World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:16, No:01, 2022

Effect of Dissolved Oxygen Concentration on Iron Dissolution by Liquid Sodium

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Abstract : This work presents the progress of studies aiming to guarantee the lifetime of 316L(N) steel in a sodium-cooled fast reactor by determining the elementary corrosion mechanism, which is akin to an accelerated dissolution by dissolved oxygen. The mechanism involving iron, the main element of steel, is particularly studied in detail, from the viewpoint of the data available in the literature, the modeling of the various mechanisms hypothesized. Experiments performed in the CORRONa facility at controlled temperature and dissolved oxygen content are used to test both literature data and hypotheses. Current tests, performed at various temperatures and oxygen content, focus on specifying the chemical reaction at play, determining its free enthalpy, as well as kinetics rate constants. Specific test configuration allows measuring the reaction kinetics and the chemical equilibrium state in the same test. In the current state of progress of these tests, the dissolution of iron accelerated by dissolved oxygen appears as directly related to a chemical complexation reaction of mixed iron-sodium oxide (Na-Fe-O), a compound that is soluble in the liquid sodium solution. Results obtained demonstrate the presence in the solution of this corrosion product, whose kinetics is the limiting step under the conditions of the test. This compound, the object of hypotheses dating back more than 50 years, is predominant in solution compared to atomic iron, presumably even for the low oxygen concentration, and cannot be neglected for the long-term corrosion modeling of any heat transfer system.

Keywords : corrosion, sodium fast reactors, iron, oxygen
Conference Title : ICPCME 2022 : International Conference on Physical Chemistry and Materials Engineering
Conference Location : New York, United States
Conference Dates : January 28-29, 2022