学位論文内容の要旨

Need and use for fuel and energy are both particular roles throughout mankind history and is simultaneously related the environmental issues such as air and water pollutions, and global climate change. Indigenous fuel and energy resources for industrialized nations are extremely begun to come to the fore while there have many questions for conventional plants as "how to manage, how to treat, how to get clean environment, which is the best or actual use technology, etc". One of the valuable solutions is energy saving technologies. They can be widely found in many sectors with various engineering fields and technologies. Electrical power and heat energy are the essential need of industrial and commercial use. Their generation procedures can save energy by using cogeneration systems although policy is still needed to develop. Most of productions in power and heat energy can be separately generated in their own processes. Cogeneration system (CGS) is needed to cooperate for both purposes in single process.

In Chapter 1, it is briefly discussed about their relationship among cogeneration systems, man-made emissions, primary use power and energy and renewable fuel production. Cogeneration system can reduce the certain percentages of man-made emissions, primary energy consumption by utilizing renewable fuel effectively. In Chapter 2, overview of the systems is described in the conventional and CGS arrangements with regarding specifications. Moreover, manufacturer's standard data and ambient temperatures for simulation procedure are also discussed. In Chapter 3, applied performance analysis of the CGS is described under three modules such as Brayton regenerative cycle, Relationship among ε-NTU-C_R and Zero order model. In Chapter 4, efficiency well-balance method and six kinds of determinable criteria are proposed to obtain the advantages of the CGS. Operation modes of the cogeneration systems are also briefly discussed.

To obtain the benefits of the CGS, micro gas turbine cogeneration system is adopted as a model plant and many approaching methods and purposes are investigated in separated models, Chapter 5 case study. In model 1, it can be found that mass flow rate and ambient temperatures significantly influence on the system and desirable temperature range can be obtained in simulation procedure. The effective efficiency well-balance method is proposed for maximum performance investigation of the CGS. It can measure the energy balance and benefits of the CGS, thermodynamically. Fuel energy saving index is also proposed to obtain profits of economy and cost for user. It can be provided to choose the selection technology for any sector.

In model 2, actual use of renewable fuel applies on cogeneration technology and it can be investigated in energy balance in actual demand and simulated supply from the CGS. Moreover, one of fuel energy storage systems is proposed to analyze for improving the overall energy efficiency of biogas production plant. Experimental data of the CGS is also compared with simulation results. Multiple operation of micro turbine can be also investigated in matching to heat demand mode. The proposed system has supported the recovery of energy from waste, providing a clean development mechanism for reducing greenhouse gas emissions.

In model 3, influence of ambient temperatures on the CGS has been briefly discussed in model 1. In here, hourly ambient temperatures are widely described as input data of the CGS for cold region between May 1, 2004 and April 31, 2005.

Energy efficiency based on maximum heat energy is also proposed to measure the advantages of the system. Moreover, the direct impact on energy saving, monetary, CO_2 emissions of the CGS is proposed to investigate in simulation procedure with regarding five periods.

In model 4, simulation procedure and input data are nearly same as model 3. However, energy efficiency based on useful heat energy is mainly proposed to obtain benefits of the CGS. It can be found that thermodynamic efficiency is not sufficient to evaluate the CGS. Five criteria are also proposed to determine the system performances and it can actually measure in technology of micro cogeneration system. This proposed system can save nearly 20% of conventional power and boiler separated systems. It is meant that if the CGS is operated in power and heat energy generation sectors, 20% of energy usage and its related economic, emissions will be reduced in operation.

After describing four models, actual determinable tools or criteria of the CGS can be discussed in this research. The CGS can effectively save energy by using sustainable ambient temperatures and renewable fuel source. Its related monetary, fuel consumptions and emissions can be saved and the CGS can be called environmental friendly technology.

論文審査結果の要旨

本研究は、将来的に懸念されるエネルギー不足に備えて、限られた燃料資源をできるだけ効率高く利用するための手法として注目されているコジェネレーションの有効性を明らかにすることを目的としている。とくに、未だ十分に把握されているとはいえないマイクロガスタービン(MGT)・コジェネレーションシステムについて、寒冷地での実証データを基にこれに計算解析を加えることでシステム性能に関する支配的な影響因子の把握と総合性能の評価を行っている。まず、MGTから排熱回収機にいたる一連の熱エネルギー入出力バランスを解析することで、特徴的な5段階の周囲温度条件の分類で稼働時の基本性能が分けられることを明らかにした。さらに、実用化を目指して下水処理施設で通常発生するバイオガスの燃料利用を想定して、季節温度変化に対するバイオガス発生量の変化とこれに伴って発生する余剰および不足バイオガス量の取扱いを考慮したシステム構成の提案を行っている。その場合、システム周囲の稼働温度条件が17～27℃の範囲内では、バイオガスハイドレート化等の貯蔵手段を講じて過不足なく通年でのエネルギー利用バランスが保持できることを示した。最後に、季節の違いに基づく温度変化の違いから、システムの有効熱電比(H/E)、あるいは燃料節約率(FESI)等の特性値導入が有効であることを示した。とくに、MGTコジェネレーションでは、通年稼働の範囲でH/Eが1.9で最良のシステム性能を示すこと、FESI値は通年で0.29～0.37の範囲で変動することを明らかにした。また、本システムの導入によって、従来のボイラを中心とした同規模のシステム構成に比べて、総合効率およびCO_2削減率の点から20%の向上効果が得られることを明らかにした。

以上を要するに、申請者は寒冷環境に至るまでの温度条件下において、マイクロガスタービン・コジェネレーションシステムの実用性を明示するとともに、その普及に著しく貢献するものである。よって申請者は北見工業大学博士（工学）の学位を授与される資格があるものと認める。