Aircraft impact analyses of a spent fuel dry storage facility by smoothed-particle hydrodynamics

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ABSTRACT

Management of spent fuel assemblies releasing high-temperature radiation has been an important concern in nuclear industry. While the assemblies can be stored in wet or dry facilities, use of the latter is increasing world-widely [1]. In this context, protection of them against mechanical and thermal loads, time dependent degradation mechanisms and hypothetical hazards et cetera are prerequisite to demonstrate that potential risks to public and environment from the radioactive materials and associated chemicals are sufficiently low.

The hazards are generally classified into two categories affecting the safety, which need to be appropriately considered in the design, commissioning and operation stages [2]: one is internal hazards such as explosion, fire, flooding, missile generation, pipe whip, jet impact, release of fluid from failed systems and so on. The other is external hazards such as meteorological, hydrological, geological and seismic events, and all credible combinations of them. Moreover, recently, human-induced extreme hazards such as aircraft crash should also be taken into account.

Aircraft collision under diverse conditions with high velocity may lead to loss of safety function of the facilities. Although lots of efforts have been dedicated on nuclear facilities, since most of them were focused on reactor containment building [3], specific information on the dry storage facility is demanded. In the present study, systematic numerical simulation of aircraft crash on a MACSTOR (Modular Air-Cooled Storage) was conducted.

Firstly, an aircraft having postulated mass distribution was fully modeled by SPH (Smoothed-Particle Hydrodynamics) which has advantage of large deformation analysis. The aircraft model was validated by comparing impact force-time histories derived from Riera method based on NEI 07-13 [4] and numerical analysis. Subsequently, comprehensive impact analyses of the MACSTOR were carried out under typical collision scenarios by changing impact angles and positions. Resulting engineering parameters such as displacements, strains as well as stresses of the MACSTOR were compared, of which details and lessons learned will be discussed.

REFERENCES