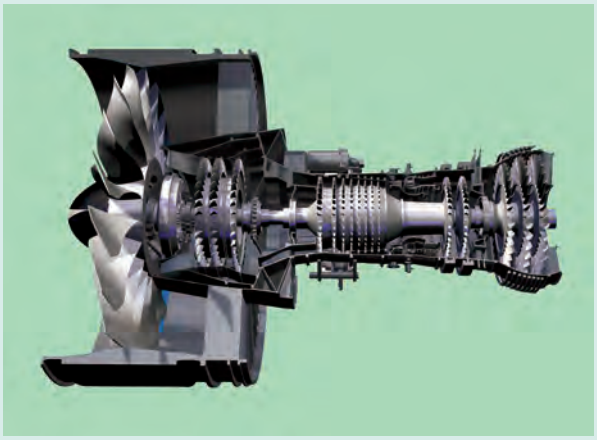
Regional Jet Engines PW1500G and PW1900G



As the global demand for aircraft has been increasing year by year, environmentally friendly engines have garnered attention. The regional jet engines PW1500G and PW1900G are geared turbo fan engines that employ an advanced gear system to attain a high bypass ratio, improve fuel efficiency by 16% and reduce noise by 50% compared with conventional aircraft, and significantly reduce CO_2 and NOx emissions as well. We are in charge of the core parts of these jet engines, that is, the combustor and the fan drive gear system.

Introduction

The demand for aircraft increases year by year in line with global population growth and the economic development in emerging countries in Asia, South America and other regions. This trend is expected to continue in the future. In this growing market, every airline wants fuel-efficient aircraft and so environmentally friendly engines are gathering attention.

1 Background

Kawasaki is participating in Pratt & Whitney's (PW) development and production program for their next line of regional jet engines, Pure Power PW1500G and PW1900G, with the RRSP method. Under this contract, contractors receive allocations of all business income from the sales, repair and other businesses of engines and spare parts in proportion to their participation, but also proportionately incur all the expenditures and risks related to development, mass-production and sales. In this program, KHI has produced combustors and is in pre-production for the manufacture of a fan drive gear system. These are some of the essential parts of the engine and they play an important role in improving engine performance.

In addition, we are developing technologies with an aim to be a supplier of three modules, that is, compressor, combustor and gear. In this program, we are in charge of two of these three modules that we are focusing on.

Although we contribute to this program mainly with our manufacturing technologies, we believe that we can realize low costs and stable quality by refining element, design and manufacturing technologies such as those we use in this program in a comprehensive way. Therefore, we are developing element technologies to sophisticate aeroengines and upgrading aviation gearbox design technologies as well.

2 Specifications

The main specifications of the PW1500G and PW1900G are shown in **Table 1**. These models realize a high bypass ratio by adopting an advanced gear system. They are geared turbo fan engines that improve fuel efficiency by 16% and reduce noise by 50% from the previous model and significantly reduce CO_2 and NOx. We are in charge of their core sections, that is, the combustor and the fan drive gear system (**Fig. 1**).

3 Features

(1) Combustor

The combustor is the part that generates hot combustion gas to drive the engine by mixing air taken into the engine with aviation fuel and combusting the mixture (**Fig. 2**). Therefore, this part becomes the hottest in the engine with the temperature of the combustion gas

Table 1 Main specifications

	PW1500G	PW1900G
Thrust [lb]	19,000 ~ 23,300	~ 23,000
Bypass ratio	12 : 1	12 : 1
Fan diameter [in]	73	73

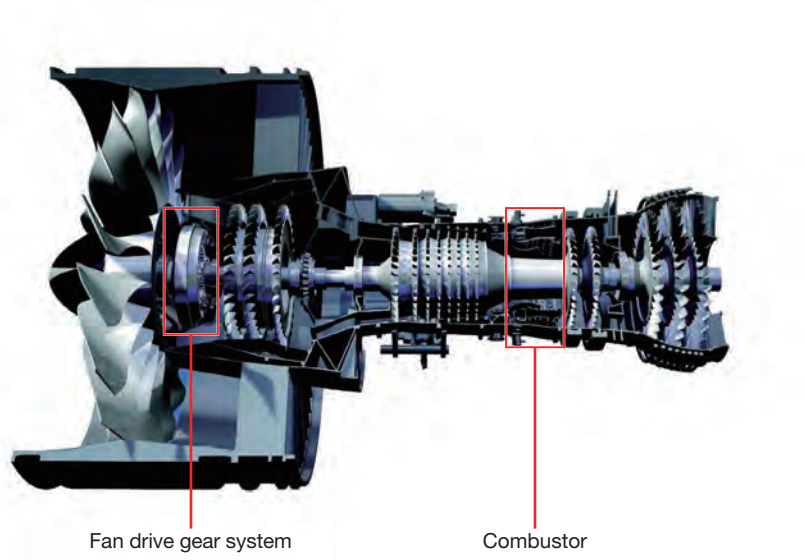


Fig. 1 Positions of combustor and fan drive gear system

exceeding 2,000°C. It is required to efficiently combust fuel in this environment, while reducing the emissions of hazardous NOx at the same time.

We make the most of our experience in designing and manufacturing combustors for military aircraft engines and in mass-producing combustors for industrial engines. For example, we have designed and manufactured the combustor for turbo fan engines with a high bypass ratio used in a fixed-wing patrol aircraft, the P-1.

(i) Temperature rise

The combustor has numerous small cooling holes to keep cool while managing hot combustion gas. We leverage a state-of-the art laser processor and discharge processor to precisely place these holes in the specified positions.

Removable molded heat-resistant panels with a highly heat-resistant coating are adopted as the inner wall that comes in contact with the combustion gas to ensure a long lifetime. In addition, these panels can be replaced as needed during maintenance.

(ii) Reduction in NOx

The combustor consists of various components including the fuel nozzle, which emits fuel to provide an even mix of the fuel into the air for the combustion mixture, along with the air holes supplying the air mixture. Our experience is put to use again to apply advanced sheet metal forming technology and welding technology to accurately reproduce their shapes and dimensions as

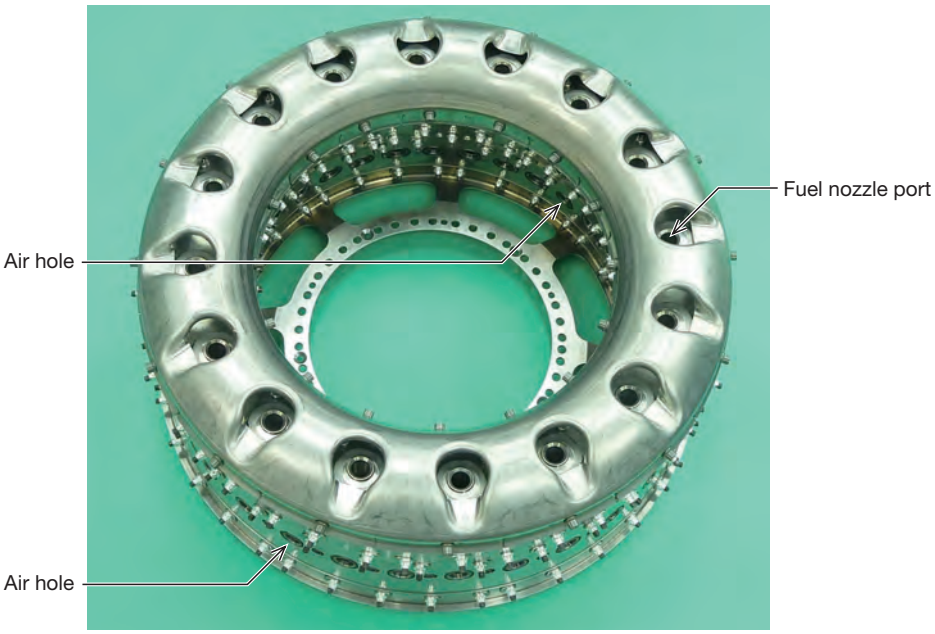


Fig. 2 Combustor

designed through repeated advanced analysis and experiments.

(2) Fan drive gear system

In a conventional two-shaft engine, the low-pressure shaft and the fan are directly connected and rotate at the same speed. Since the fan with a large diameter becomes less efficient as the tip speed approaches the speed of sound, a lower rotation speed is desirable. In contrast, it is desirable to increase the rotation speed of the low-pressure compressor and low-pressure turbine with its smaller diameter to increase the load per stage and reduce the number of stages. The geared turbo fan engine decelerates the rotation from the low-pressure system in the gearbox and rotates the fan to set desirable rotation speeds to both of them.

The fan drive gear system uses star-shaped epicyclic gearing because the input and output are on the same shaft and the horsepower delivered per capacity unit is large (**Fig. 3**).

We develop, manufacture, repair and overhaul transmissions for helicopters including the BK117, accessory boxes for aeroengines, a constant frequency generator for aircraft that applies the traction drive CVT (continuously variable transmission), the T-IDG, and other products. We have also used the experience we gained in developing the technologies for open rotor power gearboxes.

4 Product delivery

Kawasaki shipped the first PW1500G combustor for the engine in the newest regional jet airplane, the C Series of Bombardier in Canada from Akashi Works to PW on May 29, 2017. This is the first combustor that we manufactured for commercial aircraft engines.

We plan to ship specimens for rig and engine tests on the fan drive gear system to PW and start production in 2019.

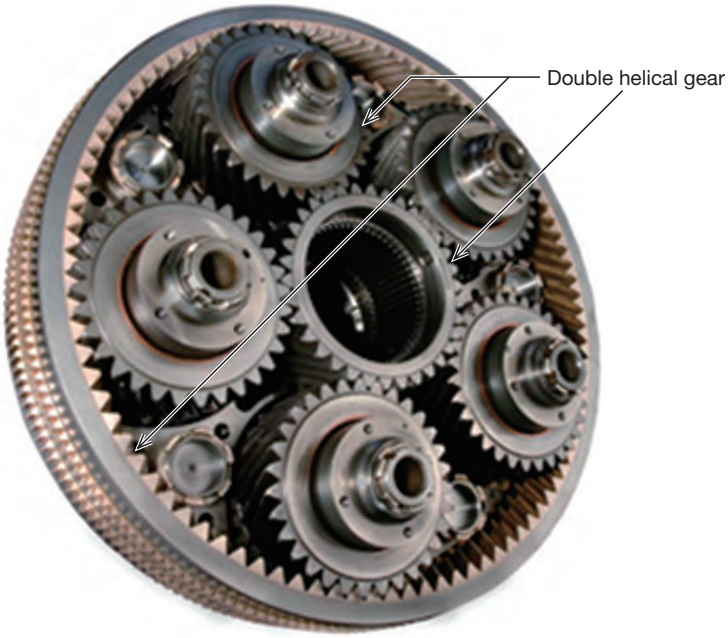


Fig. 3 Fan drive gear system

Conclusion

The PW1500G is used exclusively in the C Series. The PW1900G is a derivative engine of the PW1500G and it is used exclusively in the E190E2 and E195E2, the newest regional jet airplanes from Embraer in Brazil.

It has been published that orders for more than 600 C Series, E190E2 and E195E2 have been confirmed in total. More than 1,200 engines will be mounted on their fuselages. We will improve our technologies so that our products will remain popular.

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