SETUP FOR HIGH TEMPERATURE IRRADIATION SYSTEM AT BARC-TIFR PELLETRON ACCELERATOR FACILITY

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Abstract

A set up is indigenously designed, fabricated and being used for proton-irradiation at high temperature on stainless steel at 6M Irradiation Port of BARC-TIFR Pelletron Accelerator Facility. The facility is useful to study radiation effects on structural materials used in nuclear power plants at temperature in the range of 300-400^o C. Proton-irradiation is known to induce the irradiation damage in stainless steels qualitatively similar neutron irradiation damage in a very short span of time. In view of this, proton-irradiation is used to simulate and accelerate RIS behaviour in austenitic stainless steel.

IRRADIATION SETUP

In order to get higher DPA rates for materials science experiments, Proton beam of few MeV in µA current range is needed. The radiation shielding of the accelerator tower can accommodate beam currents of few µA but cannot be delivered to the Pelletron beam hall due to the inadequate radiation shielding there. Radiation shielding of accelerator tower can accommodate proton beam currents in µA range.

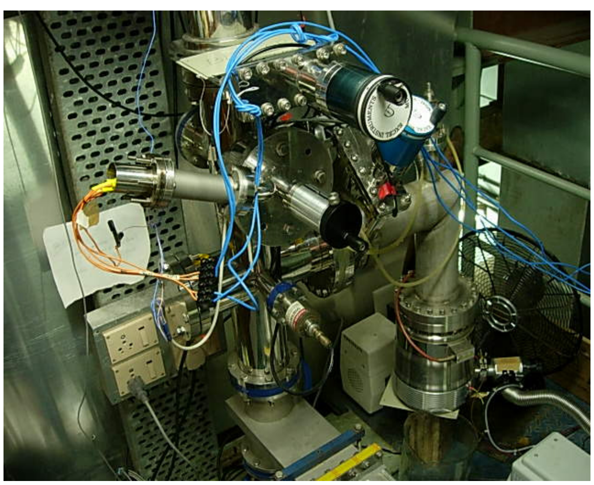

Figure -1: 6M Irradiation setup

Lay out of drift space above analyzing magnet was modified to accommodate 6M Irradiation setup [1] in tower area itself. This setup is already operational in the tower area and being utilized for many applications [2] along with High Temperature Proton irradiation for Materials Science Research.

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High Temperature Multi Target (HT-MT) Assembly

Having experiences of high temperature single target assembly, a multi target assembly has been designed, fabricated and being used at our facility which can accommodate a maximum of six targets at a time. The picture of the HT-MT is shown in figure-2. The target can be heated upto 500 ^{o}C on an OFHC copper block. The temperature of the target is measured by a thermocouple unit and is regulated by a PID controller. This assembly has been designed to be used in vacuum as per user's requirement.

Vacuum of the order of 7 x 10^{-8} torr is achieved in hot condition. The target holder plates are insulated from base plate to provide beam current read back via an MHV high vacuum feed thru. Required electrical connections are made by suitable UHV 35CF electrical feed through flange. Target holder block is coupled to a linear motion bellow sealed UHV feed thru which can be varied up to 150 mm. In UHV feed thru super bellow (SS 304L) is used which has relatively less backlash and greater life than edge welded bellow.

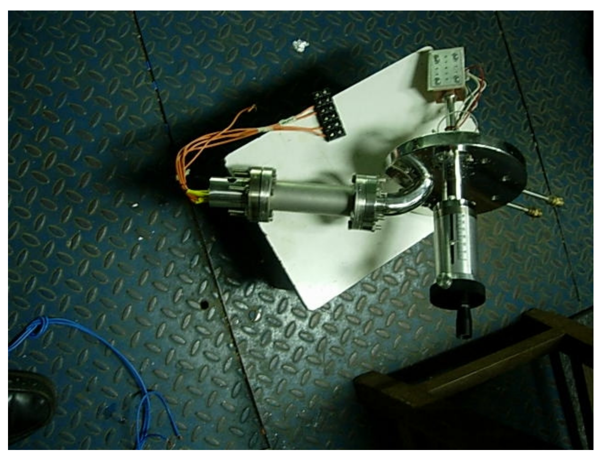

Figure -2: High Temperature- Multi Target Assembly

This assembly is designed to move a load of approximately three Kg. Two Bearings are employed at both ends of shaft to minimize. In order to read position of target in the vacuum chamber, a micrometer reader is mounted on the assembly.

The entire assembly is mounted on standard 4" NEC flange, which can be directly installed at 6M experimental port where samples can be irradiated with energetic beams. The High Temperature-multi target assembly has resulted into improved beam utilization as it permits in situ target changeover without breaking the vacuum.

UTILIZATION AND RESULTS

Setup for high temperature irradiation is being utilized by Materials Science Division, BARC. This setup is used for the simulation of irradiation damage of structural materials in light water nuclear power plants. The simulation of irradiation damage due to neutron irradiation in accelerators using protons has two distinct advantages. First, the level of radioactivity after irradiation is very less as compared to neutron irradiation and this enables to carry out post-irradiation experiments without any special arrangements for handling active materials. The second advantage is that the dpa (displacement per atom) rate for protons are more than that of neutrons, hence, a given dpa level can be achieved in a much shorter time.

The setup at 6M was used to simulate neutron irradiation damage in austenitic stainless steels using protons and several samples with different metallurgical condition were irradiated using 4.8 MeV protons at 300 °C. Samples of different austenitic stainless steels were irradiated up to 1.0 dpa. The average proton current during experiment was 400 nA and the vacuum level was maintained at 10^{-7} Torr. The damage level in the material was calculated using NRT equation,

$$dpa = \frac{0.8}{2E_d}\left(\frac{\mathrm{d}E}{\mathrm{d}x}\right)_n \frac{\phi_t}{\rho}$$

where E_d is the displacement energy, $(\mathrm{d}E/\mathrm{d}x)_n$ is the linear energy transfer (LET) per ion to target by nuclear processes, Φ_t is the fluence per unit area and ρ is the atomic density. $(\mathrm{d}E/\mathrm{d}x)_n$ and was obtained from SRIM by summing up phonon and binding energy profiles. The binding energy profile was obtained by vacancy profile multiplied by binding energy (3 eV).

The proton-irradiated samples were characterized using electrochemical techniques followed by atomic force microscopic (AFM) examinations. Various methods have adopted to improve the resistance of austenitic stainless steels to irradiation damage [3]. Of all methods, it was found that a small amount of residual cold-work will greatly enhanced [5] the resistance of austenitic stainless steels towards irradiation damage. Further experiments are planned using heavy ions to achieve higher levels of dpa in austenitic stainless steels.

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REFERENCES

[1] S.C.Sharma,Ramjilal,N.G.NinaweP.V.Bhagwat etal. "Commissioning of proton beam setup at BARC-TIFR Pelletron Accelerator Facility, Mumbai" DAE-BRNS Symposium on Nuclear Physics-2004

[2] S.C.Sharma,Ramjilal, N.G.Ninawe, and P.V.Bhagwat "Development and utilization of various target assemblies for 6M irradiation setup at BARCTIFR Pelletron Accelerator facility". (InPAC-2006)

[3] Parag Ahmedabadi, S.C. Sharma, P. V.Bhagwat, et. al. "Improving Resistance of Austenitic Stainless Steel to Irradiation Damage" (IAEA-2009) AP/P5-10

[4] Parag Ahmedabadi, Phd Thesis, Indian Institute of Technology Bombay, Mumbai, To be submitted in March 2011.