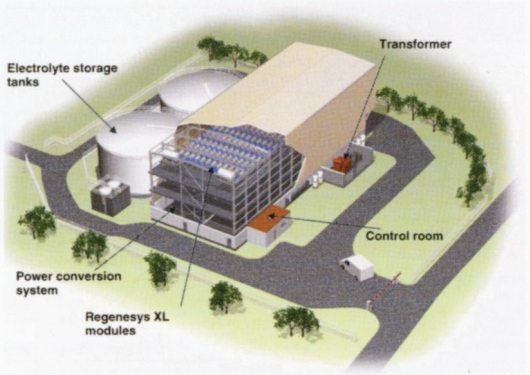
Cambridge material eyes

February 2001 Issue 10

NEW EMBEDDED COMPANY LABORATORY

Innogy plc, one of the companies formed as a result of the de-merger of National Power in October 2000, is about to take its place in the Department as a University Technology Centre, researching in the area of materials for fuel cells. Innogy plc, describes itself as an integrated energy business, focused on generation and retail supply. In particular, the company has an interest in new solutions to energy storage through its subsidiary Innogy Technology Ventures Limited. In August the company announced its energy storage technology known as Regenesys®, that was invented and developed in the UK. This technology allows utility scale levels of energy to be stored and released on demand. It will be particularly useful for energy from 'environmentally friendly' sources such as wind farms from which the supply is dependent on the weather conditions.



Artist's impression of the proposed Little Barford Regenesys Plant.

The electrochemical process involved stores electricity when the demand is low and releases it on demand. It is a fuel cell system in that the energy output depends entirely on the supply of fuel and oxidant. In this case they are two aqueous based electrolytes containing different ions and are generated during the charging operation. Successful implementation of this technology will enhance the flexibility and reliability of renewable energy sources and could change the way that power systems are currently designed and operated, allowing for greater efficiency as well as improving environmental aspects of power generation.

The world's first plant using this technology is under construction at Little Barford in Cambridgeshire and is due to come online in mid 2002. In December a further announcement was made that a system has been sold to the Tennessee Valley Authority in the US and that further sales in the US were anticipated.

The new University Technology Centre will be called New Materials For Innovative Electrochemistry and will focus on fuel cells. Professor Derek Fray, Professor of Materials Chemistry, who has expertise in the relevant area of electrochemistry and electrochemical technology, will head the unit. A new ADR will be appointed early in 2001 together with further research staff who will be involved in optimising the process.

The new laboratory will be positioned on the fourth floor, next door to the National Power laboratory for Polymer Analysis which contains equipment donated on an earlier occasion by National Power. This laboratory will be renamed the Innogy laboratory for polymer analysis.

For further information, please contact Professor Derek Fray
Tel: 01223 334306; djf25@hermes.cam.ac.uk

MAVERICKS

The future of the Department, indeed the future of the University, depends on a maverick element. Institutions age and die if they are not continually renewed from within. Where they are marked by rigid internal discipline, as befits a multinational company or even the Civil Service, then renewal is more difficult except in times of danger or cataclysm. The University survives in comparative strength because of the concept of academic tenure, that a junior academic cannot be sacked for disagreeing with the professor. The party line is that there is no party line. We can rehearse defining moments in recent Cambridge history: physicists who started thinking biology, engineers who saw the study of management as part of their discipline, and mathematicians who took experiments seriously, leading to the creation of new institutions such as the MRC Laboratory of Molecular Biology, the Judge Institute and DAMTP. However, renewal starts at the bench, and this Department's own engine for change lies in its Research School, and in particular with its research students. Research studentships are really our gilt on the gingerbread, for they enable entirely new ideas to be turned into projects without needing to tell the world first or to follow the labyrinth of institutionalised science to get grant money. Good research students are themselves mavericks. They are taught to question the literature, but they must also steer their own projects by dint of following the pathway that they find most fun. My five-year stint as Head of Department is now complete and it was fun too. Derek Fray took over on 01/01/01. I wish him well.

AHW

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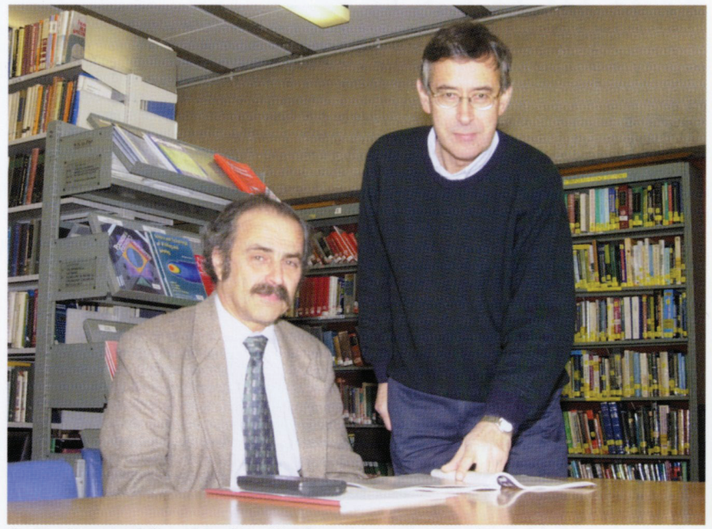
Annealing in a test-tube

Austenite that is harder than martensite in the same steel, and which hardens even more on annealing? To anyone with a basic knowledge of metallurgy that sounds pretty unlikely, yet it is the result of groundbreaking research carried out recently in the Department. The new electrochemically-induced surface annealing process that makes this possible in stainless steels was developed as a result of a "blue skies" research program funded by the EPSRC under the ROPA scheme, involving Dr Ian Hutchings and Dr Tim Burstein (pictured), and Dr Kotaro Sasaki. The results have already generated sufficient excitement for a letter published in 'Nature' (19 October, 2000) and considerable press coverage.

"The original aim of the project was to develop ways of enhancing the surface properties of austenitic stainless steels", explains Ian Hutchings.

"This type of material is used in many environments where corrosion resistance is important, such as the pharmaceutical and food processing industries. Unfortunately, it is notoriously susceptible to galling, and suffers surface damage and high friction when sliding against other stainless steel parts. We were hoping to develop new electrochemical treatments to produce a galling-resistant surface layer. We succeeded in that, but as a side-effect we also found that this treatment, carried out at low temperature, led to the disappearance of strain-induced martensite from the near-surface region. That was a great surprise since it would normally need heat-treatment at several hundred degrees Celsius to achieve the same effect".



Dr Tim Burstein (left) and Prof. Ian Hutchings (right) who have discovered a new type of surface treatment process.

The process involves applying a series of anodic/cathodic pulses to the stainless steel in an aqueous solution of sodium nitrite at a temperature of 80°C. X-Ray diffraction shows that the martensitic structure generated in the steel by mechanical deformation can be completely removed from the near-surface region by the electrochemical process, leaving austenite which is nevertheless significantly harder than the original martensite. Subsequent heat treatment at 550 °C produces an even higher hardness.

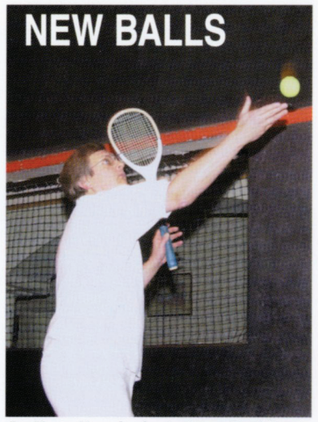
"We have not yet established the mechanisms causing this phase transformation" explains Tim, "but it is likely that both hydrogen and nitrogen are produced during the electrochemical treatment. The cyclic polarization causes hydrogen and probably nitrogen to diffuse in and out of the metal, and this process is probably responsible for the transformation of the martensite structure. There are also signs that nitrogen plays a key role in the hardening process. Although we have good ideas about what is going on, we need to do a lot more work to understand it fully and to optimise the process. To our knowledge, the removal of martensite by a low-temperature electrochemical method has never been reported before, and we have coined the term 'electrochemically-induced annealing' for it."

The team has already filed a patent application, and is now seeking funding to continue development of this novel method of surface engineering.

For more information, please contact Tim Burstein Tel 01223 334361; email gtb1000@cus.cam.ac.uk or Prof. Ian Hutchings email imh2@cam.ac.uk

For any comments about this newsletter or alterations to your address, please contact Navini Nynan by email nn210@msm.cam.ac.uk

NEW BALLS



Dr Kevin Knowles beginning a Real Tennis 'railroad' serve.

Luckily for devotees of the game, Cambridge is home to two of the world's forty or so Real Tennis courts. Unlike the comparatively modern game of lawn tennis which has kept abreast of changes in technology in the equipment used, the essence of the materials and the manufacturing processes for the balls and racquets used for Real Tennis have not changed since the game began in the twelfth century. In a recent project, Dr Kevin Knowles from our Department, a 43 handicap Real Tennis player, and three colleagues from the Advanced Course in Design, Manufacture and Management at the Department of Engineering have looked at ways of trying to improve upon the age old practice of hand-making real tennis balls.

The current balls, which are hand-made by the sport's Professionals, consist of a cork core, covered by tightly tied cotton webbing, with a felt cover that has to be hand-stitched in place. It typically takes 50 minutes to make a new ball from scratch, and 25 minutes to refurbish one. A set of 72 balls will last only two weeks on court, so it is no wonder that a manufactured ball is seen as a desirable item by Professionals, giving them more time to play and coach.

The team set about their task in text-book manner by first of all establishing the playing properties of the hand-made balls such as coefficient of restitution and compressibility. They then took into account appropriate design considerations such as cost, drag, durability and sound during play. The possible alternative materials to produce a manufactured ball were examined using the Cambridge Materials Selector designed by Professor Mike Ashby, which has become a standard part of the undergraduate course in Materials. Materials were assessed on the basis of stiffness and mean density requirements. Not suprisingly cork came out as good choice of material for the core of the ball, but no single material fulfilled all the design criteria.

The closest the team could come to an ideal material was to incorporate a cork centre in a relatively dense foamed polyurethane coating, covered with felt. This structure could be manufactured using a rotational moulding process in which the cork centre is held in place with restraints. Some trial balls have been manufactured for playability trials, which produced favourable reports from the Head Professional at the Cambridge University Real Tennis Club, Kees Ludekens.

'What needs to happen next is a refinement of the basic prototype to produce a ball that players are happy to use' comments Dr Knowles. 'The stumbling block is financial – the number of real tennis balls required per year world-wide is tiny in comparison with lawn tennis balls and golf balls, so that manufacturers aren't interested in spending money on the necessary development. We're now looking for sponsorship instead to do this ourselves at Cambridge'.

For more information, please contact: Dr Kevin Knowles, 01223 334312, e-mail kmk10@cam.ac.uk.

The research team working with Kevin Knowles consisted of Dr Alison Cooke, Tim Lennox and Stefano Mastropietro from the Department of Engineering.

In Brief

Recent visitors to the Department will have seen the new Reception area created by the enclosure of the Arup Tower concrete 'legs', coupled with the provision of a first floor seminar room seating 48 people.

Dr John Leake, Dr Jeff Edington and Prof. Anthony Kelly. (from left to right – front row)

The new facilities were opened on 10 November by Sir Robin Nicholson, in the presence of past and present academic staff, including Professor Derek Hull, Sir Alan Cottrell, Sir Robert Honeycombe, Professors Colin Humphreys and Alan Windle. [pictured above from left to right].

Sir Robin Nicholson gave the inaugural lecture in the new seminar room with many reminiscences and anecdotes of his time as a student in the Department.

Sir Robin Nicholson and Professor Alan Windle at the inauguration of the reception area.

Seeds of Change – a profile of Lorraine Dann

Lorraine Dann has been Secretary to the Department since the beginning of January 1991. Her appointment coincided with that of Professor Colin Humphreys as Head of Department. Now, having seen Professor Windle through his five year stint as Head of Department she is about to start working with her third Head of Department, Professor Derek Fray.

Although her job is largely concerned with making sure the Department's finances run smoothly, there is also a fair amount of personnel work involved. Everyone working in the Department will come into contact with her at some point, whether to sort out contracts or get their work permits and visas renewed. " There are many more post-docs coming from overseas now, than when I first started" she comments, "which is most welcome".

Lorraine's first love (academically speaking) was for botany, and she took a degree in agricultural botany at Leeds. She started her working life with a grain trading company in Suffolk, but after a few years decided to return to Cambridge, the city of her birth.

Employment with the University runs in Lorraine's family, as is the case for many of the administrative and college staff. Her grandfather was the Head Porter at the UL and her parents actually met when they were also both working at the UL. Apparently there is a photo at the UL of Lorraine's grandfather at the opening of the Library, in the presence of the King George V.

Lorraine found employment as a job analyst working in the Assistant office and then as an Administrator at the Old Schools. This put her in the position of having a good overview of which jobs it was possible to pursue in the University and she saw that the post of Secretary to a Department was an interesting one to hold. Luckily that has turned out to be the case.

When Lorraine first took on the job ten years ago, the Department was a lot smaller, both in terms of accommodation and numbers of people employed. She initially had quite a lot to do with up-keep and maintenance of the buildings ("I have been in more mens' lavatories than most women!") but that responsibility has now given way to keeping the finances in order and dealing with employment contracts. She enjoys the dual roles.

Lorraine has recently moved out of the city to the delights of a larger garden with her house in Hardwick. She enjoys gardening and maintains two ponds as well as the garden. Perhaps she does miss botany after all. Now that she does not walk to work and endures the tedium of endless traffic jams into Cambridge, Lorraine keeps fit by attending two aerobic classes a week combined with swimming.

Congratulations to

Dr Paul Bristowe on his promotion to University Senior Lecturer.

Dr Tim Burstein on his promotion to University Reader.

Professor Robert Cahn on the award of the Luigi Losana Gold Medal.

Professor Derek Fray on his appointment as Head of Department.

Professor Colin Humphreys on his election to President of the Institute of Materials as from December 2001 and to Professor Alan Windle who joins Professor Bill Bonfield as a Vice President.

Dr Ian Hutchings on his appointment to the GKN Professorship of Manufacturing Engineering at the Department of Engineering.

Dr David Knowles on his promotion to University Senior Lecturer.

Dr Kevin Knowles on his promotion to University Senior Lecturer.

Dr John Leake on his promotion to University Senior Lecturer.

Dr John Little on his promotion to University Senior Lecturer.

Dr Roger Reed on his appointment as University Lecturer.

Dr Rob Wallach on his promotion to University Senior Lecturer.

Professor Alan Windle on his appointment as Director of Cambridge Massachussetts Institute and as a Commissioner of the Royal Commission for the Exhibition of 1851.

This newsletter is edited by Sue Jackson, produced by Navini Nynan and printed by ABS Print Services Ltd.