Introducing New MHIAEL Nagasaki Aero Engine Components Plant and New Combustor Center

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To respond to increased production of aircraft engine parts due to strong aircraft demand, Mitsubishi Heavy Industries Aero Engines, Ltd. (MHIAEL) completed construction of a new plant for aircraft engine components in the Nagasaki area at the end of August 2020, marking the company's first development of another base. As the "New Combustor Center" responsible for the production of combustor components for engines for narrow-body aircraft, which are produced in large numbers, this plant has finally started operation of some lines in January 2021 and started shipping combustor assemblies in July. ***Figure 1*** *shows the first combustor shipping ceremony. This report presents the Nagasaki Aero Engine Components Plant.*

Figure 1 First combustor shipping ceremony

1. Plant overview

The new aero engine components plant was constructed to the south of the brick building of the former Pattern Shop, which is registered as a UNESCO World Heritage Site among the "Sites of Japan's Meiji Industrial Revolution," within the Akunoura district of Nagasaki Shipyard & Machinery Works in Nagasaki City, Nagasaki Prefecture, the home of Mitsubishi Heavy Industries' inherited business. **Figure 2** is a bird's-eye view of the plant.

The plant has an area of 5,400 m^2, 180 m from east to west, 30 m from north to south and the material receiving area, components manufacturing area, components assembly area and packing/shipping area are located from the east side therein, which allows consistent production flow from east to west. Welcoming customers visiting the plant, the PW1000G series engine is on display at the west entrance of the plant. In addition, a dedicated visitors' observation walkway has been constructed on the 2nd floor, from which visitors can overlook the entire plant in a safe environment. **Figure 3** is a picture of the entrance to the plant and **Figure 4** is the visitors' observation walkway.

Figure 2 Bird's-eye view of Nagasaki Aero Engine Components Plant

Figure 3 Entrance to plant

Figure 4 Visitors' observation walkway

Based on our intention of establishing a plant that can meet the vigorous aircraft demand in a firmly grounded manner with world-class productivity and initiative, in addition to the fact that Nagasaki is a place historically related to Mitsubishi Heavy Industries, the construction project of the new aero engine components plant was promoted with the catchphrase "From the Past - To the Present - To the Future." Construction began in December 2019 and the building was completed at the end of August 2020. Since then, the commencement of production has been carried out in a planned manner, from carrying-in of various manufacturing equipment to test processing and manufacturing approval. In January 2021, mass production of combustor components was started. Since then, progress on the commencement of production has been steadily made and the shipping of combustor assemblies began in July. From now on, the complete production area will be launched toward the end of 2021, with production throughout the entire plant commencing in 2022.

2. Components manufactured

We are participating in a program for the PW1100G-JM engine installed in the A320neo manufactured by Airbus, which is the best-selling commercial aircraft, with our involvement in maintenance, manufacturing and supplying components. The PW1100G-JM is a state-of-the-art 11-ton to 15-ton thrust class engine with improved environmental performance that was jointly developed internationally by five manufacturers (including our company) in Japan, the United States and Germany. The new aero engine components plant constructed in Nagasaki manufactures the combustor and combustor case, which can be said to be the heart of the engine. **Figure 5** depicts the appearance of the A320neo and **Figure 6** gives a cross-sectional view of the PW1100G-JM engine and the components manufactured at the Nagasaki Aero Engine Components Plant.

Figure 5 Appearance of A320neo

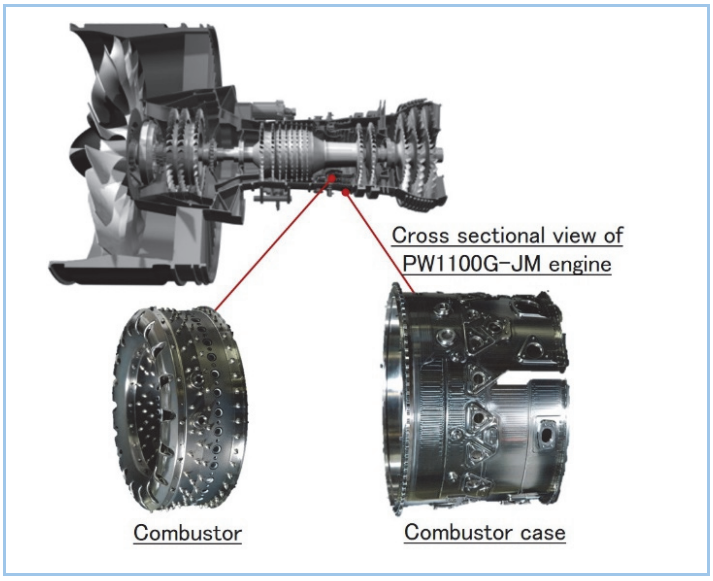

Figure 6 Components manufactured at Nagasaki Aero Engine Components Plant

The combustor plays an important role in quickly mixing compressed air taken from the fore-stage compressor with fuel and burning the mixture and then sending high-temperature gas to the subsequent turbine. It is one of the components that is exposed to the highest temperature among all engine parts, so in addition to being made of a Ni-based heat-resistant alloy, it was designed to withstand a high temperature environment. These measures include a heat resistant coating on areas directly exposed to combustion, innumerable small diameter holes for taking in air for cooling the vicinity and other features. In order to deal with the manufacture of such components, we have introduced coating equipment for incorporating the coating process (which previously relied on overseas specialized manufacturers) into in-house production. We have also introduced machine tools developed based on the latest high-speed laser cutting technology of the Mitsubishi Heavy Industries Group and manufacturing has already commenced on a dedicated line at the new plant.

On the other hand, the combustor case that surrounds the combustor is exposed to high pressure in addition to high temperatures and is required to have sufficient strength at such temperatures. Therefore, the combustor case is formed by machining a ring-shaped forged material. This part is exposed to extremely harsh environments, so even small invisible scratches are unacceptable. Mass production of this part can be started only after repeating necessary preliminary inspections, confirming that all the quality requirements are satisfied and obtaining manufacturing approval from the customer. This part must be produced in a tightly controlled manufacturing environment.

3. Features of production line

In order to produce the components described in the previous section, the Nagasaki Aero Engine Components Plant has a dedicated production line for each component. The combustor component-dedicated lines include one for producing the liners that form the inner and outer walls and another for producing heat-resistant panels that are installed on the inner surface of the combustion area. In addition, a dedicated line for producing combustor cases has also been constructed, giving the plant a total of three major production line areas.

The production of combustor liners and heat-resistant panels requires various manufacturing equipment for welding, heat treatment, coating, laser cutting, inspections, etc. At the new plant, all such equipment is placed roughly in a circle, which realizes a manufacturing flow that enables components to be completed by moving around the production line while being handled by each component of manufacturing equipment.

On the other hand, for the production of combustor cases, which are formed by gradually machining a material in several divided machining processes in order to suppress distortion during processing as much as possible, a production line in which several pieces of machining equipment for ensuring the required production capacity are arranged and automatic component/tool carrying equipment for transferring workpieces between them is installed is provided. This line not only maximizes equipment utilization by identifying vacant equipment and automatically mounting workpieces and tools thereon, but can also be operated unattended at night and on holidays.

We are also proceeding with plans to further enhance quality control according to the characteristics of each component in the future. For example, since several dozen heat-resistant panels are required for each combustor, their production quantity is large and the production interval is set in seconds. For the production of such products, management from the perspective of how to prevent nonconforming products is required. On the other hand, for combustor cases, the material cost of which is high and which require a lot of time for machining, management from the perspective of how to prevent problems caused by equipment and tool problems to prevent nonconformities is important. For this new plant, we are also considering further advancing the management of these components, which will be carried out according to their characteristics, by making more advanced use of IoT and AI, which have already been adopted at our main plant (Komaki City, Aichi Prefecture).

The parts manufactured in this way are finally assembled into components to be delivered such as combustors and combustor cases in the assembly area on the west side of the plant. The assembled components are then shipped from the shipping area at the western end of the plant.

Since all components are required to be manufactured with extremely high accuracy and high precision, the entire plant is controlled at a constant temperature. In addition, since the area for the final dimensional inspection of components requires even stricter environmental control, an internal building has been set up inside the plant building to provide an environment for high-precision quality inspection and quality control, realizing a plant where customers can order the production of aero engine parts with peace of mind.

4. Future prospects

Despite being influenced somewhat by the COVID-19 disaster, demand for narrow-body aircraft that are widely used mainly on short-haul routes around the world—especially the best-selling Airbus A320neo and the PW1100G-JM engine installed thereon—has mostly recovered. Furthermore, the growth curve of aircraft demand in general is expected to recover in a few years to the state before the COVID-19 disaster. As such, we also plan to consider expanding the Nagasaki Aero Engine Components Plant in preparation for a further increase in production.

5. Future development

The application of this system is being promoted mainly in newly constructed plants. We have also been working on the expansion of future application destinations and functions of this system, including at plants that have already been delivered and are in operation.