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Materials corrosion in Fast Reactor environment

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The design objectives of Fast Reactors (FR) are mostly related to safety, sustainability and economics; waste minimisation is also considered. To meet these objectives, the selection of structural and fuel clad materials is a crucial issue to be considered. Indeed, the materials in FR environment can be subject to intense mechanical stresses, a high energetic neutron field and circulating heat removal fluids [1]. The fluids considered to remove the heat from fast reactor cores should fulfil a number of properties. Among the possible coolants selected for FR, within the Generation IV initiative, there are either liquid metals (Sodium, Lead and Lead-Bismuth) or gas (Helium).
The focus of this overview is to address the importance that parameters, such as temperature, flow velocity, impurities etc., have on the materials corrosion in the liquid metals [2]. From these considerations, a summary is given on the available knowledge on corrosion mechanism and rates of austenitic and ferritic/martensitic steels (and their ODS variants).
The corrosion mechanism observed in liquid Na and in liquid Pb/Pb-Bi is driven by the oxygen concentration in the liquid metal. However, different corrosion products are observed in the two liquid metals.
The corrosion rate is also affected by the temperature gradient and the flow velocity of the liquid metal. Equations to calculate corrosion rates of steels in liquid metals have been defined. However, they all have an empirical character and need extensive experimental validation.
In addition, potential degradation of the mechanical properties of reference materials in contact with the liquid metal is also discussed. Due to the potential severity of these phenomena, independently from the intensity of their corrosion rates, they have an important impact on the materials selection.
The liquid metals corrosion data available for steels are then compared with typical design parameters and requirements of key components for both Sodium Fast Reactors (SFR) and Lead/Lead-Bismuth Fast Reactors (LFR) in order to discuss potentialities and challenges in FR environments.
Finally, this overview discusses corrosion protection methods investigated so far and on potential future needs to reach the design objectives stated.

References
[1] Structural Materials for Generation IV Nuclear Reactors. Edited by P. Yvon. Woodhead Publishing Series in Energy Nr. 106. Elsevier, 2016.
[2] C. Fazio, F. Balbaud. Chapter 2 in Structural Materials for Generation IV Nuclear Reactors. Edited by P. Yvon. Woodhead Publishing Series in Energy Nr. 106. Elsevier, 2016.

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