A technology used in zero fighters continued to be preserved, revival in automobile components, MHI

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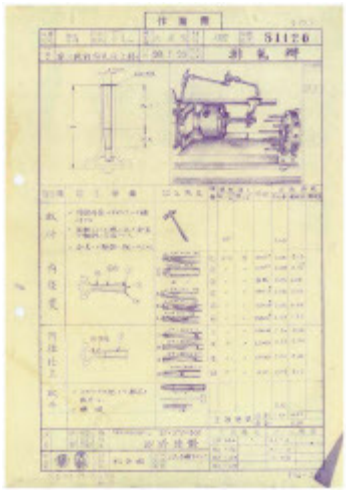
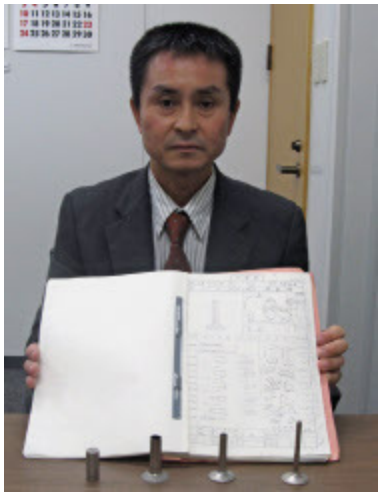
Mitsubishi Heavy Industries has revived a technology for manufacturing prewar aircrafts in today's automobile components with an up-to-date technique. It's a technology for forming an engine valve with a hollow umbrella portion that contributes to the weight reduction of the engine and the improvement of the fuel efficiency. What made the achievement possible are the efforts of a wartime engineer who had protected the technology from incineration to hand it over to the next generation and forging engineers of the Showa and Heisei periods who polished it up with today’s technology.

*Technical document, in danger of destruction



The preserved blueprint document Figure 1



Mr. Morii holding the wartime document in his hands Figure 2

"Reactions from the manufacturers are very positive. We may need to move up the mass-production schedule." - Mr. Hirokazu Morii, the principal engineer of the hollow umbrella portion team of the engine valve engineering department of the engineering division of the machine tool business headquarters (Ritto City, Shiga Prefecture) was feeling a sense of expectation when receiving feedback about the engine valve with a hollow umbrella portion. He had visited British, German, and French major automobile manufacturers in late January.

When forming an engine valve with a hollow umbrella portion that can be created through a combination of drawing and punching processes, first, the end of the metal rod is pressed to be the head of the pulled valve. After that, a hole is punched in the shaft portion, and the shaft portion is drawn to form a narrow shaft being cold forged little by little. Then, an engine valve “with a hollow umbrella portion” that has hollow space spread also inside the umbrella of the valve is complete.

In addition to the shaft, the umbrella portion is also hollow, so the valve has been 10-20% lighter compared to the previous one.

It also has a high capability of releasing the high-temperature air out of the engine. This is because the hollow part is larger, spreading also into the umbrella portion, where highly thermally conductive sodium can be accommodated, compared to the normal “hollow” valve created by drilling a hole into its shaft portion only, and that allows the high-temperature air to be released out of the engine block quickly.

The Daiko Factory, in which engine valves were produced during the war Figure 3

This technology was utilized by the Daiko Factory of the Nagoya Works and the Kyoto Factory for the production of engine valves of military aircrafts. At earlier stages, domestically-made valves had been broken so often that forming methods were improved based on design drawings obtained from Europe. At that time, as the mass-production was the highest priority, as many as 600 process steps, mainly hot forgings, were performed by sheer force of numbers. Amazingly, it is reported that 5,000 workers were engaged in the production of 80,000 valves per month.

The technical document with the detailed descriptions of this processing technology was exposed to danger of destruction at the end of the war. But at that time, a university graduated young engineer in the Kyoto Factory personally "hid it somewhere assuming that military-related documents would be incinerated". As of 1966, the document has already been stored in the company. After a long time had passed, the document was handed over to Mr. Morii with a message, "Our company had this technology. Use it when needed sometime in the future."

*"Does not make sense unless molded integrally"

However, for components of today's mass-produced automobiles, which require the price range of hundreds of yen because of incessant needs for cost reductions, the same processing method as the wartime cannot be used. A number of attempts made to utilize this technology continued to result in failure until the Heisei period, due to the issue that "the amount of the part that needs to be forged was too large".

In 2007, a new project was started under the slogan of "Let's create an additional value with an engine valve." Mr. Morii was pushed by a current member of the Board of Directors and Executive Committee, Mr. Yukio Kodama, who was controlling the engineering divisions in Ritto, with a message "Doing the same things as other companies does not work. It does not make sense for Mitsubishi Heavy to develop the engine valve unless it is molded integrally, instead of by welded connection. "

Even though he approached people inside and outside of the company with this idea, everywhere he got a response "It is absolutely impossible to mass-produce using this technology." and the reaction of

giving up. Just then, Mr. Ryoji Yoshimura visited him on another matter.

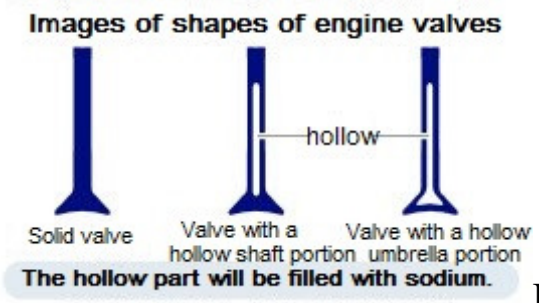


Figure 4

In February, 2008, Mr. Morii made a proposal to Mr. Yoshimura reversely, "I would like you to consider whether it is possible to mass-produce automobile engine valves using the technology of the hollow umbrella portion." showing him a prewar blueprint drawing document of 94 pages. The development was started in April.

Mr. Yoshimura has been engaged solely in forging since he was assigned to the Daiko Factory in Nagoya in 1957, and constantly developed new technologies such as closed-die forging. He had left MHI when the Daiko Factory had been closed in 1986, and after that, became an official of a mold manufacturer, and continued the research of the forging technology there.


Working process to form the (rightmost) engine valve with a hollow umbrella portion Figure 5

The blueprint document was full with detailed instructions, including illustrations, such as manufacturers of the processing equipment to be used and types and grain sizes of the grindstones.

Mr. Yoshimura's proposal was an idea of cold forging a high-strength and high-heat resistant alloy. He said "The first one of the more than 10 processing methods I'd come up with made a hit. It's something like Columbus' egg." Mr. Morii said "This is like an invention of a car

that can fly in the sky. Mr. Yoshimura's idea for creating existence out of nothing is great." being deeply impressed by Mr. Yoshimura's idea.

*Achieved by the integrated efforts made at designing and manufacturing floors

However, the drawing of stretching a hollow rod to make it thinner was extremely difficult. The thin shaft could be crushed unless that is done under appropriate conditions. Trial and error, such as applying tons of pressure in several steps and changing the shape of the mold, were repeated with the cooperation of small-to-medium sized processing manufacturers.

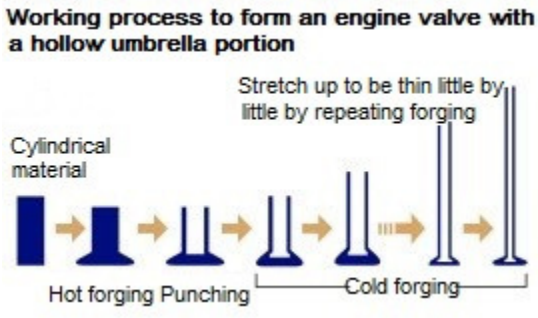


Figure 6

Mitsubishi Heavy Industries, this time, established the technology for mass-producing high-quality valves with hollow umbrella portions in a short period of time by performing the process of punching holes prior to the drawing. They aggressively promote the sales with the new technology not only to Japanese companies but also to European automobile manufacturers.

What should be learned from the past is not only individual technologies. According to the manufacturing and engineering division of MHI, in the Nagoya Aircraft Works, before and during the war, the conceptions of concurrent-engineering (CE) and front-loading (FL) have already been rooted. These are conceptions of shortening the development time frame, by reflecting the failures predicted to occur during the stages of manufacturing the products such as zero fighters and heavy bombers in designing them, beforehand.

Of course, computers were not available at that time. It has been reported that "the attempts that can be performed by making full use of three-dimensional (3D) CAD (computer-aided design) and 3D printers in the manufacturing industry of the Heisei period, were achieved with the integrated efforts made both at designing and

manufacturing floors because of the needs the wartime era, where overwhelmingly short time frame was required". The entire team was gathered in a large room for a discussion, just like in the world of the cinema, "The Wind Rises".

In a gallery of the Nagoya Guidance & Propulsion Systems Works located in Komaki City, Aichi Prefecture, where engines of missiles and aircrafts are manufactured, engines of wartime military aircrafts and engines with the valves with hollow umbrella portions are displayed. Director of the gallery, Mr. Seiichi Tsutsumi also worked for the Daiko Plant for a long time. He says "Perspective views of engines that were created mainly for use by mechanics are precise enough to look like CG images, even though they were handwritten. They show the high level of the manufacturing technology of that time."

However, it was not easy to transfer the technology. In the reference room of the Nagoya Aerospace Systems Works, beside the exhibits such as zero fighters, "pans and toasters that were created to make living for employees" when the production of aircrafts was prohibited because of the end of the war, are displayed. This is one of the "measures" taken not only to maintain sales but also to "avoid dispersion of engineers" (according to Mr. Toshihiko Ito in the administrative control division).

Mr. Ryuji Yoshimura who co-developed the engine valve with a hollow umbrella portion. Figure 7

*Toward the shipments to major automobile manufacturers

Even though Mitsubishi Heavy acquired engineers who had knowledge of aircrafts, the company did not resume the aircraft business until 1952, after the San Francisco Peace Treaty. The best they could do was to introduce the U.S.'s aircraft technologies that had already made progress after the war. "The blank period of 7 years had a so large impact".

The company is scheduled to start shipping the valves with hollow umbrella portions to major automobile manufacturers within this fiscal year. They will invest approximately one billion yen to build a facility in Ritto to perform a series of processes such as cutting, heat treatment, punching, drawing, and sodium injection on one line. It will start with a capacity to produce 500 thousand valves per month, and the company has a plan to make an additional investment of 2.5 billion yen after years to increase the capacity to 2 million per month.

Mitsubishi Heavy was able to make progress on the hollow umbrella portion technology. The wartime engineers who left the document, Mr. Yoshimura, and Mr. Morii contributed to this achievement. This technology would not have been revived if anyone among them had been dropped out. However, it is also a fact that the company, equipped with a lot of laboratories and facilities, was unable to solve the issue by themselves, and that Mr. Yoshimura, who has was running a business almost independently, although he was a former employee, was able to solve it.

Mr. Yoshimura took the occasion of the development of the hollow umbrella portion technology to establish a forging consulting company of Yoshimura Company (Nagoya City). The company proposes forging technologies to the clients such as automobile manufacturers. He sometimes gives a lecture also in Mitsubishi Heavy, though, regretting "The important successors get away from the fields once they go to the management positions."

*Pass the baton of the technology to the next generation

Mr. Yamauchi creating a windmill generator with elementary school kids. Figure 8

Not only MHI, other major companies are also promoting the transfer of the expertise by creating opportunities such as expertise seminars. In the seminars, young engineers absorb the basic expertise through activities such as camping. However, "even if it is possible to duplicate previous technologies through training, it is another thing to combine them with the up-to-date ones to make a new technology that can be a real strength" (according to Mr. Morii).

"Do you know how the electricity can be made? There are various ways to run a power generator."

Mitsubishi Heavy has been hosting visiting science classes at elementary schools for years on themes such as creating a power generator using a windmill. One of the instructors is a former employee, Mr. Norio Yamanouchi. He contributed to the development of the Japanese airline industry by being engaged in designing YS-11, the first domestically-made passenger aircraft after the war. He also served as a test pilot for the aircraft. Mr. Yamanouchi was showing the pleasure of the science at an elementary school near the headquarters together with a former executive of another manufacturer last summer also.

From the pre-war to the post-war, and to children who will lead the future, making steady efforts to pass the baton of the manufacturing technologies will lead to the future of Japanese manufacturing industry.

(By Yoshikazu Miura, Industrial Division)