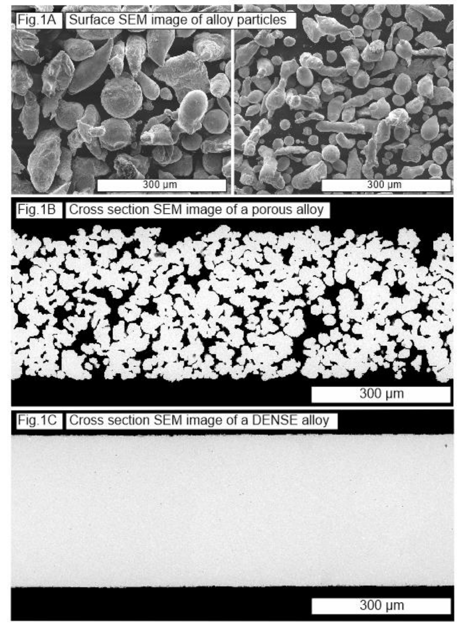
Modern advanced alloys are used in many high-tech applications where they are exposed to high temperatures: jet engines, gas turbines, superheaters in power plants etc. Though vast literature exists on the high-temperature corrosion and mechanical properties of dense alloys, **alloy powders** and **sintered porous alloys** have been studied to a much lesser degree. As presented in Figure 1, these materials have completely different microstructure than the dense alloys. The surface-to-volume ratio for these materials is high, leading to peculiar oxidation and mechanical properties. The available reports show, that these materials oxidize rapidly and their lifetime is limited. Porous alloys can find important applications in high temperature fuel/electrolysis cells, gas separation membranes, filters and other technologies to be developed.

Research project objective/research hypothesis

Hypothesis of the project is that it is possible to develop a generalized high temperature corrosion model for the description of lifetime of the alloy powders and sintered porous alloys based on their microstructure, chemical composition and other important parameters. Both mechanical and oxidation kinetics related phenomena will be taken into account. An extensive model will be developed in a form of the open-source code, possibly with a simplified version in the form of general mathematical expressions. In order to develop the model, the project will determine how does the alloy microstructure (porosity, particle and pore size) and composition influence its high temperature (>500°C) properties. The project will determine the most important high-temperature properties of a range of porous alloys: high-temperature corrosion rates and mechanical properties (creep, hardness change) – the limiting factors for practical use of porous alloys at high-temperatures.



Research project methodology

The experimental part of the project will focus on testing different alloy powders, that will be specially developed for the project. These powders will have a specific chemical composition (e.g. Fe-Cr content) and will be sieved to get specific particle sizes. These powders, along with the commercially available powders will be studied for their corrosion properties (500°C – 900°C in air). The powders will be used for sintering of porous alloys, which will be further studied for corrosion properties. Porous samples will be prepared by die pressing, tape-casting and 3D printing of special filaments. In addition, sintered alloys will be studied in high temperature mechanical rigs to determine their creep rates and the influence of oxide scales etc. A dedicated rig for mechanical testing will be built for the project. Moreover, project original measurements will include quantification of chromium evaporation and gas permeation measurements. Extensive corrosion and mechanical measurements will allow to describe the limiting factors in the lifetime of the alloys, whether they are of mechanical (stresses at the oxide/alloy interface) or compositional origin (i.e. too low content of the protective element). These data will be used for input data for model formation and validation. Model development will start with geometrical considerations of mechanical stresses as a function of temperature and will take into account depletion of the protective element. These phenomena occur at the same time and can lead to alloy breakaway oxidation.

Expected impact of the research project on the development of science

In comparison to the existing data and the current state of the art, project realization will greatly enhance the available knowledge about the high temperature properties of the porous alloys, including oxidation data and mechanical properties and will basically form a new research field: high-temperature studies of alloy powders/particles. It is expected that alloy powders can be used as model materials to study high temperature oxidation phenomena, including especially the effects of geometry and chemical composition, which will be an important tool in future research.