Electrolysis makes a winning solution

Electrochem's electrolytic approach to recovering pure iron from titanium dioxide waste and iron sulphate pickling solutions yields a cost-efficient recycling route

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Huge amounts of ferrous sulphate heptahydrate – known as copperas – and other ferrous sulphate-containing wastes are produced worldwide each year, amounting to around 22m tonnes in all. These are usually disposed of without any attempt to recycle them.

This was the main driving force behind the development by Electrochem Technologies & Materials of a technology for producing electrolytic iron from copperas. "The technology, now patented worldwide, is an electrochemical process that transforms ferrous sulphate [into iron] using electricity," says Dr Francois Cardarelli, president of the Canadian firm.

Electrolysis takes places inside an electrolyser and reduces ferrous cations at the cathode, while sulphate anions cross a membrane towards the anode where oxygen gas evolves, leaving behind sulphuric acid.

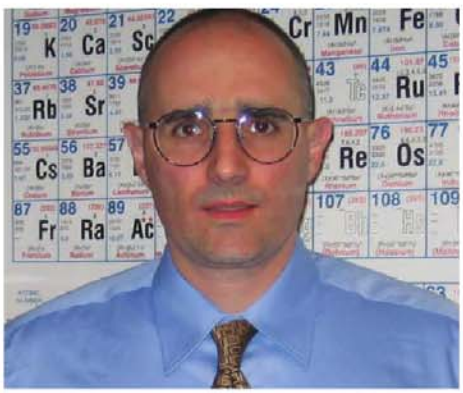
According to Cardarelli, the technology is simple and requires only existing and affordable equipment. It is also modular in design so that additional capacity on a greenfield plant can be obtained by adding more cells, making scale-up simple.

Moreover, he adds, the operating cost to produce a tonne of iron and the capital expenditure of an electrowinning plant are much more attractive than those of a new iron smelter.

"We have run several cost and benefit analyses for both greenfield and brownfield installations in various jurisdictions [where the patent is now enforced and where suitable economic factors such as cheap electricity and skilled labour are available] and the preliminary financial analysis reveals net present values and an internal rate of return that are very attractive."

Another driver behind the innovation was recent industry interest in finding an alternative and greener way to produce iron without using a carbon as a reducing agent, thereby avoiding the release of greenhouse gases. In short, an alternative solution to the blast furnace.

According to Cardarelli, the energy consumption required to produce electrolytic iron is half that of the conventional process and rather than emitting 1.8 tonnes of carbon dioxide per tonne of steel, the process releases oxygen. A final advantage is that the regenerated sulphuric acid can be reused upstream or further concentrated, making the entire process a recycling loop.



FRANCOIS CARDARELLI
President, Electrochem Technologies & Materials

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The pure electrolytic iron can be produced in various forms: flakes, nodules, powder or plates. These can be used directly or sintered or melted for the production of high-quality steels. At present, electrolytic iron is mainly used in the magnet and food industries and is considered somewhat niche. But that could change given the economics of the new technology.

"It's a high quality product that you can melt – the iron is so pure that you can do whatever you want with it. But it's very competitive – you can produce pure iron at lower price than pig iron. That's why it makes sense – it doesn't just work technically, but commercially too," maintains Cardarelli.

Cardarelli says the company started developing the product eight years ago. Suitable electrode and membrane materials that could withstand the operating conditions had to be found and the developers had to determine suitable operating conditions compatible with maximum current efficiency and product yields. This had to be done while also obtaining the minimum specific energy consumption and maximum throughput to minimise the cell footprint and make it compatible with an industrial operation.

"It takes a long time and a lot of energy and money to promote a novel technology, even though it has been tested successfully by several industrial clients. The chemical and metallurgical industries are among the most conservative for good reason," says Cardarelli.

"They always want to implement affordable technologies, relying on known equipment and most importantly with products which are technically simple to scale-up.

"We financially supported the entire project ourselves (development, patents, materials, piloting), using only the cash flow generated from Electrochem's other activities. Now that the technology is de-risked we are being approached by parties interested in purchasing licences, rather than the other way around."

Cardarelli points out that commercially, you must make more than 50,000 tonnes/year of electrolytic iron to become profitable. "It wasn't our intention to do this in-house. It takes a larger multinational to do this, so the company favoured licensing the technology.

"Some clients have tested it with a commercial unit, but we did not build a big pilot installation – it was one-fiftieth the size of a commercial unit but it mimicked all that a full-scale plant would do, which meant we could test it at our site and also at the client location."

There is the possibility to develop the technology further, says Cardarelli. "We also manufacture industrial electrodes and have been working to devise special formulations that will allow us to lower costs and increase the service life of the iron. This gives us a competitive advantage for future commercial deployment. We are also working to integrate this technology vertically with other technologies. ■