REE4EU: Integrated High Temperature Electrolysis (HTE) and Ion Liquid Extraction (ILE) for a Strong and Independent European Rare Earth Elements Supply Chain

Enjoy reading the REE4EU newsletter!

News from the participating companies

In the next coming months and approaching midterm, the REE4EU project will realise the completion of the main pilot build-up at Elkem's Pilot Plant location and the completion of the pilot trials at LCM.

This Newsletter gathers the latest news of the work performed up to now by the large industries and SME partners.

Pilot electrolysis cell built and tested by Less Common Metals Ltd.

Over the last months, thanks to the development of the REE4EU project, LCM has adapted, built and tested the key functions of the pilot electrolysis cell which can be used to convert calcined REO-mix from permanent magnet swarf (PMS), supplied by VAC, into rare earth alloy (REA). The 1KA pilot cell has flexibility of consumable cathode and different fluoride mixtures to produce various REA metal outputs with a production rate above 1kg/hour.

Preliminary trials allowed to verify the key functions of the electrolysis cell at high temperature and full fluoride load.

Pilot tests are still on-going to meet the overall REE4EU objectives, i.e. production of 600 kg batch strip cast REA and subsequent manufacture and test function of a PM with that material by VAC.

With over 20 years' experience in the production of materials to tight compositional tolerances and controlled microstructures, LCM participates in a number of other EU-funded projects, such as EURARE (GA No 309373), EREAN (GA No 607411), REECover (GA No 603564), REE4EU (GA No 680507), DEMETER (GA No 674973), and SCALE (GA No 730105).

Trials of the pilot electrolysis cell at LCM

Meanwhile in backstage of VACUUMSCHMELZE GMBH...

VAC has provided grinding sludge from its running production for the lab-scale activities, as well as off-line integration and pilot trials. 300 kg of REO-mix derived from PMS was delivered to LCM for its direct conversion to REA. In the framework of the REE4EU project the next steps for the qualification of strip cast alloy will start in the upcoming months, when LCM provides the 600 kg batches of strip casted alloy produced from different REA electrolysis outputs. VAC will produce Nd-based magnets in its production line and will determine the quality of both RE magnetic alloy inputs and PM outputs in terms of magnetic properties and chemical composition as well as compare them with materials derived from the virgin input.

Waiting for the Elkem's Pilot in Norway

In close cooperation with scientific partners SINTEF and Tecnalia, Elkem has provided valuable input to the design and completion of the high temperature electrolysis (HTE) and the ionic liquid extraction (ILE) processes, respectively. Moreover, Elkem has been deeply involved in conceptual and basic engineering of the REE4EU pilot, in close cooperation with engineering partners INOVERTIS and IDENER. At the current project phase, Elkem is responsible for detailed engineering and preparation for pilot build-up. Within the next 4 to 5 months the REE4EU pilot will be implemented at Elkem's Pilot Plant location in Kristiansand, Norway.

IDENER: Modelling of HTE process and the most important engineering steps

The work of IDENER in the REE4EU project has been focused on two main aspects: the modelling of the HTE process and the engineering tasks towards an efficient prototype for the project testing.

- In the modelling area, a study of dependence of kinetics on operational parameters is crucial in the development of a model based in mass and energy balances. Learning the reactions which are taking place and their dependence on operational and design parameters allows us to be able to make predictions, to improve the design of the HTE system, allows to provide a realistic scaling up of the process and optimisation. In this way, this information given by SINTEF has been analysed and used for the development of semi-empirical relations related to kinetics and, therefore, efficiency of the HTE system. This methodology has laid the groundwork for a multidisciplinary design optimisation of the process and has helped to predict its behaviour successfully whiting a window of stablished operational parameters. In this way, a grey-box model with a dynamic behaviour has been developed and used as a base for the optimisation process according to the HTE needs.
- Regarding the engineering work, IDENER team has been working intensively on the definition of engineering documents for the pilot. Together with SINTEF and Elkem, the process demonstrated at lab scale has been translated into a realistic industrial setup that will allow the project to verify the REE4EU HTE process. This process has required a strong use of "smart engineering" due to a tight budget restriction of the process, including the purchase of the HTE equipment. This work has comprised the iteration over two different process configurations aiming to completely optimise the use of resources and the cost of the pilot facility. Thanks to the modelling above-described, the current design of the HTE cell ensures the maximum use of the available resources. One of the main actions performed towards the economic optimisation of the pilot has been the maximisation of off-the-shelf and already available devices for its construction, also minimising the delivery time of the equipment. To enable this, great efforts have been made in the mechanical area, reaching an optimal furnace design.

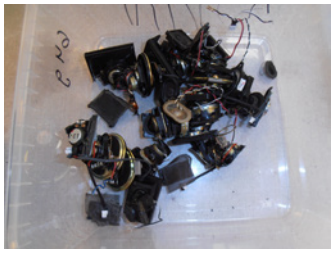
In conclusion, the last months have been very fruitful in the engineering aspects and currently the design of the HTE process has reached a mature status that enables the construction of the pilot within the planned schedule.

SNAM: replication activities using spent batteries waste

SNAM is providing raw material, i.e. black mass from spent nickel metal hydride batteries (NiMHB), both to the lab-scale activities and also to the off-line integration and pilot trials. For this, full pre-treatment steps of spent NiMHB waste have been carried out on a 100-kg scale batch size. Moreover, together with CEA, SNAM is developing a pilot unit to upgrade the NiMHB waste using an advanced hydrometallurgical route, which will be benchmarked towards the REE4EU's solution.

STENA: How to separate the Nd components from end-of-life products?

Apart from delivering spent permanent magnet (SPM) material to be treated in the REE4EU's pilot, STENA is working on the market and socio-economic impact analysis and the Nd recovery potential in a selection of end-of-life (EoL) products in focus: loudspeakers, hard disk drives, engines on e-bike and air conditioning units.



Loudspeaker element from EoL Laptops collected and separated at STENA

The investigations show that to separate the Nd components is difficult due to very big difference in design and the fact that not all devices (e.g. loudspeakers) contain a Nd.

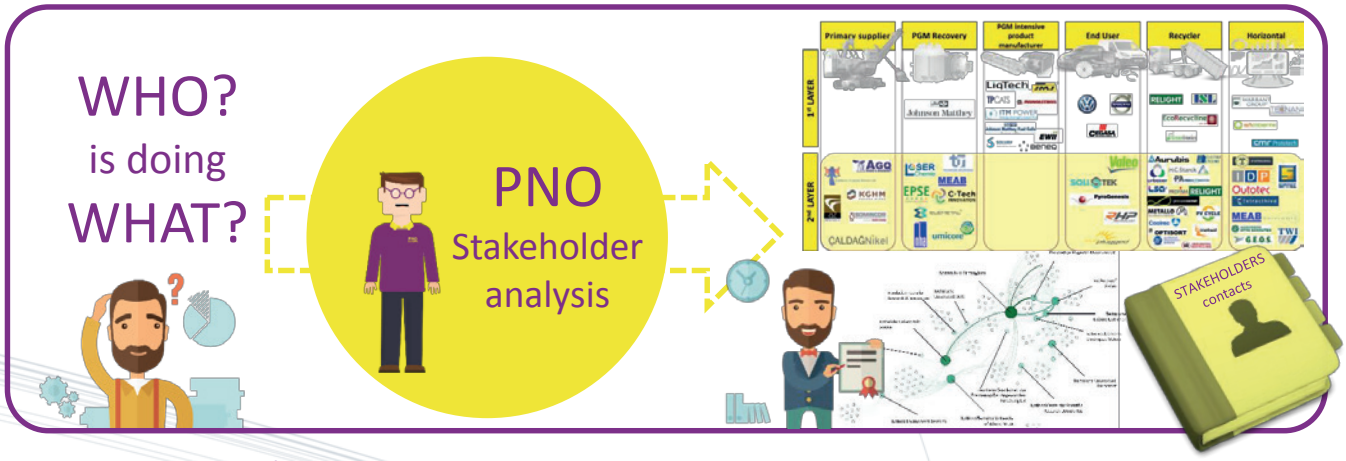
Just to give a good example of the design aspect, we can think about an e-bike engine where the design shall prevent the humidity and moisture water coming into the engine. This directly makes it more difficult to get to the magnet in a cost efficient way.

The analysis of the loudspeakers elements is an ongoing process which started recently and will be developed in the upcoming months.

PNO INNOVATION maximises the impact of the REE4EU project

PNO has successfully completed the stakeholder analysis, the results of which are collected in the Stakeholder Analysis report (link). The work has been done following a novel methodology developed by the PNO's innovation services team and adopting the group proprietary tool, Innovation Place. The EU-funded project database, the EU and WO patent repositories as well as market reports and associations webpages were screened, resulting in a helicopter view on WHO is doing WHAT within the REE value chain.

Currently, the PNO team is working on the market analysis in order to evaluate the current and prospective market of EoL products that could serve as feedstock for REE recovery at industrial scale. The findings of the milestone ERECON report directed the partitioning of this future market into EoL product streams, such as hard disk drives from laptops and desktops, offshore wind turbines, electric vehicles, etc. The analysis, though by no means exhaustive, sheds light to product attributes which are key to a sound recycling business (e.g. REE material flows, legislation barriers, geographical resource allocation, etc.). Quantitative and qualitative factors were established to showcase the levers and hurdles pertained to the recycling of the selected products, such as theoretical amounts and values of REEs contained in an EoL product stream, supply chain considerations, policies in place, etc.



CLIENT'S SECTOR OF INTEREST AND SURROUNDING ENVIRONMENT

A3I-INOVERTIS: engineering of the ILE step and LCA of the REE4EU's solution

According to its background of innovative industrial engineering, INOVERTIS has conceived and managed the conceptual and basic engineering of the ILE process in close collaboration with Elkem's team.

Knowledge, experience and creativity have led to an operational and optimised process in due time within a controlled budget. INOVERTIS is also working on the Socio-Economic Analysis and the Life Cycle Assessment aspects.

The specialised collaborators from INOVERTIS Clean Tech Division are dedicated to that kind of complementary studies that are considered essential in any industrial process elaboration.

REE4EU Consortium

SINTEF
www.sintef.no

TECNALIA
www.tecnalia.com

LCM
www.lesscommonmetals.com

VAC
www.vacuumschmelze.com

ELKEM
www.ELKEM.com

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www.idener.es

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For more info about project visit the REE4EU website at: www.ree4eu.eu

REE4EU is a project funded by the European Commission

This project has received funding from the European Union's Horizon 2020 Research and Innovation program under Grant Agreement n° 680507