

Automatic Production System for Machining Aircraft Parts



Mitsubishi Heavy Industries
Machine Tool Co., Ltd.

The aircraft parts processing industry is expected to continue to grow significantly in the future due to the expanding field of small jet planes represented by the Mitsubishi Regional Jet (MRJ), in addition to the plans of Boeing and Airbus to increase the production of jet planes.

Most aircraft parts are characteristically hard-to-process workpieces because some of them have complex shapes consisting of free curved surfaces and others have complexities in terms of the shape such as the great length and large deformations because of the small thickness. In addition, many aircraft parts are made of difficult-to-process materials such as titanium that generate a large amount of heat during processing, or CFRP (carbon fiber composite material), which tends to generate burrs or chips.

With the background where the production of aircraft has been increasing globally, improvement in production efficiency is required. Therefore, there has been increasing demand for production systems that combine manpower-saving and automation functions such as specialized functions for the target workpieces, automatic workpiece exchanging functions that enable continuous long-time processing, and automatic measuring functions using various sensors.

Mitsubishi Heavy Industries Machine Tool Co., Ltd. has delivered many production systems and machine tools to the aircraft parts processing industry, utilizing our background where group companies manufacture aircraft parts and our expertise and response capabilities cultivated in the development of automatic processing lines for the automotive parts processing industry.

This paper presents examples of our machine tools and automatic production systems exclusively for aircraft parts processing.

1. Automatic long aluminum part production system

An aircraft uses many long aluminum parts. We have realized the automatic production of long aluminum parts using automatic clamping fixtures, which can be used for more than 80 machine tool models and multiple processes, automatic workpiece conveying devices, etc., in addition to specialized machine tools that can perform the high-efficiency and high-quality processing of aluminum parts.

(1) High-speed and high-torque spindle

We developed a high-speed and high-power spindle with a maximum rotation speed of $17,000 \text{ min}^{-1}$, a power output of 75/95 kW and a spindle taper of HSK-A100 to enable the high-efficiency processing of aluminum parts. In addition, we adopted spindle internal cooling oil circulation (spindle core cooling) to reduce the thermal elongation of the spindle and improve the processed surface quality, resulting in the reduction of the work load for polishing in the subsequent process. At the same time, this suppressed the increase in the bearing preload and realized a longer service life of the spindle itself.

(2) Automatic clamping fixture

It is necessary to process both sides of a workpiece for entire circumference processing from its material phase. We developed an automatic hydraulic clamping fixture that enables both sides to be processed without a set-up change.

(3) Automatic production system

We established an automatic production system consisting of material pallets, a workpiece turnover device, a finished product conveyer, a gantry conveying device that performs conveying between facilities and a computer system that operates and controls them (**Figure 1**). When an operator puts a workpiece onto a material pallet, this system performs all processes to the discharge of the processed workpiece onto a finished product conveyer in a fully-automatic manner.

In addition, automatic production including the command of conveying operations, the transfer of NC programs to machine tools, etc., is controlled in an integrated fashion by the operation control system.



Figure 1 Automatic long aluminum part production system

2. Automatic complex-shaped part production system using 5-axis machining center

The production of some complex-shaped aircraft parts requires simultaneous 5-axis machining or several fixture set-up changes during processing. We realized automatic processing of complex-shaped parts through the development of an exclusively designed automatic hydraulic clamping fixture and an automatic production system, in addition to a rotating 2-axis table that enables simultaneous 5-axis machining.

(1) 5-axis machining using rotating 2-axis table

A rotating 2-axis table that allows a pallet rotating radius of 1300 mm is mounted on a machine tool to perform simultaneous 5-axis machining. The table has several piping ports that allow the use of hydraulic clamping fixtures. In addition, pallet clamps and auto-couplers for automatic attachment/detachment of the fixture are installed on the upper surface of the table so that FMS (Flexible Manufacturing System) can be used (**Figure 2**).



Figure 2 5-axis machining using rotating 2-axis table

(2) Turnkey system including fixtures, tools, and machining program

We comprehensively studied and optimized fixtures and processes by dealing with the planning of the machining method, the selection of tools, the creation of a machining program and the design and manufacture of fixtures in an integrated manner. In the planning of a machining method and the designing of fixtures, meeting customer requirements for accuracy and processing time, which had been a problematic issue, was made possible by integrating our expertise with that of the customer.

Specialized fixtures that enable automatic clamp exchange during processing were developed, thereby eliminating set-up changes during processing.

(3) Automatic production system

Automatic production was made possible using pallet type fixtures, a stacker crane conveying device and an operation control system.

3. Conclusion

The automatic production systems presented in this paper are only some of the examples of our developed systems for the aircraft part processing industry. In addition to the above, there are many manufacturing cases where we shared problems with the customer and worked on the creation of solutions cooperatively. As a result, we have proudly provided products that are truly needed, rather than simply manufacturing products for our own self-satisfaction. We will continue to keep this approach and produce automatic production systems that contribute to the aircraft industry through the accumulation of experience and technological development.