Aircraft Gas Turbines

TAKAHASHI Teruo
Ishikawajima－Harima Heavy Industries Co., Ltd.

1. Introduction

This paper describes the recent activities in the research, development and production of aircraft gas turbines in Japan.

2. Engine for Commercial Aircraft

2.1 Large turbofan engine

The growth versions of the Boeing 777 engines were certified in 1996(GE90-92B), 1998(PW4098 and Trent895) and 2000(GE90-94B). Then GE90-115B(Fig.1), the further growth version, has been developed intensively for the application to the Boeing 777 ,which is for ultra-extended range and is aiming the entry into service in early 2004. Improved version of Trent 500 is also being developed for the stretched Airbus A340. Furthermore, the development of the Trent900/GP7000 has been initiated for completely new A380 super large aircraft, which is aiming to enter into service in 2006.

Japanese companies (IHI, KHI and MHI) have been contributing to design, development, manufacturing and testing of those engines as risk-sharing partner, and will continue cooperative relationship with GE, PWA and RR.

2.2 Medium Turbofan engine

The V2500 international collaborative development program started in 1983 by five nations. The original -A1 engine version for Airbus A320 has been expanded to -A5 and -D5 version for Airbus A321 and Boeing MD90 respectively. V2533-A5 and V2522-A5 entered into service in 1997 on Airbus A321-200 and on Airbus A319 respectively. The number of the engines in the field exceeded 2000,and the orders and options now exceed 4800. New growth up engine program (VISTA) started in 2001 for the next 20 years. The Japanese Aero Engine Corporation (JAEC), a consortium of IHI, KHI and MHI, has responsibilities for design, development and manufacturing of FAN and LP compressor.

Recently MHI joined PWA's PW6000 program for Airbus A318.

Fig.1 GE90-115B

Engine Technology department
3-5-1 Mukodai-cho, Nishitokyo-shi, Tokyo, 188-8555 Japan
Phone: +81-424-60-1471 Fax: +81-424-60-1355

2.3 Small Turbofan Engines

The CF34-8C(Fig.2) international collaborative development program started in 1996, considering a growing market foreseen for 50～90 seat regional aircraft. CF34-8C was selected for Bombardier CRJ700 aircraft (70 seater). IHI and KHI in conjunction with JAEC are participating in the CF34-8C program, which is led by GE.

Japanese companies are responsible for design, development and manufacturing of LP turbine, fan rotor, HPC rear stages, accessory gearbox and some other accessory components, which compose the program share of 30%. The engine was certified by FAA in November 1999. The CRJ700 / CF34-8C completed flight test successfully and entered into service in2001.

The development of new variants, CF34-8C5 for Bombardier CRJ900 aircraft (86 seater) and CF34-8E for Embaraer EMBRAER170(70 seater) , started in

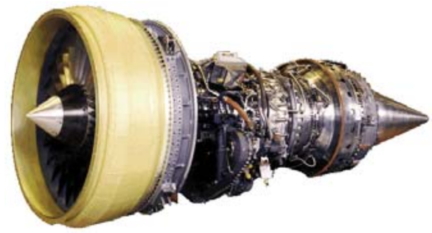

Fig.2 CF34-8C

1999. The CF34-8C5/8E engine was certified by the FAA in April 2002. Also the development of growth version of the engine (called CF34-10) for EMBRAER190 (90 to 100 seater) started in 2000.

2. 4 Small Turbo-shaft Engine

MHI's 600kW (800shp) class commercial turbo-shaft engine MG5-100 has received a Type Approval of JCAB(Japan Civil Aviation Bureau) in July 1997. The application of this engine is MHI's MH2000 commercial helicopter, which was certified by JCAB in June 1997. MH2000 entered into service in 1999 , its performance improvement version was also certified in 1999.

3. Government Engines

Technical Research and Development Institute (TRDI) of Japan Defense Agency is conducting a technical demonstrator engine development program to establish advanced engine technologies. The engine (called XF5-1, Fig.3) is a turbofan with afterburner, which will provide the thrust level of 49kN (5 tons). IHI,KHI and MHI are jointly participating to this program. The program is proceeding to Preliminary Flight Rating Test .

In the TRDI program of the small turboshaft engine (called TS1-10), flight test engines were delivered and the first flight was made on OH-1 helicopter in 1996. The first production engine was delivered in January 1999 and entered into service in January 2000.

4.Research and Development of Environmentally Compatible Propulsion System for Next-Generation Supersonic Transport (ESPR)

The ESPR has started in 1999 as a 5 year project. The ESPR project is proceeded under the framework of Ministry of Economy, Trade and Industry(METI), under the contract with New Energy and Industrial Technology Development Organization (NEDO). This program involves international joint development, and aims to develop the fundamental technologies for a practical, environment-friendly, economical propulsion system for a supersonic civil transport (SST) by applying revolutionary technologies quite different from existing technology.

Major three targets are (1)CO_2 reduction by 25%, (2) NOx reduction to 5 g/kg-fuel at SST cruise condition, (3)Airport noise reduction to ICAO Chapter 3 minus 3dB.

CO_2 reduction will be achieved by applying advanced material application such as MMC (Metal Matrix Composites), TiAl, CMC (Ceramics Matrix Composite) etc, advanced blade cooling technology and intelligent complex system control. Some advanced materials and technologies were demonstrated on the existing experimental engine (called High Temperature Core Engine;HTCE). In December 2002, four newly developed parts, such as TiAl shroud support, new Thermal Barrier Corting (TBC) for turbine blade, smart sensor (multi-optical measurement for surface temperature of turbine blade) were incorporated into HTCE, and engine test was successfully carried out under turbine inlet temperature = 1923K condition. (Fig.4)

To reduce NOx, Lean Premixed Prevaporized (LPP) combustor is being developed in the combination with CMC liners. Concept design has been completed and intensive fuel nozzle development works are done. In June 2002, NOx reduction 5 g/kg-fuel at cruise condition was achieved in high pressure single sector combustor rig test. In parallel, the study of AI(Artificial Intelligence) combustion control is being

Fig.3 XF5-1

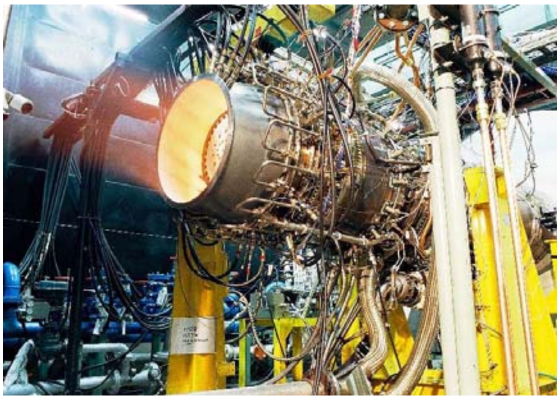

Fig.4 ESPR HTCE engine test

carried out.

As for Noise reduction, development works are focusing on advanced noise attenuation material and on low-noise mixer-ejector design, applying advanced CFD(Computer Fluid Dynamics) technology. Model test results showed that jet noise is reduced to chapter 3 minus 3 db , which met the interim target.

Demonstration on the existing experimental engine is planned , partially incorporating new-technology parts, in 2003JFY.

5. Space plane engine

The Institute of Space and Aeronautical Science (ISAS) has been developing the Air Turbo Ramjet (ATR) engine in cooperation with IHI, KHI. The expander cycle ATR engine, called ATREX, has both heat exchanger and pre-cooler, and uses liquid hydrogen fuel. (Fig.5) This airbreathing propulsion system is studied for a flyback first stage booster of a two-stage-to-orbit vehicle.

After the whole ATREX engine system had been successfully demonstrated at sea level static condition in 1997, the component performance improvement of the pre-cooler and heat exchanger has been continued. In 2002, the defrosting of the pre-cooler by methanol injection has been proven to be effective, by engine ground test.

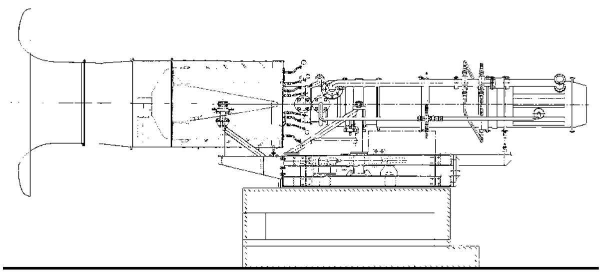

Fig.5 ATREX Engine