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Estimation of mean charge on sodium metal aerosol in the argon and nitrogen gas environment during external gamma irradiation

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The cover gas region of sodium cooled fast reactors is always being subjected to intense ionization radiation field apart from radioactive aerosols and gases. The radiation produces significant ionization of the medium resulting in large amount of bi-polar ions. The acquisition of electrical charge by sodium aerosols in cover region under bipolar ionic atmosphere draws special attention as it modifies the dynamics of aerosol transport, deposition and process inside the cover gas space. Towards this, a study has been conducted to characterize the sodium aerosols present in the cover gas region using sodium loop facility (SILVERINA loop) with and without the presence of gamma radiation field using argon as a cover gas and the experiment is repeated with nitrogen gas. The experiments demonstrated that the size of sodium aerosol is found to be relatively higher and mass concentration is lower in the presence of gamma field as compared to the condition without gamma. In order to address the behavior sodium aerosols in the presence of radiation, it is customary to understand the charge acquired by the aerosols under the radiation field. The charge acquired by aerosol is defined by the modified Boltzmann theory and determined as a function of ion mobility of argon and nitrogen gases, aerosol diameter and temperature of cover gas region. The average elementary charge is found to be negative and charge number increases with increase of aerosol size which in turn depends on the sodium pool surface temperature for both the gases. The average charge on sodium aerosol is more in argon gas as compared to the nitrogen and the difference increases with sodium pool temperature. The increase in sodium aerosol charge in argon gas is due to the higher mobility ratio of positive to negative ions for nitrogen relative to the argon. The theoretically determined charge distribution is more asymmetric in argon gas compared to the nitrogen gas. Since the charged aerosols promote more coagulation and enhance surface deposition which are indirectly indicated by the changes in the measured aerosols characteristics. Finally the mean charge can be used for calculation of coagulation and deposition rates which is important for the realistic determination of aerosol characteristics in the cover gas region. The sodium aerosol characteristics and behavior in cover gas gives significant insight into the heat and mass transfer across the cover gas space, cover gas purification, roof slab and handling machines for the fuel sub-assembly.

Country/Int. organization

India

Authors: Dr KUMAR, Amit (Radiological and Environmental Safety Division, IGCAR, Kalpakkam-603102, India.); Mrs USHA, P. (Radiological and Environmental Safety Division, IGCAR, Kalpakkam - 603102, India.); Dr SUBRAMANIAN, V. (Radiological and Environmental Safety Division, IGCAR, Kalpakkam - 603102, India.); Dr SRINIVAS, C.V. (Radiological and Environmental Safety Division, IGCAR, Kalpakkam - 603102, India.); Dr VENKATESAN, R. (Radiological and Environmental Safety Division, IGCAR, Kalpakkam - 603102, India.); Dr ATHMALINGAM, S. (Radiological and Environmental Safety Division, IGCAR, Kalpakkam - 603102, India); Dr VENKATRAMAN, B. (Radiological and Environmental Safety Division, IGCAR, Kalpakkam - 603102, India.)

Presenter: Dr KUMAR, Amit (Radiological and Environmental Safety Division, IGCAR, Kalpakkam-603102, India.)

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