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Design of Special Adapters and Furnace for Hot Helium Leak Testing of Plasma Physics Components

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Abstract

Pressure and leak testing are the two most important quality control steps followed at the end of fabrication for the components of ITER, Plasma physics and its related fields. In the current project, an elaborate procedure and facilities for the hot helium leak testing has been established. A conventional vacuum furnace has been modified to accommodate the global leak testing of high technology Plasma physics and ITER components. Special adaptors were designed and fabricated for hot helium leak testing under pressure mode. These adapters have a transfer tube which can be used to carry the helium in and out of the component under testing, without disturbing the vacuum level in the furnace chamber. These adapters were fitted to the 2000 mm long ITER components and tested successfully at the operating temperature of 200 °C. High end vacuum fittings and sealing mechanisms were installed on the mating surfaces of the furnace, to achieve high vacuum in the order of 10^{-5} mbar. Provisions have been given to address the challenge of local leak detection by installing a Wilson seal to move from one end of the component to other end; in such a way that one side of the seal is at 200 °C temperature in vacuum, other side is at room temperature in atmospheric pressure. This enables to locate the leak by moving the component form one end to other.

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Keywords: Helium Leak Testing, Plasma Physics, ITER, Copper alloy

1. Introduction

Fabrication of components for advanced technology like International Thermo-nuclear Experimental Reactor (ITER) requires high-technology joining as one of the fabrication processes. Vacuum brazing and Electron Beam Welding (EBW) are two widely used high-technology joining processes for this application [1, 2]. Leak testing is

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the mostly accepted procedure to validate the quality of such joints. When the complexity of the test component increases, leak testing is a challenging task. If the same work is carried out at high temperature, it adds the complication to highest level. In the current research, complicated copper alloy structure used in ITER is subjected to the helium leak test at 25 °C and at 200 °C + 2.4 MPa pressure. This component is fabricated by EBW which needs to be qualified by pressure and hot helium leak testing. Adapters, water cooling circuits and feed-through were designed and installed to suit the complicated component, enable the testing in smooth way. Methodology is followed such that the entire component is subjected to local and global leak/pressure tests and hot (high temperature) helium leak tests [3].

1.1. Leak Testing

In a classic leak testing arrangement, the part to be tested is maintained at different levels of pressure, on either side of the surface to be tested. A tracer element, typically a gas, is passed on the higher pressure side and the concentration (through leaks if any) of the same is measured on the lower pressure side, as shown in the schematic in Fig. 1. By measuring the rate of leak, the size of the pore, crack or flaw on the test surfaces can be evaluated. Leak testing method is more sensitive and reliable, when compared to the pressure decay test. Among all the leak testing methods, helium leak testing is one of the most common methods followed for ITER and plasma physics components [3].

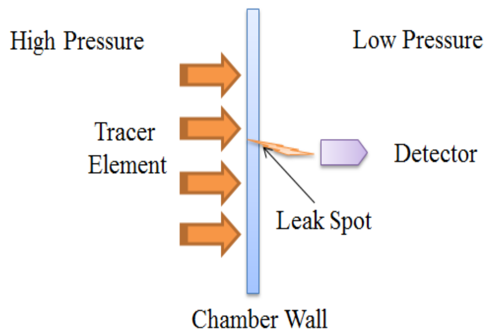

Fig.1. Schematic of Leak Testing

1.2. Helium leak testing and detector

Among many leak testing methods followed, helium leak testing is the most sensitive method, to detect leaks rates in the level of 10^{-12} mbar.lit/sec. Helium is the second smallest gas molecule, next only to hydrogen, and is highly inert. This indicates that Helium can occupy and pass through the smallest crevices (leaks) possible in safe manner [3]. (When helium is used as the tracer element, smallest leaks of the order of few nanometres can be accurately detected). Helium leak testing can be carried out in two modes – (1) pressure mode in which helium is pressurised inside the component to be tested, uses the tracer probe to detect the leaks by scanning it on the outer periphery; (2) vacuum mode in which component is subjected to low pressure, helium is sprayed on the outer periphery so as to be sucked by the possible leaks, and detected by the detector connected along with component in low pressure. These two methods are explained in the schematic in Fig. 2. The choice of the testing method is strictly dictated by the end application (leak rate sensitivity), complexity of the product being tested.