THE EMERGENCE OF ELECTRON BEAM WELDING IN THE NUCLEAR INDUSTRY- IS IT VIABLE?

Within the Nuclear industry welding of “thick section” components can be completed through various processes that are cost-effective, but the presence of residual magnetism in the materials has hindered the effective application of these processes. For many years the aim has been to find a suitable process that can be used more widely across the Nuclear industry. Even though output within nuclear is low, the safety critical nature of these components demands a solution.

Typically, the welding of “thick section” components such as pressure vessels within the nuclear industry has traditionally been performed using arc-welding techniques, which require multiple weld passes with inter stage non-destructive examination (NDE) and pre-heating of the component to reduce the risk of hydrogen cracking.

For a nuclear plant, the joining of components is currently used through the use of the Tungsten Inert Gas (TIG) process. TIG- welding of “thick-section” pressure vessels such as the Reactor Pressure vessel is an expensive and time-consuming practice involving extensive pre-work including fixtures, tooling, pre-heating of the components and multiple weld passes. Another drawback to using the TIG process is that it can only penetrate to a certain depth so thick-section welding is executed by filling the weld groove with several passes. Typically, this involves up to 100 runs of weld for a typical Reactor Pressure Vessel section of 140mm or greater.

Consequently, there are a few disadvantages of using this process, namely multiple runs requiring preheating, inter-pass temperature control and inter-stage inspection by NDE throughout the whole process. The welding, inspection and completion of an RPV therefore takes many weeks, even months thus accounting for a vast proportion of the fabrication cost and component lead-time.

Historically, there have been many attempts to deploy Electron Beam Welding (EB) with local vacuum pumping, but most were hampered by the need to work at high vacuum. Previously, trade organisation, The Welding Institute has demonstrated that operating the EB process in the pressure range of 0.1-10m bar, so called ‘Reduced Pressure’ in preference to high vacuum ~10^{-3}mbar offers possibilities of more reliable deployment of local sealing and pumping for EB welding on a large structure. In the late 1990s, TWI developed a high power (60kW) EB welding system for girth welding of long offshore oil and gas transmission pipelines. Excellent weld quality was achieved consistently with rudimentary pumping and flexible rubber seals and the process showed that there was a good tolerance to material cleanliness, fit-up, surface condition and working distance with potential to fully girth weld 40mm wall thickness 711mm diameter pipe sections in less than five minutes.

More recent development of Electron Beam Welding technology offers the opportunity to weld “thick-section” components in a single pass and negates the need for (NDE), which means there’s a significant saving in time and cost in the fabrication of nuclear pressure vessels. Furthermore, elimination of the preheat step is possible since the EB process is carried out in a vacuum environment.

Compared with other welding processes there are many advantages of using Electron Beam Welding within the Nuclear industry. It can offer significant savings in cost and time for “thick-section” fabrication due to the rapid joining rate resulting from the process welding the full joint thickness in one single pass.

However, due to the physical size and geometry of nuclear pressure vessels traditional vacuum chambers would be prohibitively expensive when considering the low volume of output in the nuclear industry.

Currently being pioneered in Britain, Cambridge Vacuum Engineering has recently launched a revolutionary local vacuum EB technology called EbFlow. The EBMan Power project which is a joint- collaboration between CVE, TWI, U-Battery and Cammell Laird will implement and validate the first EBFlow system within a large-scale fabrication facility to cost-effective manufacture of large-scale power generation infrastructure.

The EBFlow technology will specifically focus on reducing the cost of “thick section” steel structures applicable for both nuclear and off-shore wind structures. The collaborative partners are hopeful that their project will be critical in helping EBFlow to reach the marketplace and work in a real-world environment.

Compared with other welding processes there are many advantages of using EBFlow technology within the nuclear industry. The aim of this particular project is to manufacture components for Nuclear power plants. Similar processes have been successfully applied in other industrial sectors, but this is the first time this approach has been applied within the power sector.

The demand for “thick section” steel structures in the power generation is already strong and will continue to grow over the years. Currently to produce a typical 100-metre long monopile (100mm thick) it can take more than six thousand hours of ‘arc-on’ welding time. However, the EBFlow system, based on high productivity Electron Beam Welding can reduce the welding time involved to less than 200 hours equivalent to a reduction in cost of over 85%.

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Due to complete in 2021, the EBMan Power project aims to will resolve many years of development of trying to attempt and deploy Electron Beam Welding within the global industry. This will become a reality, rather than a possibility and may help to relieve some of the production pressures the world currently faces as well as contributing to the solution of what is known as the “energy trilemma” (low carbon, secure and affordable energy) and enabling a low carbon economy.

For more information about EBFLOW, visit: www.ebflow.com

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