Small and Medium Size Gas Turbines

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1. Introduction

In this section, technical trend of micro, small and medium size gas turbine is reviewed.

Small and medium size gas turbine is used mainly as core of a distributed power generation system. In point of thermal efficiency of engine alone, most of small and medium size gas turbine does not exceed diesel and gas engine. Relatively clean exhaust character of gas turbine makes it environmental friendly. But regulation on NOx emission imposed more strict value on gas turbine than on other cycle. Gas turbine engines must compete with other cycles in efficiency and environmental compatibility. Although its high level of exhaust temperature makes it possible to realize high total thermal efficiency, when it is used in a co-generation system, further increase of thermal efficiency and environmental compatibility are required.

2. Micro Gas Turbines

Some gas turbine manufacturers have released new micro gas turbine engines.

Toyota Turbine and Systems, Toho Gas, Tokyo Gas and Osaka Gas released a 270Kw micro gas turbine co-generation system on the market. A lean pre-mixed combustor has been developed(1). And it enables low NOx emission level of 80ppm (O2=0%) . The new combustor also makes the system simpler and smaller because it does not need additional boiler piping for NOx reduction.

Toyota Turbine and Systems, and Toho Gas released a new 50Kw class co-generation system. And a field operation to demonstrate performance had begun. The core engine TPC50R employs recuperated cycle, and thermal efficiency is improved to 25.5% from 12 % of the simple cycle base engine. Low Emission level of NOx (9ppm O2=16%) is achieved with pre-mixed combustor.

Mitsubishi Heavy Industries and Toho Gas have announced that testing of new 80Kw class micro gas turbine engine started. New technologies such as ceramic bearing, lean pre-mixed combustor are employed to the new engine with recuperated cycle, thus high generator efficiency of 30% which is highest level in the class and low NOx emission level of 80ppm (O2=0%) has realized. Development of co-generation system and release on the marked are planed in 2003.

3. Small and Medium Engines

Kawasaki Heavy Industries and Catalytica Energy Systems Inc applied a catalytic combustor to 1.4MW GPB15X gas turbine. First commercial operation has started in USA. Through the use of a catalyst instead of a flame, combustion at temperatures below that where NOx usually forms is enabled. It can clear the NOx regulation in California, 2.5ppm (O2=15%) which is most strict in North America. The catalytic combustion system can be retrofitted to existing M1A-13 en-

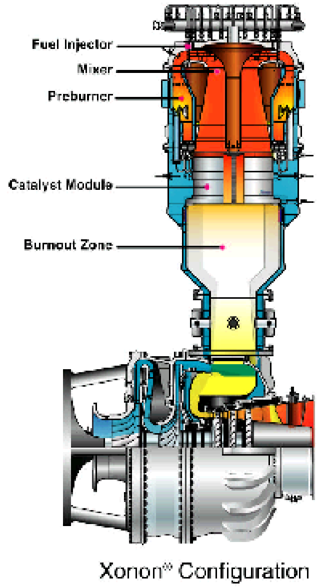

Fig 1 Kawasaki GPB15X with Xonon catalytic combustor

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gines.

4.National Project

In 2002, two projects reached engine test phase. One is HGT project for efficient co-generation system supported by Ministry of Trade and Industry (MITI). And the other is SMGT for clean and efficient marine engine supported by Ministry of Transport, the Association for Structural Improvement of the Shipbuilding Industry and the Nippon Foundation.

4.1 Hybrid Gas Turbine (HGT)(2)(3)

In 1999, Ministry of Trade and Industry (MITI) launched a project "Research and Development of Practical Industrial Co-generation Technology". The objective of the project is to prompt industrial application of co-generation technology that employs hybrid gas turbines (HGT using metal and ceramic in high temperature parts). The final goal of the project is contribute reduction of CO2 through increase of thermal efficiency of gas turbine engines. In the project, design, construction and operation of HGT engine were assigned to Kawasaki Heavy Industries. Development and evaluation of ceramic material and manufacturing of ceramic parts were assigned to Kyocera. Total research of system application was assigned to Tokyo-Gas, Osaka-Gas and Toho-Gas.

Employment of ceramic parts to gas turbine engines has various effects such as increase of thermal efficiency and power output, and reduction of NOx emission. An 8,000kW class hybrid gas turbine with heat-resistant ceramics applied to high temperature stationary parts was developed.

The targets of HGT are listed below.

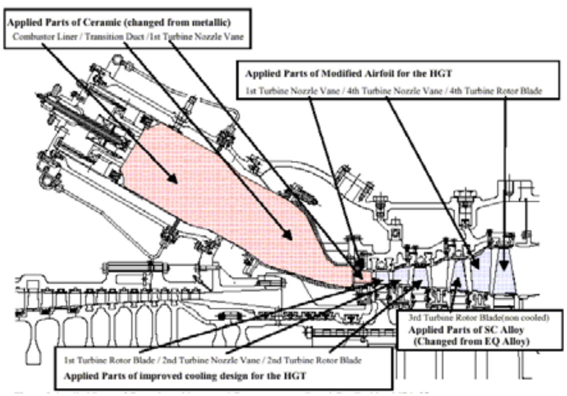

Fig 2 Applied parts of ceramic and improved components on HGT

- Output of 8,000kW
- Thermal efficiency of 34% or higher
- TIT 1250deg-C
- 4,000 hour of operation

The HGT engine is designed through applying ceramic parts to existing 7000kW class industrial gas turbine. As the base engine, Kawasaki M7A-02 single shaft engine was selected. To increase TIT to attain better thermal efficiency, stationary hot parts were replaced with ceramic ones. New metallic parts ware also developed to match increased gas temperature.

Item	Target of HGT	M7A-02
Output Power	8,000kW	7,100kW
Thermal Efficiency	34% or higher	31.5%
Turbine Inlet Temperature	1250deg-C	1160deg-C

Table 1specifications of HGT (target) and base engine

To achieve target performance, component development ware carried out.

- Development of ceramic material SN282
- Interface structure for ceramic and metallic component
- Ceramic DLE combustor
- Design of high temperature metallic parts

A prototype engine and test plant for durability test was constructed. The test started in 2002. To date, partial load test up to 2MW has completed. Full load run and 4000 hour of operation for confirmation of reliability is scheduled in 2003.

Fig 3 Ceramic components of the HGT

4.2 Super Marine Gas Turbine (SMGT)[4][5]

Since 1997, five Japanese gas turbine makers have been developing a low-NOx, high efficiency, marine gas turbine (Super Marine Gas Turbine, SMGT). After period of component development, a prototype engine of 2500 kW recuperated cycle was completed. Test operation has been continued to evaluate its performance.

The goals of this project are

- NOx emission of less than 1g/kWh
- Thermal efficiency of 38-40%
- Feasibility to use fuel oil type A

NOx emission level is about one-tenth of that of high-speed diesel engines. And thermal efficiency is same level as that of high-speed diesel engines.

To achieve these goals, various component developments were carried out.

- Dry low NOx combustor
- A plate fin type recuperator
- High efficiency cooled blades
- Power turbine with variable nozzle vane to improve efficiency under partial load
- Anti-corrosion coating suitable for marine use
- Transient response study and simulation to sudden change of load

A prototype test engine was completed at 2001. The rated output of 2500 kW has already achieved. And thermal efficiency and NOx emission level is now under evaluation.

5. Summary

- New micro gas turbine engines were released. Each of them has newly developed pre-mix combustor and good environmental compatibility. Thermal efficiency of engine was raised up to 30% in 80kw class.
- First commercial operation of catalytic combustor started. Catalytic combustion system cab be retrofitted to a existing engine, and improve emission characteristics.
- Test engine of HGT (Hybrid Gas Turbine) has begun operation. 4000 hour of operation is scheduled to verification of technology. High thermal efficiency, power output and environmental compatibility are expected through employment of ceramic to high temperature parts.
- A prototype test of SMGT (Super Marine Gas Turbine) has been continued since 2001 to evaluate its performance. In the developed recuperated engine for marine use, it is expected that efficiency as high as hi-speed diesel are compatible with high level of environmental friendliness.

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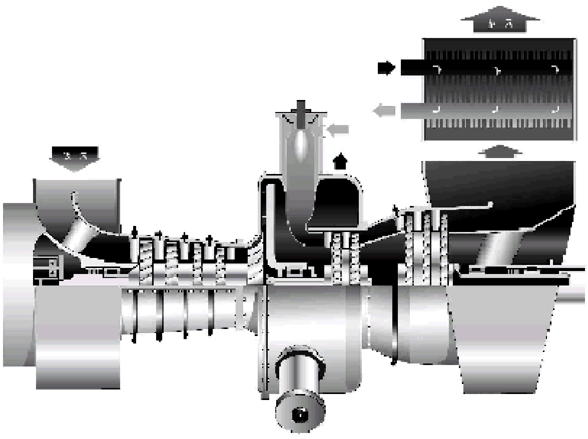

Fig 4 Concept drawing of SMGT

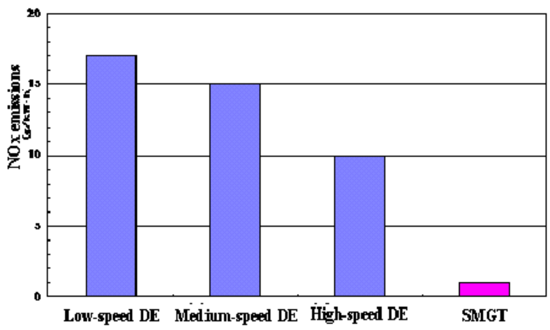

Fig5 comparison of SMGT emission level with other cycles

2) (in Japanese)