A Simulating Study on Thermal Efficiency of a Small Gas Turbine Engine With a Reciprocating Gasifier (Part 2)

OZAKI Masayuki, MIYAIRI Takeshi, ITOH Takane
Tokai University

1. Introduction

Small gas turbine engines are generally low thermal efficiency because of their lower turbine inlet gas temperature caused by difficulty of introducing complicated cooling systems as used in large engines. Generally speaking, the maximum cycle temperature and pressure in a reciprocating heat engine is very high compared with an usual gas turbine cycle. Authors have been conducted simulating study on a new gas turbine system with a reciprocating gasifire. The basic configuration has a reciprocating gasifire, which drives only a supercharging compressor and produces high temperature and high pressure gas and supplies it to a power turbine. The cycle optimization has been conducted by using the specific simulating program developed for this purpose. In the previous paper(1), they showed the possibility of an improved system with the thermal efficiency of over 46%. However, the engine configuration was rather complicated. In this paper, another improved configuration will be introduced and its performance will be analyzed.

2. Simulating Method

The compressor work and the turbine output were calculated from given pressure ratio, expansion ratio, gas flow rate and adiabatic efficiencies. In the reciprocating gasifire, temperature and pressure at any instant and exhaust gas flow rate were derived from solving the differential equations based on mass equilibrium, energy equilibrium, and state equation for cylinder gas. These equations were solved for the given operating conditions where the engine speed, heat release rate, wall temperature, valves opening and closing timing were assumed.

Tokai University
1117 Kitakaname, Hiratsuka-shi, Kanagawa 259-1292, Japan
Phone: +81-463-58-1211 Fax: +81-463-59-2207

3. Results and conclusions

The following results were obtained after several optimizing processes.

(1) When the reciprocating engine drives only a compressor, the engine load was low and then the exhaust gas temperature was not so high. The obtained thermal efficiency was 37.7%. In order to increase the load of a gasifire, it was effective to add another compressor, which supplied compressed air directly to a power turbine. Constant pressure combustion process was preferred to produce higher temperature gas for a power turbine. By introducing this "bypass compressor" and this combustion process, the thermal efficiency was improved to 51.7%.

(2) The engine configuration without a supercharging compressor, which consists of only a reciprocating engine and an exhaust turbine, where, as shown in Fig.1, the combustion gas is exhausted to the turbine during the re-compression stroke after the piston, reaches the bottom dead center, is attractive. The expected thermal efficiency was over 43% even though the system was very simple.

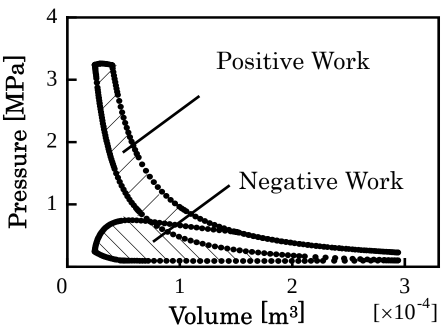

Fig. 1 P-v diagram

References

(1) Itoh T, Ozaki M. and Hasegawa S., J. GTSJ, vol.27, No.6, 1999, pp29-34 (in Japanese)