Machine Tool for Machining Aircraft Parts

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Substantial growth in the aircraft parts machining industry will continue with planned production increases by Boeing and Airbus, as well as the expected expansion of the regional jet market, including the MRJ of Mitsubishi Aircraft Corporation.

Aircraft parts are more difficult to machine than general parts. The reasons include the workpieces being long with complex curved surfaces, as well as being susceptible to deformation because of thin walls. There is also the issue of the materials used for the workpieces, namely titanium, which generates large amounts of heat, and CFRP (carbon fiber reinforced plastic), which tends to generate burrs and chips during machining.

To improve efficiency in parts machining to cope with the increase in the global production of aircraft, there is demand for dedicated machine tools that combine a function specialized for the workpieces to be machined, an automatic workpiece exchange function that enables long-term continuous machining and manpower-saving and automation functions such as automatic measurement using sensors.

Our machine tool division has delivered many machine tools to the aircraft parts machining industry utilizing our advantage as a manufacturer of aircraft parts and the expertise and response capability we have cultivated in automated machining lines in the automobile industry. This paper introduces examples of the dedicated machines among machine tools for aircraft parts machining that our division has developed.

1. Main wing panel perforating machine

The main wing box that is the target workpiece of this machine consists of composite material (CFRP and metal), exceeds 20 meters in length and has a shape consisting of complicated curved surfaces. In addition, it is necessary to process many holes in a main wing box, and therefore improvement in efficiency is an important issue.

This machine is a dedicated machine tool equipped with six separately-operating combined heads (three on the upper side and three on the lower side of the workpiece) capable of simultaneous machining, auxiliary equipment such as a workpiece holding jig, and software containing a machining scheduling function for the support of a high operation rate. As a result, a large number of holes can be made at high efficiency (**Figure 1**).

Figure 1 Main wing panel perforating machine

The features of a main wing panel perforating machine are as follows.

(1) Combined head

Each of the six combined heads has a spindle for perforating and countersinking, a pressure foot axis for improving the countersinking accuracy, and a spindle for automatic measurement of the machined part. These spindles can be positioned to an arbitrary point quickly by the NC five-axis function.

(2) Inline automatic measurement function

The measurement spindle mounted on the combined head measures the dimensions of the machined part automatically after machining by the machining spindle and can also automatically report and make determinations on the acceptance of measurement results.

(3) Various compensation functions

Because the workpiece is long with a complicated shape, a large dimensional deviation caused by a workpiece positional error, deformation by its own weight or thermal deformation due to changes in the peripheral temperature may occur when the machining is performed with an NC program created based on drawing data.

For this reason, this machine was designed to automatically sense a reference part set on the jig using a laser in order to compensate for the machining position through automatic calculation. In addition, the above problem was resolved by combining advanced correction functions including a surface orthogonal correction function that performs machining perpendicularly to the curved surface of a workpiece and a function that compensates for thermal displacement errors by reading the spindle front end position based on the reference position just before machining.

(4) Machining schedule management function

The machining area is shared by six heads and there are overlapping sections between the six head machining areas. This machine has a machining schedule management function that automatically assigns the overlapping machining section to heads with lower operational load in order to level the operating time of the heads.

This function also determines the possibility of machining and automatically adjusts the machining order in order to avoid interference between heads on overlapping machining sections. This results in a significant contribution to the improvement of the facility operating rate and the enhancement of the cycle time.

2. Fuselage stringer processing machine

A fuselage stringer is a reinforcing member that is a component of the fuselage. This is a workpiece characterized by its long size, various shapes, and thin wall. A fuselage stringer processing machine is a dedicated machine tool that realizes space-saving and high-efficiency operation even when processing a long workpiece due to the adoption of a gantry equipped with two spindles (**Figure 2**). This machine has attained a fivefold increase in production capacity in comparison to existing equipment through the development of an automatic clamping jig, an automatic workpiece conveying device, etc., that can handle various types of workpieces in addition to the machine tool itself.

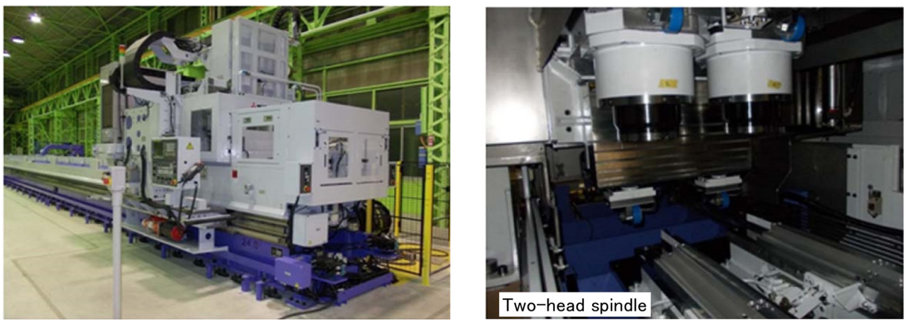

Figure 2 Fuselage stringer processing machine

The features of a fuselage stringer processing machine are as follows.

(1) High-speed, high-accuracy spindle

The spindle has an output of 22/18.5 kW and its maximum spindle speed is 20,000 min^{-1}

(or, as option, 79/95 kW, 17,000 min^{-1}). This enables cutting and reducing the wall thickness of a workpiece (high-speed heavy cutting). This machine has two spindles and therefore can simultaneously machine two workpieces. As a result, the production capability is twice as high as that of a general-purpose machine tool with only one spindle.

(2) Workpiece vacuum clamp

Conventionally, the clamping part needs to be changed according to the shape of the workpiece because the clamping mechanism uses mechanical components. This machine features a newly developed highly reliable vacuum clamping device to eliminate the mechanical clamping components. This results in a significant reduction of tool changing time during a change of workpiece type.

(3) Improvement in handling capacity of chip and coolant

In the past, a large number of chips were generated during machining and accumulated on the workpiece and the fixing jig, and therefore lengthy cleaning work after machining was necessary. This machine reduces cleaning time to one-sixth of the norm by utilizing expertise gained from automotive parts processing lines to optimize the cover shape and add a chip washing function using a coolant shower.

3. Fuselage skin processing machine

The fuselage skin is an aircraft fuselage outer panel component. This is a workpiece characterized by its long size, large warpage, and complicated curved surface along the fuselage shape. Conventionally, chemical milling that utilized chemical erosion to process the workpiece was used, but environmental considerations have required the replacement of chemical milling with machining.

Just like a fuselage stringer processing machine, a fuselage skin processing machine adopts a gantry equipped with two spindles. In addition to the features of a fuselage stringer processing machine, this machine combines a pallet changer that automatically exchanges the workpiece and a workpiece positional error compensation function. As a result, it attains lengthy unattended operation (**Figure 3**).

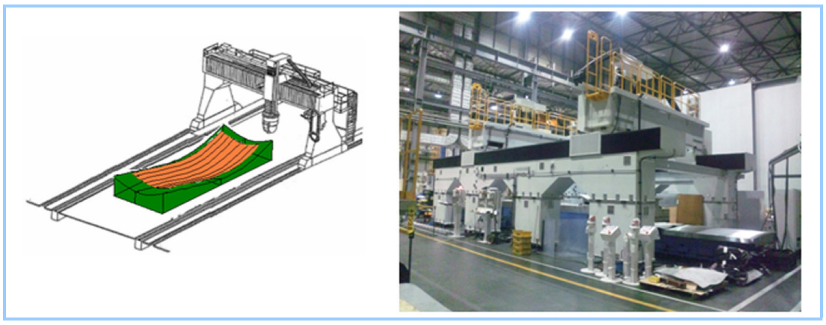

Figure 3 Fuselage skin processing machine

The features of a fuselage skin processing machine are as follows.

(1) NC two-axis head

The spindle has an output of 20 kW and its maximum rotating speed is 20,000 min^{-1}, and is additionally equipped with an NC controlled two-axis indexing function on the head side. This enables high-speed, complicated curved surface machining with NC five-axis control including the two gantry moving axes.

(2) Workpiece positional error compensation function

On this machine, workpiece positional deviation and workpiece thermal deformation in response to peripheral temperature changes can be automatically compensated for by automatic measurement of the workpiece reference dimensions through the use of touch probe-type measuring equipment mounted on the spindle. As a result, manual measurement and compensation value calculation by the operator become unnecessary, and high-accuracy processing can be carried out automatically.

We will continue to share client problems and offer dedicated machine tools as solutions, and thus contribute to the aircraft industry.