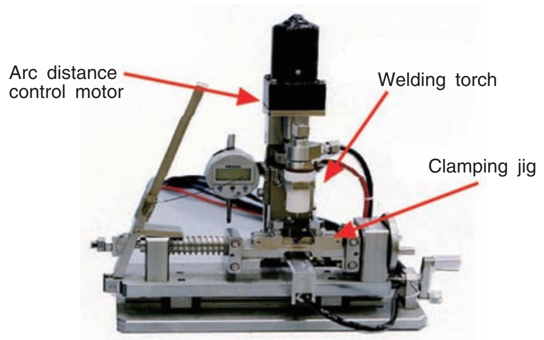
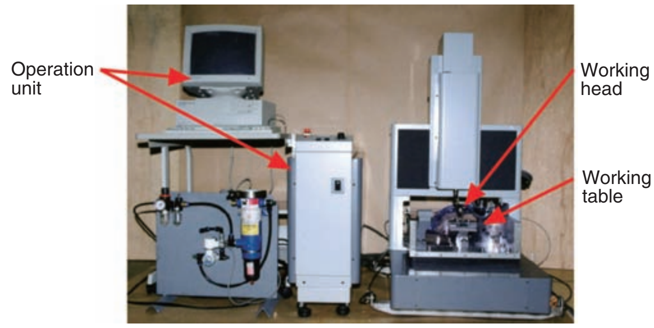
# 14-8 Contribution to “ITER” by Technical Development of Post Irradiation Examinations

## –Remote-Handling Type Welding / Processing Techniques for Irradiated Materials–




(a) TIG-welding machine
By using a manipulator for remote-handling, it is easy to clamp the specimens onto the welding machine, to adjust the welding position and to adjust the gap distance between the torch and the specimen.
A narrow heat affect zone (HAZ) in the welded specimen can be achieved by a clamping jig with high thermal conductivity.




(b) Processing machine
By using a manipulator for remote-handling, it is easy to fix the specimen onto the remote-controlled NC lathe. This machine warrants the high accuracy of processing, the same as the out of the hot cell processing.

**Fig.14-16 Technical development of a remote-handling type welding/processing machines**

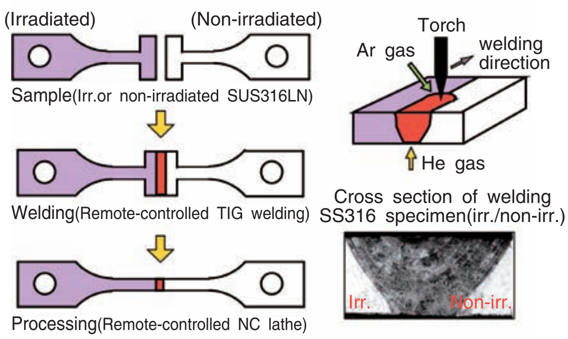



**Fig.14-17 Welding/processing procedures for fabrication of test specimens**
The weldment specimen was fabricated from irradiated and non-irradiated specimens by remotely handled welding/processing machines in a hot cell. The plate type specimen with a tab was chosen, and the conditions for welding and processing were determined. By applying this technique, data can be obtained from the specimens after re-irradiation.

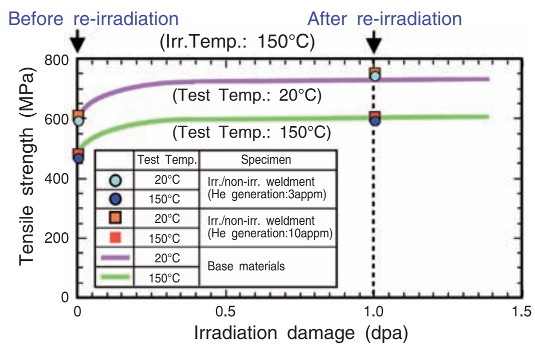



**Fig.14-18 Neutron irradiation test results of welding material before and after irradiation**
Neutron re-irradiation tests on SS316LN weldment specimens, joined with irradiated and non-irradiated materials, were performed. From the results of a mechanical property test, it was clarified that the tensile strength of the weldment specimens is the same as that of the base materials.

For maintenance and/or replacement of the fusion blanket, new cooling pipes for the blanket will be joined by welding to the existing cooling pipes irradiated by high energy neutrons. Therefore, it is necessary to evaluate the effect of helium generation by neutron irradiation on the mechanical properties of the weldment. In this study, all the work from the welding and processing of test specimens, to the installation of the specimens into the irradiation capsule, were performed in the hot cell by remote handling. Therefore, the remote-handling welding/processing machines, and the assembling procedure of the irradiation capsules were developed based on the experiences of the post irradiation examinations in the Japan Materials Testing Reactor (JMTR) hot laboratory.

The remote-handling type Tungsten inert gas (TIG) welding machine (Fig.14-16 (a)) was developed. In order to evaluate the mechanical properties of the weldment correctly, a plate with a tab where the crater part is able to be removed, was adopted as the shape of the test specimens. On the other hand, the processing machine (Fig.14-16 (b)) with the end-milling type numerical control (NC) lathe was developed. It is possible to fabricate the weldment specimens with high accuracy in dimensions to within 50 $\mu$m. These developments for remote-handling techniques enabled a systematic evaluation on the mechanical properties of weldment specimens with irradiated and non-irradiated materials.

Using austenitic stainless steel SS316-LN-IG (IG means “ITER” grade) irradiated up to the “ITER” irradiation conditions in “JMTR”, the TIG welding between the irradiated and non-irradiated materials was tested in a hot cell (Fig.14-17). From the test results, it was obvious that the sealed gas and the welding heat affected the welding, as there were defects such as, a crack on the surface and the cross section of weldment, an undercut and insufficient welding. Especially, it was found that when the welding heat input was about 1 to 2 kJ/cm, a good weldment specimen without cracks could be obtained. Furthermore, their welding test specimens were processed as tensile-type weldment specimens, and they were installed onto the irradiation capsule in the hot cell. The neutron re-irradiation test was successful in ”JMTR”, and the mechanical properties of a re-irradiated weldment was obtained for the first time in the world (Fig.14-18).

**Reference**
Tsuchiya, K. et al., Effect of Re-irradiation by Neutrons on Mechanical Properties of Un-irradiated/Irradiated SS316LN Weldments, Journal of Nuclear Materials, vol.373, 2008, p.212-216.