Synchrotron technology can help manufacturers

Located in Melbourne, the Australian Synchrotron is already playing a significant part in manufacturing innovation. As **Hartley Henderson** writes, there are substantial opportunities for further uptake and utilisation of this highly advanced technology.

THE synchrotron is a very large, circular, megavoltage machine about the size of an (Australian Rules) football field. This world-class facility uses accelerator technology to produce a powerful source of light (X-rays and infrared radiation) a million times brighter than the sun.

High-energy electrons are forced to travel in a circular orbit inside the synchrotron tunnels by 'synchronised' application of strong magnetic fields. These electron beams travel at just under the speed of light – about 299,792 kilometres per second.

The Australian Synchrotron's Industry Support Scientist, Dr Robert Acres, explains that the intense light produced is filtered and adjusted to travel into experimental work stations where the light reveals the innermost sub-microscopic secrets of materials under investigation, including human tissue, plants and metals.

"Academic researchers and industry from across Australia and New Zealand can use the synchrotron to understand the fundamental structure, composition and behaviour of materials, on scales ranging from the atomic to the macroscopic – with a level of detail and accuracy not possible using conventional laboratory-based equipment," he told *Manufacturers' Monthly*.

"Applications relating to the manufacturing industry include investigation of the structure and characterisation of alloys, catalysts, fibres, textiles, adhesives, polymers, plastics, surfaces, interfaces and coatings, as well as analysing stresses in engineered components.

"For example, mass production processes such as polymer moulding, spinning and extrusion can be improved through better understanding of the nanostructure of the formed products. The synchrotron can also assist in the development of high-tech products including implantable medical devices that rely on a deep understanding of their constituent components.

"In addition, the development of advanced materials, including superior alloys that are more resistant to corrosion or structural failure, can be accelerated by mapping chemical speciation or elemental composition."

Surface engineering

Operating from sites in Sydney and Adelaide, LaserBond specialises in the research and development of surface engineering techniques to dramatically reduce the wear rates, maintenance, and operating costs of production-vital components for industrial customers.

The company's founder and Executive Director R&D, Greg Hooper, says that although LaserBond is one of the very few companies to have an in-house scanning electron microscope (SEM), it was believed that the advanced imagery available from the Australian Synchrotron would provide high image resolution across a larger sample than the company could process internally on the SEM.

"Our material scientist prepared a number of samples of different metallurgy using the normal laser application method and our new Laser Deposition method that utilises an advanced additive manufacturing process. She then worked at the Australian Synchrotron with its staff to analyse the samples using the X-ray Fluorescence Beamline," he told *Manufacturers' Monthly*.

"We were able to analyse a wider sample and therefore clearly identify the dilution bands that occurs with the old method, and contrast it with the new method, which offers a stunning improvement in performance and efficiency.

"The synchrotron image solution enabled our team to determine the efficiency of the matrix bonding over a range of metallurgical formulations. This enables LaserBond to deliver a higher wearing surface than previously available to industry, at a lower cost.

"Importantly, the synchrotron image also enabled our scientists to explain the difference to lay-person customers."

Hooper added that from LaserBond's perspective, the confirmation of the metallurgical performance of the company's new method enables it to consider a number of new applications that now become possible and/or economic.

"These include hard chrome replacement in hydraulics, thin surface applications to ground engagement tools, and many others across the industries we serve. We are looking at embedding our application method and new metallurgy into more high wearing products, and developing a global market," he said.

"We believe there is potential for the synchrotron to further expand its operations and benefit a broad range of manufacturing industry. The synchrotron proved to us that our internal R&D efforts had delivered a substantial development in surface engineered wear resistant surfaces, and in a way that can be confidently communicated to customers."

Coatings innovation

The Australian Synchrotron was utilised in a recent ARC Research Hub for an Australian Steel Manufacturing project investigating surface engineering of coatings.

Work on the project at the Synchrotron which related to BlueScope's Colorbond steel, was undertaken by Professor Elena Ivanova's group from the Swinburne University of Technology.

BlueScope's Dr Shane MacLaughlin said the objective was to harness academic resources to introduce product modifications that will provide an enhanced level of performance for customers, and hence a competitive advantage for Colorbond steel.

"As part of this work it was necessary to provide an analysis of the Colorbond steel surface at a more detailed level than what had been achieved in the past. The reason for this was to understand how the proposed surface modifications would perform over the long term in the harsh Australian environment," he said.

"Spectroscopy, in this case infrared, is a valuable source of information about the chemical changes that materials undergo in the environment. Infrared spectroscopic techniques typically provide bulk surface information.

"In this case it was necessary to obtain high lateral spacial resolution to provide an accurate map of the changes on the surface, and the synchrotron provides this facility. The spectroscopic analysis achieved with the synchrotron delivered important new information on the evolution of the product surface during long term weathering."

MacLaughlin said the commercial benefit of the work is to provide greater confidence that the innovation will meet Colorbond steel standards for long term performance.

Designer coke

Because coke is an essential input for iron production, scientists are investigating how the blast furnace environment affects coke structure and microporosity. (Their aim is to design stronger coke and improve blast furnace efficiency).

BlueScope Steel, in partnership with the University of Newcastle, is using the Imaging and Medical Beamline at the Australian Synchrotron to examine detailed pore structure and the behaviour of mineral inclusions in coke samples from a blast furnace and laboratory experiments simulating the blast furnace.

Acres says a better understanding of coke's structural characteristics will benefit the design of coking coal blends for improved furnace efficiency and reduced costs.

[Hartley Henderson is a regular contributing writer to Food & Beverage Industry News, covering industry developments in Victoria and South Australia. Prior to that, he held senior positions in government, semi-government and business enterprises and was National Program Director with the Productivity Promotion Council of Australia]

Australian Synchrotron
03 8540 4100
www.synchrotron.org.au
BlueScope Steel
02 4275 7522
www.bluescope.com
LaserBond
1300 527 372
www.laserbond.com.au