use hot water to transfer the heat of steam.

(2) SPRINT™ system

Some models of the aeroderivative gas turbines that IHI deals with are equipped with an output-enhancing system called SPRINT™ (SPRay INTercooling). This system increases the fuel supply to achieve enhanced output by spraying water at the compressor inlet to reduce the temperature at the compressor outlet via heat of vaporization. The system is capable of seamlessly controlling gas-turbine output under rated-load operation by controlling the amount of water sprayed according to the gas-turbine required output determined on the basis of electricity demand.

To use these two systems effectively, we also developed a control system that achieves an optimum combination of inlet-air heating and the operation of the SPRINT™ system on the basis of data collected in real time, such as electricity demand, outside air conditions, and the operating conditions of the gas turbine. This control system automatically optimizes the operating state of the gas turbine even when electricity demand decreases depending on the time of use and season, thereby allowing the power plant to be operated with high efficiency even under a partial load. This control significantly reduced fuel costs.



(Note) Performance conditions
· Ambient temperature : 25°C, Atmospheric pressure : 101.3 kPa, Fuel : Natural gas

Net plant efficiency under a partial load

IHI will continue making efforts to achieve higher levels of efficiency and to meet the needs of our clients by optimizing the entire power-generation system based on a deep understanding of the characteristics of gas turbines and our advantages as a gas-turbine packager and EPC (Engineering, Procurement, and Construction) contractor.

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