Aero-engine component technology development in IHI

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1. Introduction

Aero-engine and gas turbine technologies on component, material, control system have been developed at aero-engine research & engineering center of Ishikawajima-Harima Heavy Industries Co. Ltd. Here are presented our current research on aerodynamics, heat transfer, combustion, and environment technologies.

2. Technology developments

2.1 Aerodynamics

High performance and lightweight components of fan, compressor and turbine are always required for aero-engines. The component technology developments are followed by production engine development program. In the blade airfoil and passage designs, a single blade CFD calculation has been extensively applied as a practical analysis. However experimental calibration processes are still incorporated in the design methodology, because the single blade CFD cannot account for the blade row interaction phenomena. A simulation tool to predict the real flows in the multi-stage environment has been demanded. Then full stage CFD analysis has been developed in the collaboration with JAXA. The result is shown in Fig.1. This full stage analysis is going to be utilized as virtual component test in the current stage. And the analysis can be a powerful design tool with increasing computer capability.

Concurrent design processes of aero and mechanical design have been developed. One of these processes is prediction method of blade vibration level before engine test measurement. Resonance free design approach has been applied in the operating range. It becomes difficult, however, to avoid resonance in the current high performance aerofoil because of many high frequency resonances due to thinner and 3D shape. Then, blade vibration response analysis by FEM is carried out using aero exiting force and damping predicted by CFD analysis as shown in Fig.2.

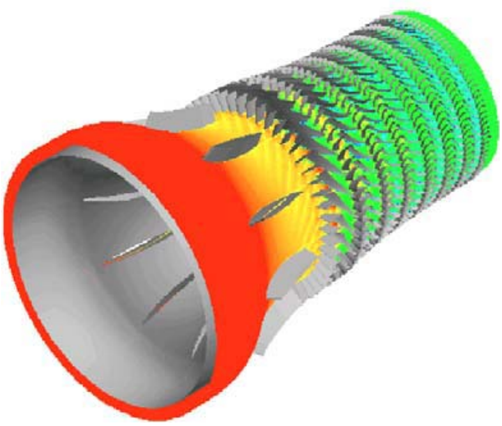

Fig. 1 CFD analysis result on full stage compressor (collaboration with JAXA)

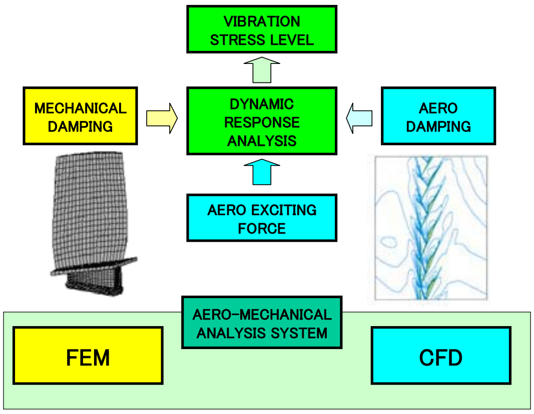

Fig. 2 Aeromechanical analysis system

2.2 Heat Transfer

Aero-engine turbine inlet temperature is as high as 1700℃, turbine nozzle and blade cooling technology is required to improve cooling efficiency as well as heat resisting material and thermal barrier coating technologies. Quasi-porous transpiration cooling, for exam-

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ple, is being developed using micro manufacturing technology as shown in Fig.3. Cooling air reduction of 30% was achieved based on the test results in the ESPR (Environmentally Compatible Propulsion System for Next-Generation Supersonic Transport) program. Also fatigue strength at high temperature is evaluated.

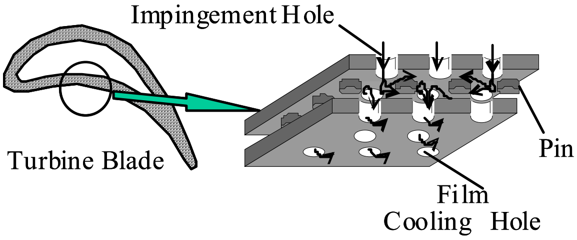

Fig. 3 Quasi-porous transpiration cooling

2.3 Combustion

Recent key technology of combustion is low emission such as NOx and CO_2. Reduction of CO_2 requires high performance engine system, that is, high pressure and temperature. Premixed combustion is effective to NOx reduction, but stable combustion control is more difficult at higher temperature and pressure conditions. Then spiral flame burner as shown in Fig.4 is being developed using numerical simulation and component test. Higher shear flow around outer wall zone induced by air supplied to tangential direction accelerate fuel diffusion while low speed zone at the core keeps flame stable.

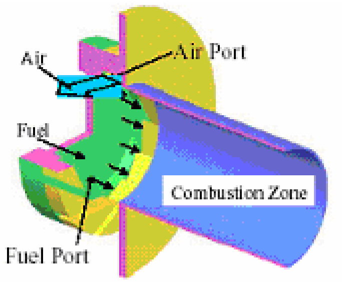

Fig. 4 Spiral flame burner

2.4 Noise reduction

Aero-engine noise is another environment issue. Major causes of the aero-engine noise are fan and jet noise. One of the fan noise cause is interation of fan blade wakes with outlet gide vanes. The noise generation mecahnism was investigated and reduction design aproach was developed using 3D unsteady CFD analysis on fan blades and vanes. They are verified with model tests. Sweep and lean vanes are developed and achieved 3 EPNdB reduction with maintaining aerodynamic performances in the ESPR project.

Jet velocity reduction is effective to the jet noise reduction. High bypass turbo fan engines have been used in order to reduce jet velocity and jet noise. In the super sonic transfer engines, however, it is difficult to reduce jet velocity, so a device like mixer ejector is required. Mixing mechanism are analyzed using LES (Large Eddy Simulation), nozzle design optimization are accomplished and demonstrated to clear new rule for subsonic airplanes ICAO Annex 16 Chapter 4 at ESPR engine noise test as shown in Fig.5.

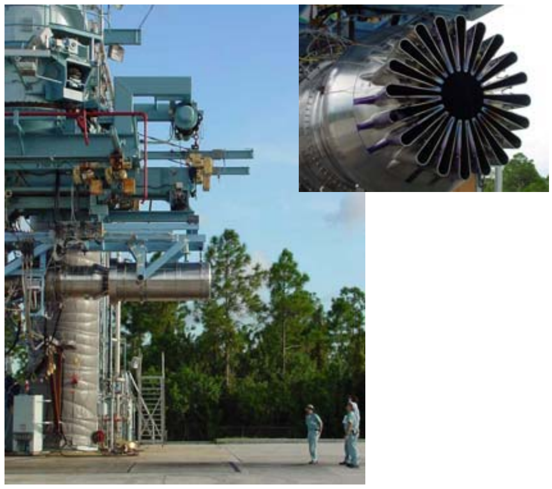

Fig. 5 ESPR engine noise test

3. Concluding remarks

Activities on aero-engine component technology development in IHI are introduced. Aero-engine research & engineering center continue to develop further technologies in order to satisfy customer and social needs such as reasonable operating cost, high reliability and environment compatibility considering collaboration with universities and other research centers.

References

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