Proposition of PhD thesis subject

Design and characterisation of nickel alloys
with an improved resistance to hydrogen embrittlement

Context and aims

As many metals, nickel alloys can become brittle in the presence of hydrogen, which can have severe economical, human and environmental consequences, for instance in the nuclear industry or in the oil & gas sector. Therefore, there is a need for new alloys with an improved resistance to hydrogen embrittlement (RHE) as well as good mechanical properties and corrosion resistance, a low cost... Instead of alloy selection from available grades, the trend is now the design of made-to-measure alloys to reach a given set of properties. Recently, computer-aided alloy design has been implemented, notably using thermodynamics as well as artificial intelligence including data mining / machine learning and multi-objective optimisation by genetic algorithms. The aim of this project is the computational design of nickel alloys with, among others, an optimised RHE.

Description of subject

The first issue that will be dealt with is a better understanding and description of some material-hydrogen interaction mechanisms. For this, model alloys will be designed with specific structural features or with simple microstructures, i.e. containing precipitates with a controlled nature, volume fraction and solubility. This will be made using a combination of existing genetic algorithm optimisation, physical models, data mining models and computational thermodynamics. Such alloys will then be elaborated by vacuum melting and hot working, and investigated for mechanical properties and microstructure (SEM, EDS, WDS, EBSD...). They will also be studied in the presence of hydrogen: permeation, TDS, tensile testing on hydrogen-precharged specimens or under in-situ cathodic charging to assess the RHE. Based on the gained knowledge, “industrial” alloys with an improved RHE will be designed, produced and experimentally studied, using the same set of tools as in the first part of the project.