Technology Introduction

Make Fabrication of Manifold In-House for Commercial Aircraft

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1 Introduction

The Aircraft Components Div. has been expanding sales among private companies. As part of such sales among private companies, we received an order for the valve module used in the flight control system, which is installed in commercial aircraft (business jet aircraft).

However, the setup capabilities are low in the fabrication method of a similar manifold, which is manufactured with the existing facilities, forcing us to promote large lot production. Due to this, the lead time (hereinafter referred to as “L/T”) is prolonged. It would be difficult to respond to a production increase in the future.

Because of this, we decided to internally fabricate the manifold, which is a component. I would like to introduce the newly established special fabrication line with great setup capabilities that can accommodate small lot production (lot: 1 unit).

2 Overview of Manifold Fabrication

2.1 Characteristics of Manifold Fabrication

The manifold, which is a component in a valve module, must be carved out of a rod (Photo 1).

While it is possible to fabricate this with a machining center alone, the precision requirements for the hole diameter and positions are strict due to the fact that the component must be lightweight and have a complex profile and many holes.

Photo 1 Valve module

2.2 Basic Fabrication Parts of the Manifold

Below are the basic fabrication parts of the manifold. There are multiple fabrication angles, and we must consider the movement range of the equipment and dimension requirement precision when determining the processes (Fig. 1).

① Profile fabrication
② Hole drilling fabrication
③ Port fabrication
④ Solenoid installation part fabrication
⑤ Main valve hole fabrication

Fig. 1 Fabricated part

3 Objective

Consider the issues with the existing facilities and establish a fabrication line with great setup capabilities that can accommodate small single-lot production (lot: 1 unit).

4 Objectives

① Operation rate: 85.0% or above
② Setup loss: Within 5 min.
③ Fabrication L/T: 30% reduction

5 Requirements

① Automate manual work, reduce the work time, and remove setup mistakes.
② Fabrication line that can accommodate small single-lot production (lot: 1 unit).

6 Implemented Initiatives

6.1 Fabrication Facilities

To select the fabrication facilities, we focused on space conservation and versatility. We also selected a high-speed and high-torque main spindle so that we can use it with various materials. Furthermore, in consideration of reducing setup time, we selected facilities that can permanently install the required number of tools.

6.2 Automatic Measuring Device within Equipment

By using an automatic measurement device, we can automate manual work.

To select the measuring device within the equipment, we focused on the measurement precision and versatility with the existing facilities. We also considered the work measurement parts to select the stylus with the optimal length (Photo 2).

Photo 2 Automatic measuring device within equipment

6.3 Consideration of Fabrication Processes

In general, fabrication processes can be roughly divided into the process division-type process and process aggregation-type process.

6.3.1 Process Division Type

In the process division-type (Fig. 2), a line is established by appointing facilities for each process to fabricate the units. Due to this, the machine time (hereinafter referred to as “MT”) for each facility is reduced, reducing the L/T. On the other hand, the number of setups increases due to the increased number of facilities, reducing the operation rate. In order to secure high productivity, we need to enhance the setup capabilities.

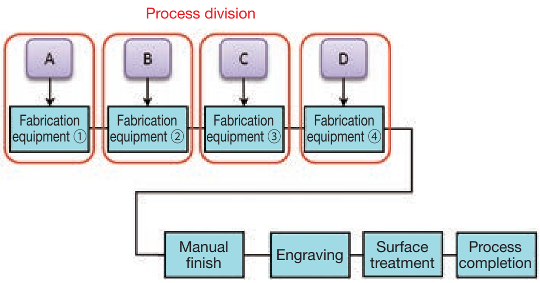

Fig. 2 Process division type

6.3.2 Process Aggregation Type

Since the process aggregation type (Fig. 3) aggregates various fabrication processes (A, B, C, and D), we can establish a line with a small number of facilities. However, it increases the MT for each facility, resulting in longer L/T. In addition, process aggregation often uses multiple-shaft-control fabrication equipment, meaning that it is difficult to maintain the quality from age-related deterioration, etc.

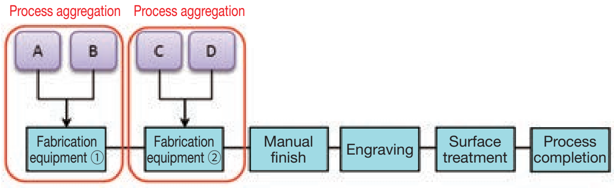

Fig. 3 Process aggregation type

6.3.3 Production System

Large lot production has work-in-process in each process, and it causes stagnation in each process (Fig. 4).

Single-lot production removes work-in-process in each process, resulting in reduced inventory (Fig. 5).

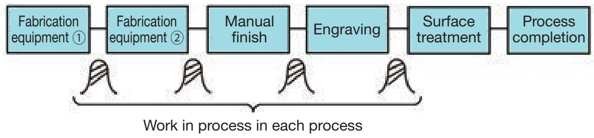

Fig. 4 Large lot production

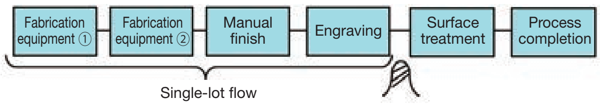

Fig. 5 Single-lot production

With the new line, it is easy to maintain the quality during a long course of production. We also utilized the single-lot production system so that we can reduce inventory and shorten the L/T, and we selected the process division-type fabrication process.

6.4 Improvement of Setup Capabilities

In general, setup work involves the following items. In order to promote small-lot production, great setup capabilities are required.

① Installation of fabrication tools
② Installation of jigs
③ Confirmation of the zero position (hereinafter referred to as “zero positioning”)
④ Setting of the fabrication program

6.4.1 Fabrication Tools

By identifying the required tools beforehand and selecting the facilities that can permanently install those, we were able to abolish the installation and removal of the tools that had been done every setup change. We also prepared tool lists for tool part numbers, tool names, part numbers of products for which the tools are used, etc. in order to simplify tool management.

By standardizing the tools used through this initiative, we reduced tool inventory.

6.4.2 Fabrication jigs

In order to standardize jigs and simplify installation, we utilized one-step clamp-type jigs (Photo 3).

As for production jigs, we standardized the installation work by standardizing the base shape when the jigs were being designed. As an error-proofing system to prevent installation mistakes caused by the standardized base shape, we chamfered the base corners and installed blocks for discrimination.

Through this method, we removed tool collision risks caused by jig installation mistakes.

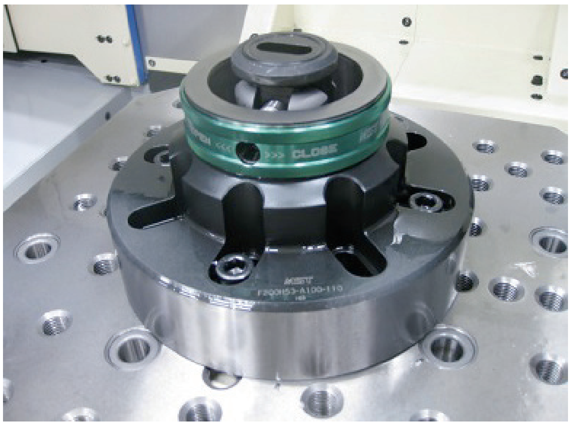

Photo 3 Fabrication jig

6.4.3 Zero Positioning

Zero positioning work, which is promoted to maintain the fabrication precision, must be performed every setup. This was manually performed by workers. Due to this, there were variations caused by workers' skill level differences, and there were more risks of measurement mistakes, requiring a lot of time. This was one of the causes for the reduction of productivity.

By utilizing an automatic measuring device within the equipment, we can measure outer diameters, etc. By automatically inputting them into the fabrication facility, we automated the zero positioning work at the time of setup.

Through this initiative, we were able to significantly reduce manual work and completely removed work mistakes (Fig. 6).

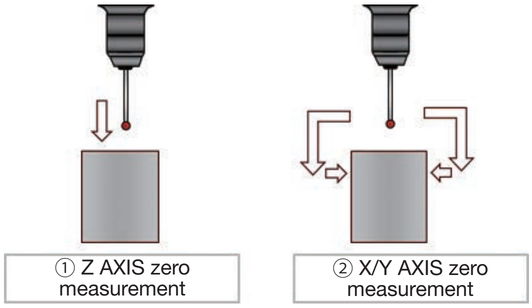

Fig. 6 Zero measurement

6.4.4 Fabrication Program Setting

Since the material is rods, their forms are very similar. Due to this, there are extremely high risks of facility collisions and defects caused by material installation mistakes and fabrication program setting mistakes.

Therefore, we developed a special program using an automatic measuring device within the equipment and custom macro.

By performing automatic product discrimination based on the material or jig shape difference for each product, the fabrication program can be automatically called. Due to this, operation is possible without workers having to reset the fabrication program, which used to be required every setup (Fig. 7).

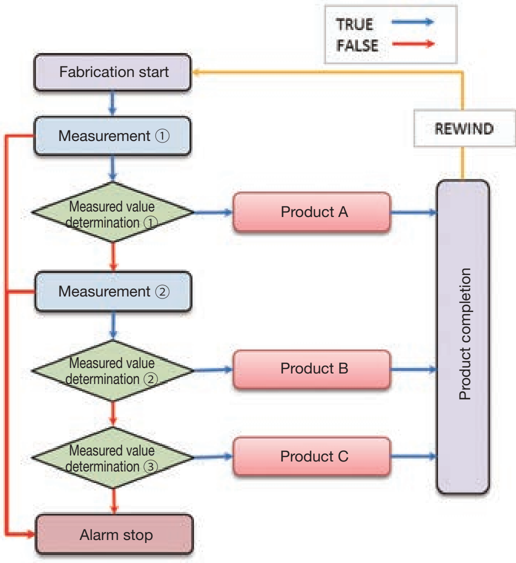

Fig. 7 Automatic discrimination program flow

6.5 L/T Reduction

Since the manifold is one of the major components, it is required to have product traceability through serial number (hereinafter referred to as "S/N") labeling (Photo 4).

Photo 4 S/N labeling

Since S/N are consecutive numbers, a special machining facility with the count-up function is required. Although we considered modifying the existing facility to control the investment amount, the existing facility also receives mixed-flow from other lines and often has general work for high-mix low-volume production. Since its setup capabilities are also low, the production is large lot production, meaning that the L/T is long.

In order to perform the engraving work within the line to reduce the L/T without investing in a special machining facility in the new line, we developed a special program using custom macro (Fig. 8).

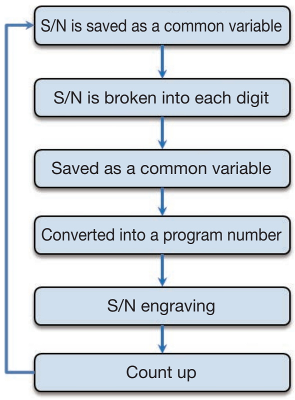

Fig. 8 Engraving program flow

With this program, we were able to engrave consecutive S/N numbers without using a special machining facility, and we were able to not only reduce the L/T but also save space and control the investment amount (Fig. 9).

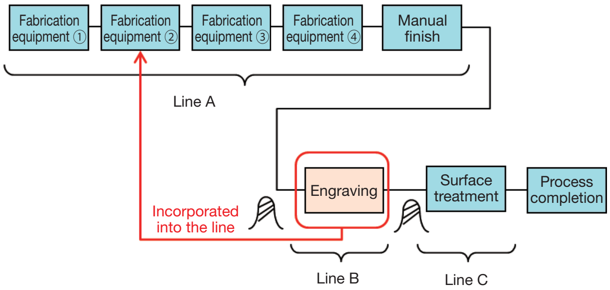

Fig. 9 Process flow

7 Result

① Operation rate: 86.4%
② Setup loss: 0 min.
③ Fabrication L/T: 35% reduction

8 Summary and Future Tasks

With this new line, we were able to establish a fabrication line with great setup capabilities that can accommodate small lot fabrication.

In the future, we will deploy and develop this initiative to other lines by using this technology as the base.

9 In Closing

I would like to express my appreciation to relevant divisions that have provided us with cooperation in the establishment of this line as well as everyone who has provided us with guidance and support.

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Joined the company in 1999.
Production Engineering Sect., Production Dept., Aircraft Components Div.
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