# Designing a Variety of Jet Engine Shafts with Deep Expertise in the Manufacturing Line

## — A Key Person in Engine Shaft Manufacturing —

The Kure Aero-Engine & Turbo Machinery Works manufactures 70-80% of the world's long shafts used in jet engines. The key person who manages the design and execution of the manufacturing line has to create a manufacturing setup that can cater to the advanced demands of global customers, while also remaining sensitive to local needs. His role is like that of an orchestra conductor.

### The responsibility of a 70-80% global share

Inside a charming, time-worn brick building that once flourished as a shipbuilding works, state-of-the-art technology is being applied to create jet engine shafts. There are over 30 main types of jet engine shafts being produced, primarily for the three global manufacturing leaders General Electric (USA), Rolls-Royce (UK), and Pratt & Whitney (USA). When low-volume specialty parts are included, the number of shaft varieties is approximately 50. Roughly 4 000 shafts are manufactured per year.

In the aftermath of the March 2011 Tohoku earthquake and tsunami, concerned customers around the world contacted IHI to ask, "Is the Kure site OK?" The reason is because if this facility were to stop, the manufacture of jet engines around the world would have no choice but to stop. Maintaining a stable manufacturing output is a large responsibility.

"Maybe being large myself made me want to create large things," says the 188 cm Norimasa Taga, a key person in engine shaft manufacturing. After researching non-destructive testing at university, Taga originally joined IHI in an operation testing role, but became interested in processing through a six-month training period at the Kure Works, and later requested a transfer to Kure. Since then, Taga has spent 18 years engaged in the shaft manufacturing process.

To briefly explain the shaft manufacturing process, first, a metal bar obtained from a materials supplier is trimmed by shaving the outer circumference, and then the inner bore is hollowed out. The bar is hollowed out to lighten it, but the bar's strength must be preserved. In particular, the outer attachment sites for components such as fans must be strong and sturdy. For this reason, although the bar is hollowed out into a tube, the wall thickness is not constant along the bar's length, but varies complexly. In order to cut the inner surface of a tube made of a hard material that is resistant to normal machining processes, a special processing technique that secures the cutting tool by surrounding it with a flow of molten sulfur is used. After that, the outer circumference is finished, and a coating is applied both inside and out to prevent rust and improve heat resistance. This coating process is another tricky challenge, and IHI is proud of its solution, but that is a story for another article. Other components are then attached, non-destructive testing is conducted to ensure there are no scratches or other processing defects, and after checking for any bending and

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Long shaft

warping via balance testing, the completed shaft is packaged and shipped. The bending tolerance for a shaft is approximately 0.1 mm for a shaft 3 m in length. This is a tiny deformation, approximately equivalent to a 1 cm deflection at the tip of Tokyo Tower.

## Process changes require complicated procedures

Described in a single sentence, Taga's job in the production engineering department is to coordinate and arrange the steps of shaft manufacturing so that they all go smoothly, and to maintain and improve the manufacturing technology. When there is a manufacturing inquiry, Taga first receives drawings, creates an estimate, and designs the steps needed to finish the job according to the specified demands, such as what machine tools to use, what production line to use, and the order in which to process materials. In other words, Taga creates combinations of tools, cutting tools, and fixtures, designs machine tool programming schedules, and also manages costs. These steps are not simply decided according to whatever is most convenient for the production facility, but are also monitored by international third parties. This monitoring is conducted in order to ensure and maintain aircraft component safety and quality.

Even if manufacturing steps are assembled according to a well-documented procedure, it can be a nerve-wracking experience when a problem occurs. In most cases, processing is carried out while checking for signs of malfunction before trouble develops, such as by listening to the sounds made during processing, feeling the vibrations of the material being worked, and visually inspecting the shapes of chips (shaving debris). Even if a malfunction is discovered and the cause is known, the processing procedure cannot simply be changed at will. First, a modification approval is obtained from the manufacturer who placed the order, and proof is supplied to show that safety will still be maintained even if the shaft is fabricated according to the modified steps. The modification can then take place after obtaining the customer's approval.

"These negotiations with our business partners about everything from procedure checks to manufacturing step modifications and auditing checks are all in English, so I still struggle. Sometimes, the engine manufacturer makes a request to cut costs. So I travel overseas, show them the schematics, and negotiate by making proposals, such as explaining that if the requirements were to be changed like this, we would be able to cut costs by about this much."

## Finding improvements through close communication with factory staff

Fostering the next generation of skilled workers is also an important issue. For employees like Taga who oversee manufacturing processes, the main workplace is an office. However, Taga also tells his younger associates to "Stay on your feet, go to the floor (factory) if there's an issue of course, but even when there isn't, get out on the factory floor and touch the products and the machines. You should have to wash your hands five times a day."

Taga says that hints for better workflows and cost savings emerge from casual conversations with workers at the factory. The factory floor is the place to discover the techniques of the true craftsman, which cannot be fully captured in a tutorial or procedure manual.

"The most gratifying thing is when the workers on the factory floor tell you that the work is so much easier this time as a result of applying a number of tricks and minor improvements that I have introduced. Other times, I catch a customer saying, "it's a good thing we went with Kure." When we are recognized for reliably delivering a precision shaft that meets a customer's advanced needs, I think to myself, 'Yes! We did it!' " (*laughs*).

Thanks to this steady buildup of trust, shaft orders are increasing. Recently, an agreement was finalized for mass production of shafts for the Airbus A320neo. Aiming for a mass production setup starting in 2015, Taga is currently busy starting up the production lines. For the time being, the work will involve a lot of trial and error, but for a key person like Taga, that's what makes the job worthwhile, and even fun.


Shaft factory in Kure Aero-Engine & Turbo Machinery Works