05/2203 Iron oxide extraction from lunar and Martian regoliths

Type of activity: Medium Study (4 months, 25 KEUR)

Background

The Reformer iron Sponge Cycle (RESC) has been proposed as a valid process to produce highly pure hydrogen from virtually any kind of hydrocarbon fuel on a bed of iron oxide (magnetite Fe_3O_4), present in the soils of the Moon and Mars. The process has been investigated in the frame of the Ariadna Call for Proposals 04/01 in view of future long-term manned lunar and Martian exploration.
The process permits to operate a hydrogen-oxygen fuel cell for electrical power generation by producing hydrogen from either high energy density fuels brought from Earth or from fuels produced in situ (e.g. methane from the Sabatier process of from biomass decomposition).

Fuels are converted into a mixture of hydrogen and carbon monoxide in a reforming reactor. In the following Iron Sponge Cycle iron oxide (magnetite/wuestite) is initially reduced by hydrogen and carbon monoxide to a lower oxide or down to iron metal with production of water steam and carbon dioxide. In a second step water steam is passed on the formed iron metal bed; iron oxide is replenished and water steam is reduced to highly pure hydrogen which can be fed without further purification treatments to the anodic compartment of a fuel cell for electrical power generation.

The contact mass (iron/iron oxide) properties as size, porosity and composition of the pellets are very critical.
The use of pure iron would theoretically maximise the efficiency of the cycle; the lifetime of the pellets is however limited by sintering effects. Addition of silica SiO_2, alumina Al_2O_3 and calcium oxide CaO has resulted in reduction of the sintering effect with consequent extension of the contact mass lifetime.
All considered oxides are present in the regolith of Mars and the Moon although in different proportions compared to the composition of pellets used during preliminary research.

The investigation of the feasibility of the production of iron oxide rich pellets mined from the lunar soil, resembling optimum physical properties (size, porosity, composition) is required to assess whether the RESC has a real potential as hydrogen production and purification process.

Study Objectives

The study shall provide:

- An analysis of the physical characteristics of the lunar and Martian regoliths.

- An investigation of the effects of minerals contained in the regolith, and not taking part to the Sponge Iron Cycle reactions, on the efficiency of the process.
- An estimation of the process steps and infrastructure required to manufacture the contact mass pellets.
- An assessment of the feasibility of iron oxide rich pellets manufacture in terms of technical complexity, infrastructure mass, required energy input.