# ABSTRACT

This work deals with the study of proton irradiation effects on Zircaloy-4 properties. The Zircaloy-4 specimens were irradiated with protons of energies 1 MeV, 2 MeV, 3 MeV and 4 MeV at constant dose $1 \times 10^{14}$ protons/$cm^2$ using Pelletron Accelerator. The range of proton ions inside Zircaloy-4 at 1 MeV, 2 MeV, 3 MeV and 4 MeV was 10.4 $\mu$m, 29.1 $\mu$m, 54.1 $\mu$m and 85 $\mu$m as found by the SRIM software. The structural study of Zircaloy-4 before and after proton irradiation was made through x-ray diffraction (XRD). The morphology of unirradiated and irradiated specimens was studied by field emission scanning electron microscopy (FESEM). The hardness was measured using Vickers hardness tester whereas the universal testing machine was used for the measurement of tensile properties of the specimens. The XRD results show structural changes in Zircaloy-4 due to variations in width and position of diffraction peaks by proton irradiation. The Williamson-Hall method (W-H) was used to find out the crystallite size and strain in the specimens. The W-H analysis shows inconsistent variations both in the crystallite size and strain with increase of proton energy. The FESEM images showed the bubbles and cavities formation in Zircaloy-4 irradiated with 1 MeV protons. After irradiating the alloy with protons of energy greater than 1 MeV, small cavities and particles clusters were formed. The hardness of Zircaloy-4 was increased after its irradiation 1 MeV whereas by further increasing the protons energy, the hardness was decreased. The tensile testing results also shown an increased yield stress (YS) and ultimate tensile stress (UTS) after 1 MeV proton irradiation, however, with further increasing the protons energy, the YS and UTS were decreased. The changes in the structural, morphological and mechanical properties of Zircaloy-4 were explained on the basis of variable energy protons interaction with Zircaloy-4 and annihilation of protons induced in the material at higher energies.