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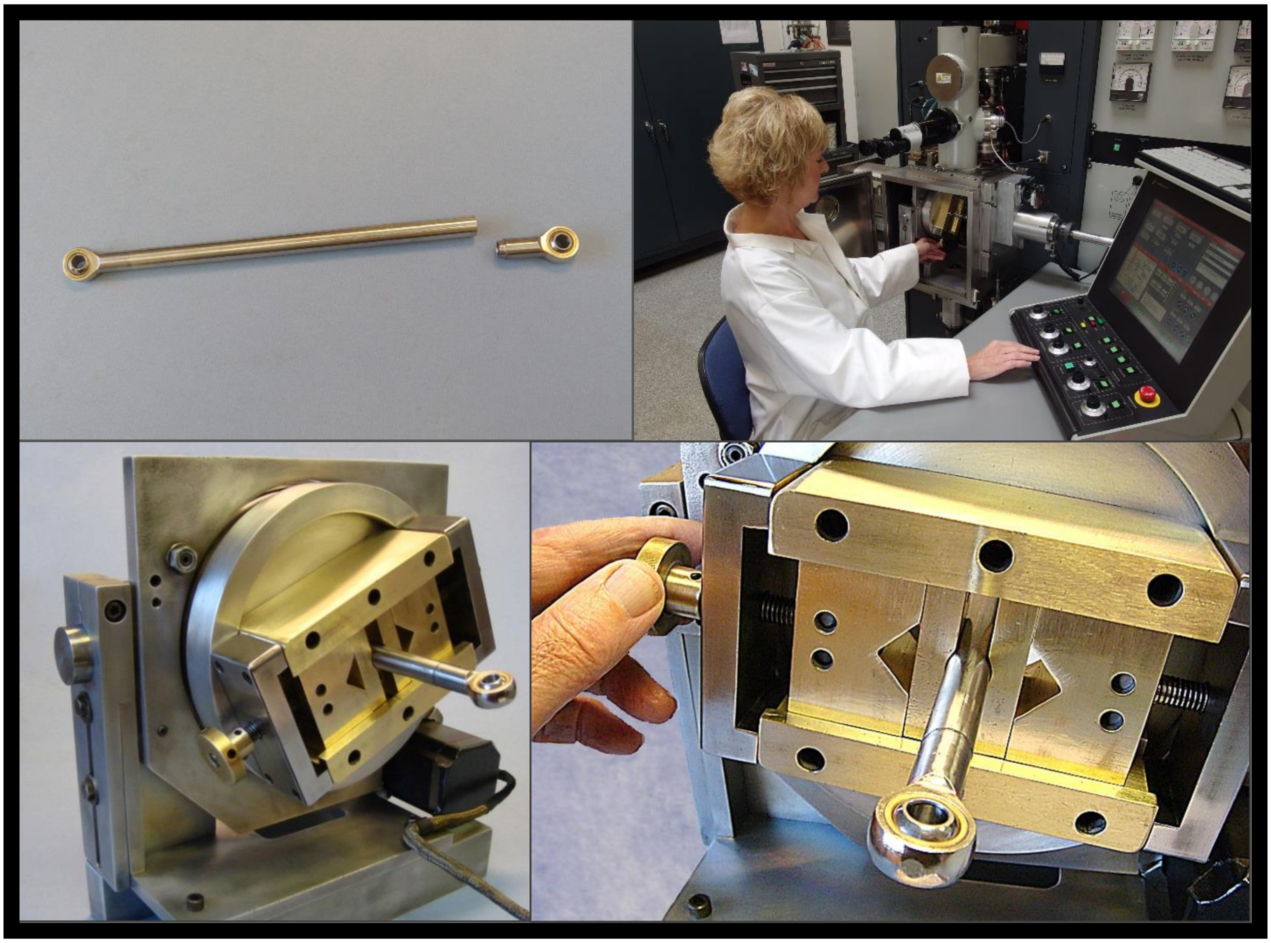
Electron Beam Engineering Presents

Case Study: Aircraft Engine Link

By Richard E. Trillwood, Founder and CEO of EBE



Case Study: Aircraft Engine Link

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In 1981, an aerospace parts manufacturer approached Electron Beam Engineering Inc. (EBE) with a request to electron beam weld a variety of link assemblies that, when mass-produced, would be used in the General Electric and Pratt & Whitney engines for civilian and military aircraft across the nation.

The assembly is made of a proprietary metal – the nickel-chromium-based superalloy Inconel 718 – and it includes two end bearings one on each end of a hollow tube. (Tube is used instead of rod for weight reduction) The end-bearings ultimately get fitted with balls that go into the engine providing some flexibility to allow the high speed rotating engine some movement and isolation from the aircraft frame.

With all the load of the engine and elevated temperature and exposure to the elements that an aircraft engine would endure while it's in use, they are critical welds joining the rod and the end-bearings together. It is equally critical that there be no welding splatter or "BBs" that could come loose within the assembly during flight which would degrade the integrity of the link assembly and compromise the ability to achieve a satisfactory x-ray of the welds.

"The stresses and environment are especially great in military aircraft and require that at routine intervals the links are replaced with new ones" said Richard Trillwood, the founder and President of EBE, an Anaheim, Calif.-based high tech welding shop that specializes in welding aerospace components, as well as sensors, medical devices and many precision assemblies.

When the project was brought to EBE, Trillwood said there were issues with the previous conventional GTAW (Gas Tungsten Arc Welding or TIG) welding processes, which require a more invasive handling of the Inconel tube so as to provide Argon shielding gas to the underside of the weld in addition to the top. Typically, holes have to be drilled through the tubes at each end to allow the flow of the purge gas. Subsequently, these holes have to be welded shut, which introduces two additional welding operations not necessary when using electron beam welding.

There are many advantages in using electron beam welding for this part; namely:

- The heat input and distortion are minimized
- The vacuum inside the tube (a byproduct of welding a sealed component in a vacuum chamber) reduces the problems of oxidation and stress during the subsequent vacuum heat treatment, which is performed to optimize the material strength and remove residual stresses

Since these are very critical components and despite the repeatability of the electron beam welding processes, there are added precautions taken to ensure that no substandard component gets into service that would compromise safety. The weld profile has a minimum width requirement that allows for a few thousandths of an inch misplacement of the weld position which will occur as tooling wears in volume production. Before every welding batch, a "first article" test sample that simulates the actual joint is electron beam welded. Its position is optically checked, and then it is sectioned to confirm the correct weld profile, lack of visible defects and absence of weld splatter inside the tube. Every production component also undergoes visual and positional inspection of the weld which is logged by the operator as part of the production data collection. To complete the process the parts are vacuum heat treated and subjected to 100 percent x-rayed as a final quality assurance

"What they are looking for are smooth welds, top to bottom so as not to create stress points – and the absence of weld splatter that gives a clean, sealed tube inside," Trillwood said, adding that his company has been welding such link assemblies in large quantities since the problem was first brought to him more than 30 years ago. EBE has been performing these welds on all sizes of link assemblies, including smaller ones for military jets that are only about 6” long and ones that span 18” and are larger in diameter for the bigger engines used on civilian aircraft.

In collaboration between the customer and EBE, some changes were made from the initial design to allow for post-weld machining of one end to compensate for weld shrinkage and to avoid the necessity to ensure perfect angular orientation of the rod end-bearing pieces.

Inconel 718 is a good alloy to use for this component because it is strong yet heat treatable and it can operate at higher temperatures than similar alloys. As a bonus it also happens to be a good alloy for electron beam welding.

The machine and the tooling used for this project were all designed and made by EBE. The machine is named a 312 BEAMER, an electron beam welder operating at 3 KW maximum power and fitted with a 12-inch cube stainless steel chamber with one extension tube. Special tooling included:

- A weld-tacking fixture to ensure alignment orientation and intimate contact of the joint
- A special rotator later named “Bigmouth” to rotate the assembly in the vacuum chamber PIX
- An optical measuring tool which was specially designed and built to check the position of the weld joint and then check the centerline of the weld to ensure that the weld was centered on the joint.

All the EBE machines are fully upgraded to current standards for power, optics and vacuum systems. Additionally, EBE’s machines can store all the weld parameters and log all the data on every weld in production. None of this requires operator participation. The machine operating data, including vacuum levels, are automatically recorded every few milliseconds. The data can be stored internally or on a dedicated server and shared within the company or if permitted shared outside of EBE for analysis.

EBE provides precision electron beam and laser beam welding services throughout the United States, Europe, and provides sample welds throughout the world for companies anxious to evaluate the electron beam welding process on their assemblies. It specializes in working with companies designing or producing complex components for a variety of applications, including aerospace and defense, medical devices, oil and gas exploration, sensors, automotive and transportation products, communications, electronics, jewelry, semi-conductors and commercial uses.

Trillwood says that best results are obtained using laser and electron beam welding when a specialist in these processes is consulted at the design stage of the part.

EBE was founded in 1991 by Richard Trillwood, the designer of the world’s first compact production electron beam welding machine. Its quality and welding processes are AS9100, ISO and, Nadcap (National Aerospace and Defense Contractors Accreditation Program) certified, Quality systems that are required by many major aerospace and medical companies.

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