Ceramics – when Evolutionary Innovation Turns into Revolutionary Innovation

Geopolymer cements are a low-carbon footprint alternative in various applications.

There is often a distinct line drawn between evolutionary and revolutionary innovations [1]. While revolutionary innovation aims to adapt the world to cutting edge ideas, evolutionary technology provides novel solutions to existing world issues. Contrary to the current either/or approach to categorising innovation, change is often more subtle with current scientific breakthroughs becoming revolutionary, through small evolutionary steps.

In ceramics, Additive Manufacturing (AM) has been the flagship revolutionary innovation that has enabled the fabrication of complex detailed ceramic components.

Born from rapid prototyping and already credible in metals and polymers, AM has advanced in ceramics as a result of understanding every step of production, from particle interactions in the early stages of organic and inorganic raw-materials preparation to drying and sintering of ceramic components.

Although the application of AM in ceramics is revolutionary, the principal science and engineering of ceramics has gone through years of evolutionary development to enable the adoption of a different processing technique.

At Lucideon, the work in the field of geopolymer cements has demonstrated the transition from evolutionary to revolutionary technology. Geopolymer technology uses a low temperature chemical reaction to consolidate aluminosilicate materials into a robust solid inorganic amorphous ceramic with high mechanical strength and chemical stability. Such material may then be used, for instance, as a high performance – low-carbon footprint alternative to Ordinary Portland Cement (OPC) in various applications.

Keywords
geopolymer, alumosilicate, carbon footprint, encapsulation

Fig. 1
Cross section of a 12-l container with ion exchanger fully encapsulated in geopolymer resin

Although the market penetration of geopolymer cement is yet insignificant, many companies realise the potential of this technology and are experimenting with geopolymer cements to futureproof their market position. At the moment, the economy of geopolymer cement favours high value added applications where high performance compensates for higher costs relative to OPC. For instance, geopolymer cement was successfully used for the encapsulation of nuclear waste (that would otherwise be difficult to treat with OPC). A good example of such waste is a spent zeolite based ion exchanger: Lucideon developed a special geopolymer resin allowing it to be pumped directly into the metal skips used to store the waste. The geopolymer resin, having very low viscosity, has the ability to penetrate the porous waste body, encapsulating the content into a robust solid mass as well as solidifying the free standing water in situ without the need for mechanical mixing (Fig. 1).

Kambiz Kalantari
Lucideon Ltd
Stoke-on-Trent, ST4 7LQ
Great Britain

E-mail: enquiries@lucideon.com
www.lucideon.com

Fig. 2
10 m³ of near freezing water solidified with geopolymer technology

The process incurs a lower cost and is rapid and safer relative to the competing multi-step process based on OPC.

The evolutionary experience and knowledge gained from years of geopolymer development technology for encapsulation of nuclear waste allowed Lucideon to commercially showcase a revolutionary innovation: water solidification capabilities of geopolymer technology. Consequently, on a different project, Lucideon was commissioned to propose a solution for issues with radioactive water leaking from large tanks used to collect nuclear waste water after cooling of the nuclear reactors. Lucideon proposed to apply the knowhow gained in geopolymer technology to solidify the water inside the waste containers. The technology was then successfully demonstrated, on a representative scale, by treating water at near freezing temperatures without mechanical agitation at Lucideon's pilot plant in Stoke-on-Trent (Fig. 2).

To summarise, the introduction of new innovations that can revolutionise the ceramic industry are often based on the acquired knowledge of research that has been developed over decades. Hence, the current examples of the break-through technologies in ceramics are based on an underlying understanding of ceramic materials and processes.

Reference

[1] www.jamesfahey.com/2013/05/03/revolution-vs-evolution/