Prediction of power generation capacity of a gas turbine combined cycle cogeneration plant

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LongAbstract

Introduction

A cogeneration plant is an electric power generation system that produces electricity and heat simultaneously and has an advantage of efficient use of natural resources. In general, the gas turbine is very suitable for cogeneration purposes. Gas turbines with a variety of power range are availabe for cogeneration applications and researches are being performed steadily [1,2]. In particular, electric power generation combined with district heating using gas turbines is a popular large-scale congeneration system in Korea. The power generation capacities of such power plants vary with the change of heat demand, ambient, fuel conditions and so on. In addition, they decrease naturally because of degradation of the gas turbine with the cumulation of operating hours. A typical and the most influencial exmaple is the performacne reduction caused by compressor fouling. Prediction of the exact power generation capacity of a power plant is important both for the health monitoring of facilities and electric grid management. In this work, we set up a methodology to precisely predict power generation capacity of gas turbine combined cycle cogeneration plants using correction curves of the gas turbine and thermodynamic modeling of the bottoming cycle. This paper describes a brief of the methodology and results of the prediction for a specific power plant.

Method and Result

GateCycle 6.0[3] was used as the calculation engine of the analysis. The combined cycle cogeneration plant was modeled based on the heat and mass balance diagram under the ISO condition (15℃, 1.013bar and 60% relative humidity). Figure 1 shows the configuration of the combined cycle cogeneration plant. The system is composed of two gas turbines, two heat recovery steam generators and a dual-pressure steam turbine. At the ISO condition, the power outputs of the gas turbine and the steam turbine are 200MW (2x100MW) and 111MW, respectively. To predict the performance under various conditions, correction curves were used for the gas turbine and an off-design model was used for the bottoming cycle.

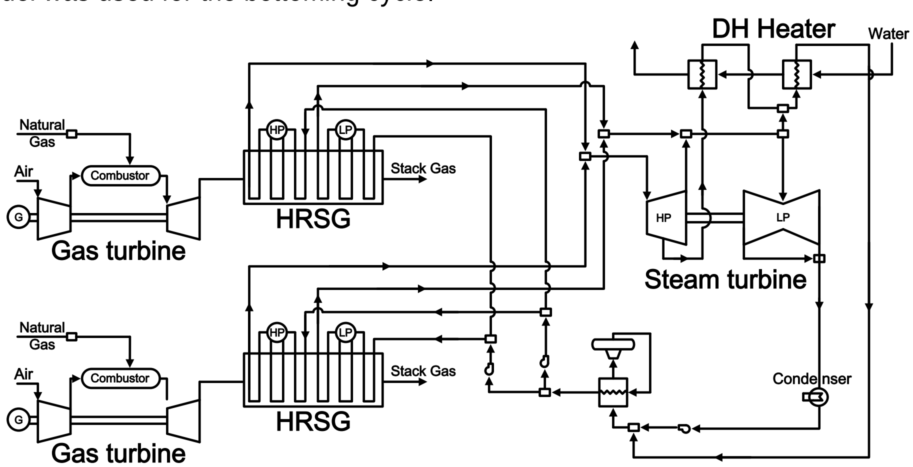

Figure 1. Configuration of the combined cycle cogeneration plant

We collected operating data from the power plant and selected several periods for our analysis. For a period which consists of seven days, we used the first five-day data for training the prediction tool (or deriving correction factors) and the last two-day data for tool validation. In other words, we considered the first five days as ‘the past’ and the last two days as ‘the future’. Firstly, the plant performance of the past five days were calculated using the given operating data including ambient temperature, pressure and relative humidity and gas turbine load factors. Figure 2 shows an example of the variation of ambient temperature during a specific seven-day preriod. A comparison between the calculated and measured powers during ‘the past’ was made. The comparison produced an average degradation factor, which made the difference between the two data sets minimal. The trends of the two data sets are usually very similar, which means that the standard deviation of the difference is small. Figure 3.(a) shows an example of the comparison. The average degradation factor of Figure 3(a) is about 0.97, which means that the measured power was 3% lower than the calculated one on the average. Then, the future power was calculated by using the operation data (ambient temperature and so on) of the last two days and the degradatrion factor, which provided the power generation capacity of the future. Figure 3.(b) shows the results of the prediction for ‘the future’. The discrepancy was less than 1%, which validated our metholodogy. The developed methodolody can be applied to any gas turbine based power plants with some site-specific considerations such as the discrepancy between the forcasted ambient air condition and the real engine inlet air condition.

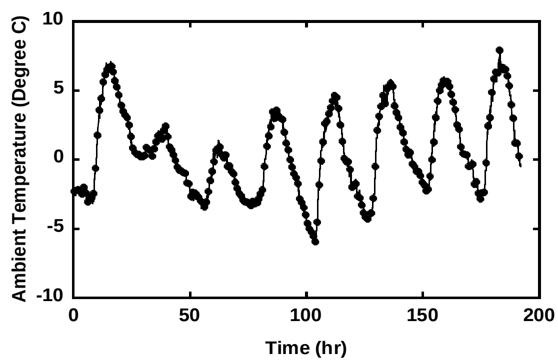

Figure 2. Variation of ambient temperature

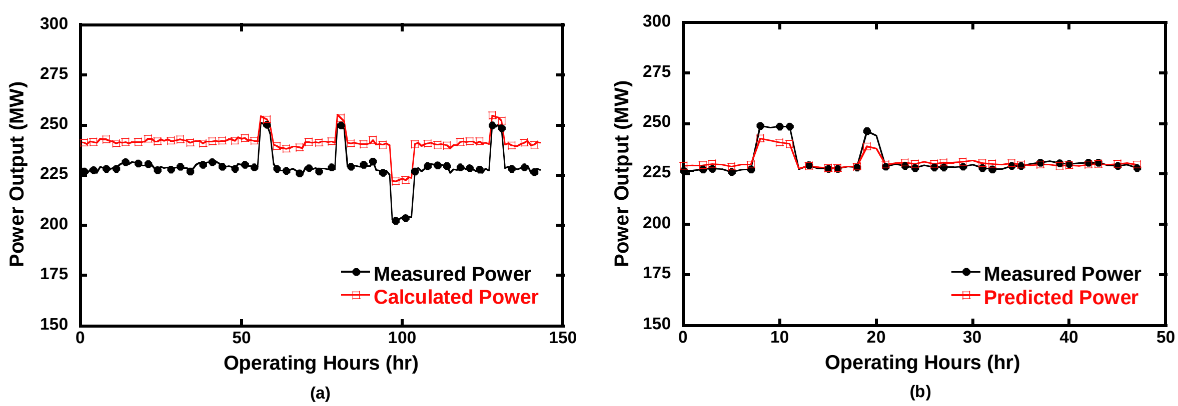

Figure 3. Comparison and validation of the methodology : (a) calculated and measured powers, (b) predicted and measured powers

References

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[3] GE Energy, GateCycle 6.0, 2006.