

Dissertation Award

Development of Fabrication Process for Ceramic Gas Turbine Components

Hirofumi TERAZONO, Koichi TANAKA, Toshifumi KUBO, Sazo TSURUZONO
and Makoto YOSHIDA

R&D Center Kagoshima, Kyocera Corporation

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ABSTRACT

The 300kW Industrial Ceramic Gas Turbine (CGT) Research and Development Project was completed under a contract of Ministry of International Trade and Industry (MITI) in Japan. Under this project, Kyocera has been developing various ceramic gas turbine components. Besides the production of ceramic gas turbine components, we have also developed a net shape forming process for silicon nitride components of complex shapes. The Hybrid molding process is an original molding technique we developed, which is well suited for complex components and mass production for parts such as rotors and nozzle segments. We are able to fabricate the large sized rotors by optimizing forming conditions of Hybrid molding. As the result, the large sized monolithic power turbine (PT) rotor of 192mm outer diameter has been fabricated and exhibited fracture rotating speeds greater than 130% of the design rotating speed in cold spin tests.

Dissertation Award

R&D and Simulated Altitude Testing of HYPER Combined Cycle Engine

Takeo MITSUOKA¹, Yasushi NAKATA¹, Hiroyuki MIYAGI¹, Hideo KIMURA², Kimihiro KISHI³,
Gary WELLS⁴, Jerry L.CABE⁵ and Ryoji YANAGI⁶

¹Ishikawajima-Harima Heavy Industries, Co., Ltd

²Kawasaki Heavy Industries Co., Ltd.

³Mitsubishi Heavy Industries Co., Ltd.

⁴United Technologies Pratt & Whitney

⁵GE Aircraft Engines

⁶National Aerospace Laboratory

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ABSTRACT

The Hypersonic Transport Propulsion System Research Project (HYPR) was launched in 1989 to develop technologies for the propulsion system of a Mach 5 hypersonic transport (HST) airplane. The engine being studied is the combined cycle engine composed of a turbo jet engine, which can operate from take-off to Mach 3, and a ram jet engine, which can operate over Mach 2.5 up to Mach 5. The mode transition from turbo to ram and reverse transition are assumed in the range of Mach 2.5 and 3. The combined cycle engine demonstrator was designed and manufactured in 1997. The first combined cycle engine test was carried out in February 1998. Then the altitude test

was performed to demonstrate turbo-ram mode transition capability from December 1998 to March 1999. This paper describes the design features and ATF test results of the combined cycle engine demonstrator focusing on turbo-ram mode transition.

Dissertation Award

Investigation on Aerodynamic Damping Force Including Panel Vibration Mode

Kenji KOBAYASHI

Research & Development Dept. Aero-Engine & Space Operations,
Ishikawajima-Harima Heavy Industries Co., Ltd.

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ABSTRACT

Unsteady aerodynamic damping force on compressor blades and vanes, vibrating with a bending, a torsion or a panel (chordwise stripe) mode, was investigated both experimentally and theoretically. The aerodynamic damping force was measured using piezoelectric ceramics attached on an inlet guide vane to compare response characteristics at operation and at rest. The damping force was obtained theoretically by the combination of a singular method to obtain unsteady aerodynamic forces with Lagrange method to obtain vibration response. Experimental and theoretical studies show that the panel mode has a much smaller aerodynamic damping coefficient compared with the bending and the torsion modes.

Dissertation Award

Application of Short-Flame/Quick-Quench Combustion Concept to Ultra-Low NO_x Gas Turbine Combustors

Hideshi YAMADA, Shigeru HAYASHI and Mitaumasa MAKIDA

National Aerospace Laboratory, Aero-propulsion Center

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ABSTRACT

This paper describes the emissions characteristics of a unique combustion concept, Short-Flame/Quick-Quench Combustion, which has a potential to achieve both ultra-low NO_x emissions and complete combustion over a wide range operating conditions.

The concept combines lean premixed short flame reaction zone generated by a lot of small premixed flames stabilized on a perforated plate flame holder and quick quench of NO_x formation by injecting air to the plane region where combustion reactions have been completed. Measurements were made for natural gas at temperatures of 300 to 900 °C and pressures of 0.1 to 0.7 MPa. NO_x emissions of 3 to 4 ppm (corrected to 15% O₂) or EINO_x of 0.3-0.4

were achieved over a range of equivalence ratios required to the typical operating conditions for simple and regenerative gas turbines.

Dissertation Award

High Performance Alloys Developed for Turbocharger

NISHINO Kazuaki, KAWAURA Hiroyuki, TANAKA Kouji, HORIE Toshio, SAITO Takashi
and UCHIDA Hiroshi

Toyota Central Research & Development Laboratories, Inc.

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ABSTRACT

High performance alloys were developed in order to improve the performance of turbocharger for automotive engines by leaps and bounds. The developed alloys are (1) the γ -TiAl alloy for turbine wheels, improved its high temperature oxidation resistance by the new surface treatment and (2) the heat resistant magnesium alloy for compressor impellers with the superior specific high temperature strength to the conventional aluminum alloy, and (3) the high modulus steel for turbine shafts with the young modulus of 300 GPa strengthened by the dispersion of titanium borides. The application of these developed alloys for rotating parts can reduce the inertia moment (I_p) by 42%, and can push up the resonance frequency of shaft vibration by 44%.

Incentive Award

Development of High Strength New Ni-base Single-Crystal, TMS-82+

HINO Takehisa*, YOSHIOKA Yomei*,
KOIZUMI Yutaka**, KOBAYASHI Toshiharu**, and HARADA Hiroshi**

*Power & Industrial Systems R&D Center, Toshiba Corporation

**National Institute for Materials Science

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ABSTRACT

A new Ni-base single crystal superalloy, TMS-82+, has been developed. The creep rupture strength of this alloy is higher than those of the second and even the third generation single crystal superalloys especially in high temperature and low stress condition. Advantage of stress rupture temperature is over 30°C in comparison with the second generation single crystal superalloys at the 137MPa/10⁵ hours condition. This advantage due to TMS-82+ has a large negative lattice misfit. The large negative lattice misfit enhances the formation of continuous r' platelets,

the so-called raft structure, and a fine interfacial dislocation network on tensile creep condition. These are considered to prevent the movement of dislocations and decrease the creep strain rate. Other properties such as oxidation resistance, phase stability and processability of TMS-82+ are same as those of second generation SC superalloys. For a final evaluation of this alloy, rotating test has been conducted with 15MW Toshiba test gas turbine plant since December 2000.