Ultra-small Size Distributed Energy Systems Laboratory and Project Based Learning Programs

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1. Introduction

Our research activities concerned with micro gas turbine is executed as a part the activities of a research laboratory for ultra-small distributed energy systems. Before introducing our research activities, I would like to introduce our research laboratory briefly.

In the year of 2000, the School of Engineering of the University of Tokyo established a collaborative research laboratory for ultra-small distributed energy systems to study various research topics concerned with micro gas turbines and fuel cells. This interdisciplinary laboratory has a mission to disseminate the information on research activities of the laboratory. Therefore, we have held open seminars and international symposia besides regular laboratory seminars and meetings for faculties, research associates, and graduate and undergraduate students.

As a main facility, we have a cogeneration system with a 28kW Capstone gas turbine for investigating its reliability, energy efficiency and compatibility from a standpoint of neutral organization. We also performed a design study on a hybrid system composed of micro gas turbine and SOFC with the electric power output of 30kW, and analyzed its cycle efficiency together with the component loss based on exergy. In parallel with this system analysis, we are now developing a small-size gas turbine with the characteristics of easy operation in a recently renovated special room (Fig.1) for this particular research topic.

Our recent research projects in connection with the development of small size gas turbines are listed as follows,

(1) Prototyping of start/stop and interlock systems for 7.5kW liquid fuel and natural gas fired micro gas turbine

(2)Development of suppression device for pressure pulsations induced by gas compressors

(3)Measurement and analysis of pressure pulsations in supply gas pipelines laid down in an existing building

(4)Prototyping of foil air bearing for ultra small size micro gas turbine

(5)Evaluation of energy efficiency of micro gas turbine cogeneration system

Fig.1 Micro gas turbine test facilities

2. Introduction of research activities

In what follows, our current main research projects are introduced in detail.

(1) Measurement and analysis of pressure pulsations in supply gas pipelines laid down in an existing building [1]

Because of the fact that the pressure level of low-pressure supply gas pipeline is 200mmAq, we have to use gas compressors to raise the pressure up to 0.3 – 0.4MPa for driving micro gas turbines. In the case that reciprocating compressors are selected for this purpose, pressure pulsations may be induced in a supply gas pipeline. We are now measuring the pressure pulsation level, modes and frequencies in an existing gas pipeline laid down in Engineering Building

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#2, The University of Tokyo. In parallel, we are now developing the device to suppress pressure pulsations composed of a Roots blower and the small size tank and investigating the mechanism.

(2) Development of start/stop and interlock systems[2]

In order to operate prototype micro gas turbine safely, start/stop and interlock systems are indispensable. As a first step, we developed observation and control systems where we used twenty-four sensors to measure temperature, pressure, flow rate and rotational velocities and send these data to micro computer through A/D board and after that we constructed start/stop system by micro computer through D/A board where we controlled vale timing of fuel pump etc. and applied voltage pattern of an igniter. As a next step, we introduced interlock system based on the algorithm of larger gas turbines to avoid over temperature condition.

The projects under progress started from the year 2001 are a development of foil bearing which is a necessary item to realize maintenance free micro gas turbine under the support of NEDO and the analysis of energy efficiency evaluation and dynamic characteristics of micro gas turbine centered co-generation system under the cooperation of J/POWER.

(3) Prototyping of foil air bearing for small size micro gas turbine use[3]

At this moment, the methodology for designing small size foil bearing is not yet established. Therefore, we started to construct design theory and as a first step, we developed a test facility for testing small size air bearings for developing future ultra small size gas turbine by utilizing the rotor of a commercially available turbocharger.

Our experimental setup (Fig.2) consists of a air lubricated foil bearing for a radial bearing and an externally pressurized air bearing with multiple air

supply holes for a thrust bearing. The foil bearing used in this study is composed of a phosphor bronze foil given some hemisphere-like projections and a housing. The diameter of the rotor is 30 mm and the surface of the rotor is coated by ceramic. We are now measuring rotational speed and vibrations in the radial and axial direction.

(4) Evaluation of energy efficiency of micro gas turbine cogeneration system

The object system is composed of 28kW Capstone micro gas turbine, an exhaust heat recovery boiler, an

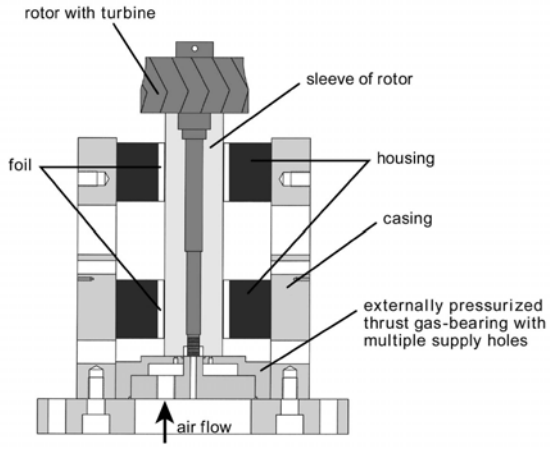

Fig.2 Radial Foil Bearing Test Setup

absorption type refrigerator, a fan coil and a cooling tower. We are measuring pressure, corresponding flow rate, temperature, generated electric power, respectively and evaluated energy. In the measurement, the temperature of heat transfer medium was found to show unstable behavior under specific conditions and dynamic characteristic analysis is under study.

3. Concluding remarks

The projects introduced so for are executing under the support and cooperation of companies and government agencies. We are dealing with these projects as alternatives of graduate and under graduate thesis programs and call these programs Micro Gas Turbine Based Project Based Learning.[4] In the year 2003, we will start to expand our target from micro gas turbines to fuel cells and combined systems composed of micro gas turbines and fuel cells.

References

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(4) Kaneko,S., Turbo machinery, Vol.29, No.4, (2001), pp.14-19