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Analyzing the Fuel Efficiency of Gas Engine in Integrated Energy System

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Abstact

An advanced system of gas engine inlet air deep cooling by chilled water from ACh, subsequently subcooled by boiling ECh, recovering waste heat of engine, has been developed, that provides decreasing specific fuel consumption by 2.5-3.0 g/kWh due to stabilized low temperature of air at the suction of turbocharger at increased ambient air temperatures.

This system does not require considerable addition investments over existing one so as the ECh consists generally of heat exchangers of quite small sizes because of reduced heat loads for cooling engine cyclic air as compared with traditional cooling all the engine room incoming air that was proved by analyzing the monitoring data

Keywords: Operation Efficiency, Air conditioning system Integrated power plant

Introduction

Gas engines, operating on natural gas or alternative gaseous fuels are widely used in integrated energy systems (IES) for combined electricity, heat and cooling [1-5]. They are manufactured as cogeneration modules with heat exchangers to produce hot water or steam through utilizing the exhaust gas heat, the heat of scavenge air or gas-air mixture, engine jacket cooling water and lubricating oil. A hot water or steam is used as a heat source for absorption chiller.

Results

The specific fuel consumption of gas engines increases with rising the temperatures of air at the inlet and scavenge gas-air mixture.

In conventional practice of IES operation the ambient air is cooled in the air cooler of central conditioner by chilled water with temperature of about 7 °C from absorption lithium-bromide chiller (ACh) and is directed into the engine room from where it is sucked by turbocharger (TC). Because of large volume of incoming air and heat influx from surroundings in the engine room the temperature at the inlet of TC is much higher than at the outlet of the central conditioner and needs increased cooling capacity as compared with delivering the chilled air directly to the suction of TC.

It is reasonably to provide deep cooling engine cyclic air and directing the chilled air from the air cooler throuh air ducting immediately to the suction of TC.

To evaluate the effect of gas engine cyclic air deep cooling the data on dependence of fuel consumption and power output of gas engine JMS 420 GS-N.L at varying ambient and its inlet air are required. These data can be received by treatment of gas engine fuel efficiency monitoring.

The goal of the research is improving the fuel efficiency of IES on the base of gas engines while operation at increased ambient air temperatures through gas engine inlet air deep cooling in absorption lithium-bromide chiller and refrigerant ejector chiller and feeding chilled air directly to the suction of turbocharger.
Research Methodology

The efficiency of cooling air at the inlet of gas engine was investigated for IES of combined energy supply at the factory "Sandora"–"PepsiCo Ukraine" (Nikolaev, Ukraine). The IES is equipped with two cogenerative Jenbacher gas engines JMS 420 GS-N.LC (each of rated electric power $P_{e\text{ISO}}$ = 1400 kW, heat power Q_h =1500 kW), in which the heat of the exhaust gases, scavenge air-gas mixture, engine jacket cooling water and lubricating oil is used for heating water to the temperature of about 90 °C. The hot water is used in AR-D500L2 Century absorption Li-Br chiller to produce a chilled water of 7 °C, which is spent for technological needs and feeding to the central air conditioner that provides cooling ambient air incoming the engine room, from where it is sucked into the engine turbocharger.

An advanced cooling system of gas engine inlet air by chilled water from the absorption lithium-bromide chiller (ACh), subsequently subcooled by boiling refrigerant of ejector chiller (ECh), was developed.

To evaluate the effect of gas engine inlet air deeper cooling, compared with conventional its procession in the central air conditioner for cooling all ambient air coming into the engine room, data on the variation of fuel consumption and power output of gas engine at varying ambient air and engine inlet temperatures were received by treating the results of gas engine JMS 420 GS-N.L efficiency monitoring.

The enhancement of gas engine fuel efficiency due to the application of developed its cyclic air cooling system was estimated by decrease in current specific fuel consumption Δb_e and its summarized daily values $\sum\Delta b_e$ due to engine inlet air cooling to the temperatures of 7, 10 and 15 °C compared with conventional cooling all the engine room incoming air followed by heat influx from surroundings, that leads to increased air temperature t_{in} at the inlet of turbocharger and enlarged cooling capacity spent for inlet air cooling.

A treatment of monitoring data on fuel efficiency of gas engine JMS 420 GS-N.L in integrated energy system for combined electricity, heat and cooling generation has proved inefficient operation of conventional cooling all the engine room incoming air followed by heat influx from surroundings, that leads to increased air temperature at the suction of turbocharger and enlarged cooling capacity spent for cooling.

Conclusions

An advanced system of gas engine inlet air deep cooling by chilled water from ACh, subsequently subcooled by boiling ECh, recovering waste heat of engine, has been developed, that provides decreasing specific fuel consumption by 2.5-3.0 g/kWh due to stabilized low temperature of air at the suction of turbocharger at increased ambient air temperatures.

This system does not require considerable addition investments over existing one so as the ECh consists generally of heat exchangers of quite small sizes because of reduced heat loads for cooling engine cyclic air as compared with traditional cooling all the engine room incoming air that was proved by analyzing the monitoring data

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