The 9th International Conference on Applied Energy – ICAE2017

The exergy and energy level difference graphic analysis of a CCHP system under compressor inlet air throttling (IAT) operating strategy

Zefeng Wang\textsuperscript{a,b}, Wei Han\textsuperscript{a,b*}, Na Zhang\textsuperscript{a,b}, Jie Sun\textsuperscript{c}

\textsuperscript{a}Institute of Engineering Thermophysics, Chinese Academy of Sciences, Beijing 100190, China
\textsuperscript{b}University of Chinese Academy of Sciences, Beijing, China
\textsuperscript{c}Xi'an Jiaotong University, Xi'an, China

Abstract

The part-load performance of combined cooling, heating and power (CCHP) system based on exergy and energy level graphic analysis under compressor inlet air throttling (IAT) operating strategy is presented in this paper. The results show that the combustor (COMB) is found to have the largest exergy destruction followed by high-pressure generator (HPG). Compared with the reducing turbine inlet temperature (TIT) operating strategy, the exergy destruction of COMB is decreased under IAT operating strategy; however, the opposite result is presented in HPG. A new graphic analysis based on energy level difference is proposed to indicate the potential to enhance the thermodynamics performance of the components under different operating strategies. The decrease of the energy level difference in the COMB and HPG is a most positive way to decrease the exergy destruction with IAT and TIT operation strategies.

© 2017 The Authors. Published by Elsevier Ltd.
Peer-review under responsibility of the scientific committee of the 9th International Conference on Applied Energy.

Keywords: CCHP, exergy analysis, energy level difference graphic analysis

1. Introduction

Global climate change and energy shortages are driving researches that focus on innovative technologies to improve energy utilization efficiency. Combined cooling, heating and power (CCHP) systems can also be regarded as the trigeneration systems which generate power, cooling and heating, simultaneously. Typically, in a cascade process, first the fuel is converted into power in gas turbine, then the surplus heat contained in the flue gas is used to generate cooling energy with absorption chiller and/or to meet the user’s heating demand. CCHP systems have been widely adopted into residential buildings, hospitals, office building and so on [1, 2].

The performances including energy, cost and environment of CCHP systems are obviously dependent upon part-load operating strategy. Typically, following electrical strategy (FEL) and following thermal
strategy (FTL) are two traditional operating strategies [3, 4]. Further, a new operating strategy following a hybrid electric-thermal load (FHL) to avoid superfluous heat in the FTL and superfluous electricity in the FHL is presented in [5, 6]. At off-design conditions, it is very important pay attention to the operating strategy of gas turbine which obviously affects the thermodynamic and economic performance of CCHP systems. Several operating strategies are used to control load for gas turbine, e.g. the reducing turbine inlet temperature (TIT), compressor inlet guide vane angle and variable stator vane angle, etc. In addition, the inlet air throttling (IAT) operating strategy has been proposed by the authors’ research group [7]. The results demonstrate that the overall system efficiency can be significantly improved compared with the TIT operating strategy.

Most literatures about the part-load performance analysis and optimization of CCHP systems analyzed the effects of off-design operating strategy; there are few literatures to investigate the operating strategy based on second low analyses. This paper is the extension of Ref. [7] and to pay attention to the exergy and energy level analysis of the CCHP system under different operating strategies to reveal the energy saving mechanism of the IAT control.

2. CCHP system description

The CCHP system analyzed in this paper has the similar structure and equipment as the CCP system in Ref. [7]. Typically, in this system, the hightemperature is recovered for power production in small-scale gas turbine followed by cooling energy production in double-effect absorption chiller. Besides, a hot water heating exchanger (HX) is applied to recover the low-temperature exhaust gas from double-effect absorption chiller to produce hot water. The detailed configuration of the CCHP system is illustrated in Fig. 1.

3. Operating strategy of CCHP system and model description

3.1 Operating strategy of CCHP system

The authors of [7] propose an alternative operating strategy known as IAT to improve the off-design performance of the CCHP system. The air (0) is throttled by the throttle valve to decrease the density of the compressor inlet air (1), as shown in Fig. 1. Because the gas turbine volume flow maintains constant, the mass flow of air (1) is decreased with the decreasing of air density at lower compressor inlet pressure.

3.2 The operating mode of the hot water exchanger

In this study, the CCHP system is simulated using ASPEN PLUS process simulation software [8], in which, every model is based on the mass balance and energy balance, with a default relative convergence error tolerance of 0.01%. The off-design performance of the gas turbine is based on the analytical
دریافت فوری
متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات