Thermal Modeling of Chlorination Reactor

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Abstract

Chlorine reactor is used to dry molten LiCl-KCl eutectic salt before it is put to use in electrorefining operation. Molten salt electrorefining is a pyrochemical method of separation of heavy elements from spent metallic nuclear fuel. It is a high temperature process which uses molten salt as supporting electrolyte for electrodeposition of heavy metals. The LiCl component in the molten LiCl-KCl salt is more reactive towards H2O. The LiCl-KCl eutectic salt likely forms hydroxides when moisture is introduced in the system. The salt is first vacuum dried and then reacted with Cl2 in chlorination reactor to remove the left out moisture.
The chlorination reactor consists of graphite crucible, graphite liner, graphite lid and an outer vessel made of Inconel. The chlorination reaction takes place in the crucible at 500˚C. The vessel is heated by resistance heating furnace. Figure1 shows the layout of the chlorination reactor.
A thermal analysis study of the chlorination reactor is being carried out in COMSOL Multiphysics®. There is a constraint to limit the top flange temperature to less than 200˚C as Viton O-rings are being provided there. The aim of current study is to find the temperature distribution in top portion of the vessel to know if forced circulation cooling is needed to meet the temperature constraint.
A 2D-axisymmetric model of chlorination reactor is setup in COMSOL Multiphysics. The Material Library within COMSOL is used to assign materials to the model. The conjugate heat transfer interface is being used for the analysis. Fig. 2 shows the temperature on the top portion of outer vessel along the height, both with and without water cooling, obtained from the study.
This paper details the thermal modeling of chlorination reactor. The findings from this study have implications on mechanical design of the reactor.

Figures used in the abstract

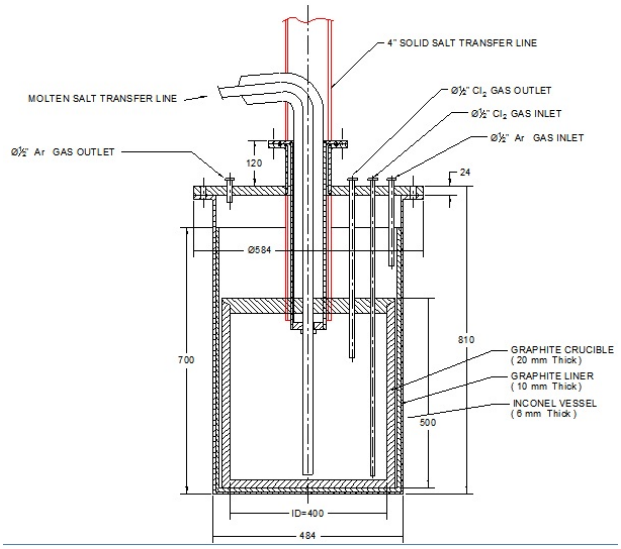

Figure 1: Schematic Layout of Chlorination Reactor.

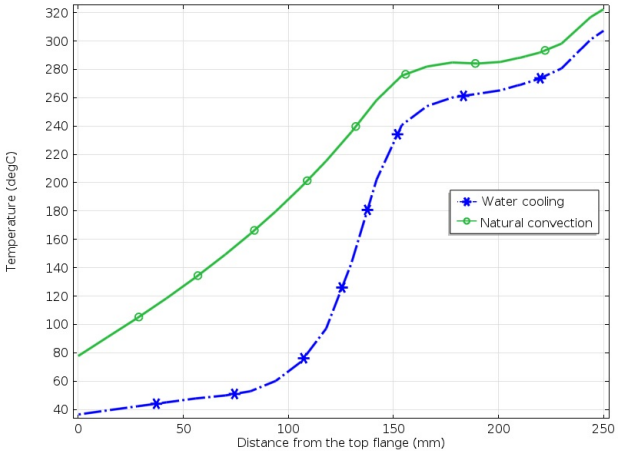

Figure 2: Temperature profile in top portion of outer vessel.