Research and Development of Gas Turbine Technologies at Technical Institute of Kawasaki Heavy Industries, Ltd.

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1. Introduction

Technical Institute of Kawasaki Heavy Industries, Ltd. was originally established at Kobe Works in 1957. After many changes, the Institute started afresh in 2001, and has continued to strengthen Kawasaki.

State of gas turbine technologies in Technical Institute is introduced bellow.

2. State of Core Technologies

2.1 Materials

Materials for the hot section components of gas turbine are required to have high thermal capability and durability. We are developing ceramic matrix composites (CMC) with high strength continuous ceramic fiber, and thermal barrier coating (TBC) that can reduce the surface temperature of the metallic parts by applying a ceramic coating.

Non-cooling CMC combustor liner can improve the temperature distribution in combustion gas, and it is also expected to provide lower NOx emissions. We have so far completed the basic phase, including the development of CMC material processing, such as optimization of interphase structure between the ceramic fiber and ceramic matrix, and the development of CMC fabricating technique for combustor liner as shown in Figure 1. We are currently developing the environmental barrier coating (EBC) to enhance durability in an actual combustion gas environment.

Fig. 1 CMC Combustor Liner

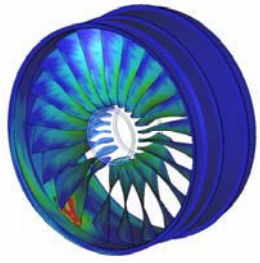
TBC has already been put to practical use in actual combustors, buckets, and nozzles, and we are now tackling technological development aimed at improving the durability of TBC by controlling the structure and composition of ceramic thermal barrier layer and metallic bond layer. Residual stress evaluation using synchrotron radiation is an expected non-destructive evaluation method for TBC, so experimental approach for it is undergoing by using SPring-8 in order to enhance the reliability of our products.

2.2 Strength Evaluation

The gas turbine blade exposed to high temperature receives creep damage by centrifugal force. Measuring temperature and stress is necessary for estimating creep damage, but precise measurement of the temperature is challengeable. Therefore, it is difficult to estimate the creep damage. The method of estimation for the creep damage has been developed in KHI using the small test piece extracted from the spent blade and is applied to evaluate the remaining life.

Regarding a casing of jet engine, containment capability is required. Containment means preventing a blade from penetrating a casing when a blade is off from a shaft in the accidents such as bird strike. The containment-rig test is obligated to verify the containment capability. Recently, development of nu-

Containment-rig Test



Simulation Result (Deformation of Casing)

Fig. 2 Numerical Simulation of Containment Capability of Casing

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merical simulation technology to verify the containment capability instead of the test has been desired. KHI has improved the simulation accuracy by comparing the simulation results with the experimental results shown in Figure 2. This simulation technology is being applied to development of jet engines.

2.3 Aerodynamics

Technical Institute has been collaborating with the design division to improve accuracy and applicability of CFD technology, which is inevitable in gas turbine design. For the aerodynamic optimization of gas turbine system, not only compressors or turbines but inlet ducts or exhaust diffusers have to be improved. However, database for the latter is not always sufficient for the design. In such cases CFD can be a very powerful tool. Figure 3 shows one of such examples. Aerodynamic design of the diffuser had been based on experiences (database) to get an optimum pressure recovery, it is now possible to include the effects of struts or inlet flow distribution in the design, which had been ignored in the database.

2.4 Cooling Technology

For much more advanced design technology of cooling turbine blade, the various heat transfer experiments with model blade are carried out. The data, such as the blade external surface heat transfer coefficient, the film cooling effectiveness and the heat transfer coefficient of internal cooling passage are acquired and accumulated. In recent years, we are concentrating on the grasp of the unsteady heat transfer characteristics in operating gas turbine condition by experiment.

2.5 Combustion Technology

The application of CFD and combustion measurement technology is necessary for the effective development of the combustor which copes with severe requirements such as high temperature, high pressure and low NOx. We have been researching on these technologies. The combustion simulation results of a combustor are shown in Figure 4. The development of the combustor for the low calorific value gas (4.2MJ/m3N) from the pressurized biomass gasification furnace is also carried out in Technical Institute.

2.6 System Integration Technology

System integration technology is important to finding an optimal configuration of gas turbine plant. Computer aided design system helps simulating

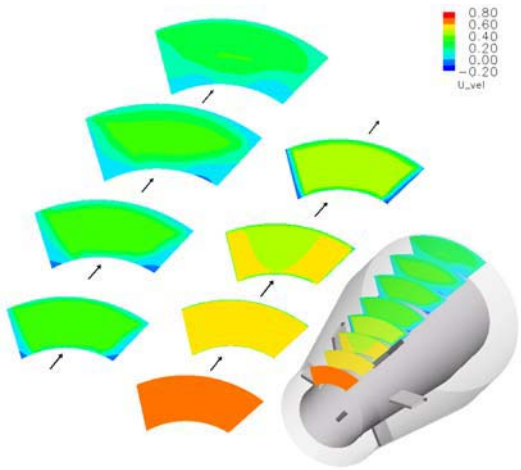

Fig. 3 CFD Results of Exhaust Diffuser

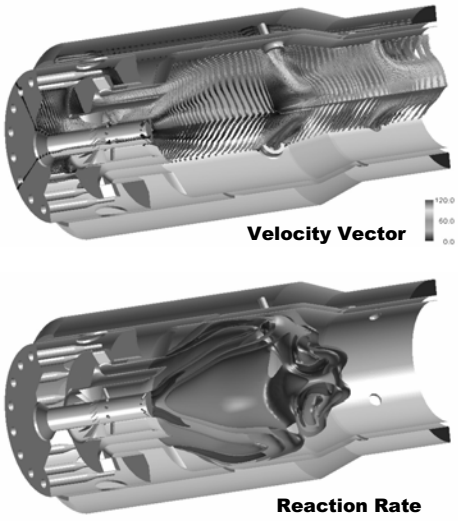

Fig. 4 Combustion Simulation

mass-heat balance and plant performance such as electric output, steam output, utility consumption, and so on. This system integration technology is also applied to feasibility study of new energy system such as gas turbine - fuel cell hybrid system.

3. Summary

Research on gas turbines at Technical Institute of KHI is outlined above. The Institute will further promote vital activities with the aim of developing original and competitive technologies to meet the future needs.