ANU Centre for Science and Engineering of Materials

Materials Monthly

Making materials matter

February 2003

Oh the strain

Engineers receive funding to better measure the stamping process

Stamping shapes out of sheet metal is a major part of many manufacturing processes, especially those in the automotive industry. It's big business with a high throughput. The Stamping Plant at Ford's Geelong manufacturing complex, for example, employs some 2800 employees. Each day it uses 320 tonnes of steel, handles more than 1200 different parts, and ships out 250,000 pieces! Any improvements to the process, therefore, can yield significant savings.

Machine learning and automation are seen as playing an important role in improving the efficiency and flexibility of the stamping process, but there are major limitations to the gains that can be made here due to a lack of quantitative data. The basis of machine learning approaches is the ability to learn or train a system from data gathered through experiments or experience. However, when it comes to what's happening when the metal is actually being deformed, it's difficult to acquire good data. While the condition of the metal is known before and after it's stamped, not much is known about what's happening during the stamping.

It's this lack of hard data that has had the stamping process frequently referred to as a bit of a black art. Different conditions are trialled to come up with an optimum output, but it's a 'suck it and see' approach that relies more on chance than science, and limits a machine learning approach.

To overcome this limitation, engineers from ANU's Department of Engineering have received a $160,000 Linkage-Infrastructure Equipment and Facilities ARC grant to put together a 'surface and strain measurement' facility. The facility will enable researchers to acquire data on how the metal's shape and strain changes during the stamping process.

The surface and strain measurement facility will have two major components: a laser scanning device to quickly and accurately map the surface profile of any shape; and a strain measurement device in the form of a high speed camera that can map deformation and strain as it takes place.

▲▲ Professor Michael Cardew-Hall and Dr Shankar Kalyanasundaram hold up test samples of pressed sheet metal. The surface and strain facility they are putting together will provide invaluable information on what's happening during the stamping

The facility will enable a database of dimensional and strain information to be compiled in support of related manufacturing R&D projects. One program which will benefit enormously from the new facility is STAMP, a scheme that aims to enhance Australia's metal stamping technology. STAMP is a collaboration between ANU, Deakin Uni and Ford (see the STAMP of success, p2), and has resulted in a very productive interaction between academia and industry.

It's hoped the surface and strain measuring facility will be operational by the end of the year.

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The STAMP of success

STAMP stands for 'Stamping Technology for Automotive Manufacturing Processes'. It's a research and training program in which graduate students spend much of their time researching metal stamping issues in an industrial plant environment rather than a uni lab. The focus of the program is real-world problems and improvements, while at the same time preparing the student to enter the work force.

Stamping, which has been in use since the advent of the mass-produced car, is the process used to produce steel body panels to a specified shape and size. It allows for the rapid production of such units as doors, mudguards and bonnets. The process involves shaping a pre-cut sheet of flat steel by pressing it between two moulds.

STAMP was launched in mid-1997 as a collaborative venture between ANU, Deakin Uni and Ford Motor Company, along with three of Ford's suppliers (BHP Steel Ltd., Castrol Pty Ltd., and Imag Australia). (See page 1 for an example of relevant research being undertaken at the ANU.)

Many stamping professionals throughout the world regard stamping as a bit of black art that needs a more scientific approach. STAMP aims to bring together a range of academic and industrial experts while training up new skilled workers to sustain the industry.

▼▼ A test stamp. The grid of circles allows the strain produced in deformation during stamping to be accurately measured.

The STAMP program has a very hands on and practical focus. Each thesis generated by participating students must have an appendix on how the results of their thesis will be adopted by industry. Projects completed to date include systems to reduce lubricant and die coating costs, increased practical understanding of the forming of bake-hardenable steels, and the study of the deep-drawing process as a system.

More information:
http://www.et.deakin.edu.au/stamp/Version3/intros frame.htm

CRC merry-go-round

The Cooperative Research Centre (CRC) program commenced in 1990. CRCs aim to link universities, government agencies and industry; but their identities are always changing as partnerships and funding shift and evolve from year to year.

Selection rounds are held every two years, and the 2002 round will once again radically alter the CRC landscape. The 2002 round attracted 57 applications. The outcome of this round, announced in December, will see 12 completely new CRCs established, nine existing CRCs will develop into new CRCs, a further nine CRCs will receive supplementary funding to expand their activities and three CRCs will expire.

In July 2003, which is when this round comes into effect, there will be 71 active CRCs, up from 62. The CRC budget will be just over $200 million.

The following new or revamped CRCs have connections with materials science and engineering:

CRC for Sustainable Resource Processing
(new CRC): will investigate the value chain from mine site to industrial minerals and metals. It will investigate economically viable ways of eliminating waste and emissions.
More information: Dr Joe Herbertson (02) 4959 8856

CRC for Greenhouse Gas Technologies
(developing from existing CRC): will develop new technologies to capture carbon dioxide and then store it in the subsurface.
More information: Dr Peter Cook (02) 6200 3366

AJ Parker CRC for Hydrometallurgy
(is receiving supplementary funding): focuses on the extraction of metals from minerals.
More information: Mr Mark Woffenden (08) 9360 6075

CRC for Advanced Composite Structures
(developing from existing CRC): will develop innovative composite science and technology towards reduced manufacturing costs.
More information: Dr Ian Mair (03) 9646 6544

CRC for Environmental Biotechnology
(developing from existing CRC): some of the key technologies being developed here include the production and management of biofilms, and the use of novel biosensors in aqueous and non-aqueous systems.
More information: Dr David Garman (02) 9385 4886

For more information on this brave new world of CRCs, see http://www.crc.gov.au/whats_new.htm

For information on a national conference on how CRCs are helping Australia meet national research priorities (in Canberra, 27-29 May, 2003), see **http://www.crca.asn.au/conference/index.htm**

Words of substance

"There are many hypotheses in science which are wrong. That's perfectly all right; they're the aperture to finding out what's right."

Carl Sagan

Advanced Manufacturing & Production Systems

Automation is essential to any modern industrial society, and is used in a wide range of industries such as materials processing, car manufacturing, steel making, and semiconductor manufacturing. The Department of Engineering established the Advanced Manufacturing and Production Systems group to explore a range of issues important to industry.

A major aim of the manufacturing group is to develop approaches that allow fast computational simulations to be displayed in an easily understandable format making extensive use of colour graphics, time-based animation, and interactive manipulation.

A key activity that supports the growth of understanding of new or established manufacturing processes / material systems is the development of appropriate mathematical models. Such models have been used to understand manufacturing processes, the failure and toughening mechanisms of advanced material systems and simulation of microstructural behaviour.

Engineering Computation and CAD

For most engineering problems it's not possible to obtain explicit analytical solutions to mathematical models. Consequently modelling involves computationally intensive numerical solution of nonlinear equations using methods such as finite elements. Computational Engineering and Computer Aided Design (CAD) underlies many of the R&D activities of the Department of Engineering.

Finite element simulations often provide a good proving ground for design changes. By simulating the natural variations that occur in a manufacturing process it's possible to arrive at an optimum design.

▲▲ The computer controlled CNC apparatus can produce parts made to measure. It forms part of the Advanced Manufacturing lab.

Manufacturing

Manufacturing research encompasses:

▷ CAD based tolerancing and error analysis of aerofoil components

▷ superplastic forming of engineering structures

▷ optimising vision-based measurement and surface inspection systems

▷ optimisation of metal stamping operations

▷ finite element model based optimisation of sheet metal stamping

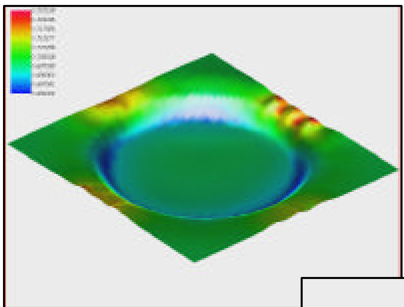
▷ optimisation of complex operational systems

Modern manufacturing systems involve processes operating in both discrete and continuous time, with both discrete and continuous variables, at varying time scales.

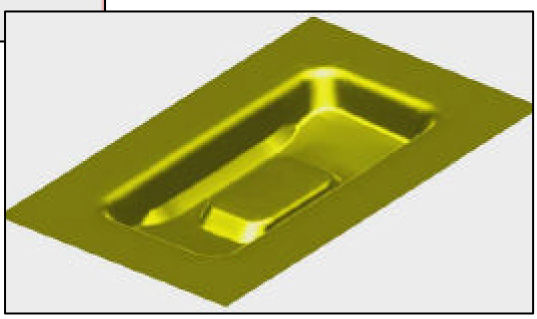
For example, supervising computer may issue instructions to a machine at certain time instants, and between these time instants the machine is an operating physical device modelled by continuous variables. Designing and controlling such systems for efficient economic operation is difficult. Discrete event systems and hybrid dynamic systems constitute a class of models designed for such complex systems.

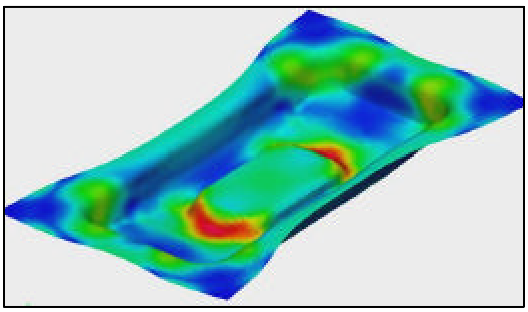
Work in this area includes modelling, analysing and controlling example applications such as robotics, assembly and mining.

More information:
http://engn.anu.edu.au/research/amps.php3



◀▼ Finite element simulations of stamp forming.





Opportunities

MRS alert

The current issue of MRS (Materials Research Society) Bulletin is devoted to microelectronics packaging and integration. It carries articles on:
- materials for 3D packaging of optoelectronic systems,
-packaging options of MEMS,
-chip to module connections
and a whole lot more. You can find out about every issue of MRS Bulletin as it comes available simply by subscribing to their news service
(see http://www.mrs.org/geninfo/enews/).

The service is free and allows you to read any abstract you want (though to read the whole story you'll need to subscribe.)

►► Find out what's coming in the MRS Bulletin as soon as it comes out.

Science Prizes

Nominations for the 2003:

- Prime Minister's Prize for Science
- Science Minister's Prize for Life Scientist of the Year
- Malcolm McIntosh Prize for Physical Scientist of the Year
- Prime Minister's Prize for Excellence in Science Teaching in Secondary Schools
- Prime Minister's Prize for Excellence in Science Teaching in Primary Schools

will **close** on **26th March 2003**.

More information (and entry forms):
https://sciencegrants.dest.gov.au/SciencePrize/

►► Prof Marcela Bilek, a materials scientist at Sydney Uni won the Malcolm McIntosh Prize for Physical Scientist of the Year in 2002. Will you be in the running in 2003?

Conferences / Seminars

◄✧► **IGORR 9** — **24-28 March**
International Group on Research Reactors,
Sydney, http://www.frm2.tu-muenchen.de/igorr/igorr.html

◄✧► **Commercialisation Forum and Fair of Ideas** — **26-28 March**
Sydney, http://www.kca.asn.au/

◄✧► **ICT 2003** — **8-10 April**
The 2003 International Conference on Information and Communication Technologies
Bangkok, Thailand, http://www.ict.s-t.au.ac.th/

◄✧► **CRCs meeting national research priorities** — **27-29 May**
Canberra
http://www.crca.asn.au/conference/index.htm

◄✧► **Nanoengineering World Summit** — **23-25 June**
Boston Massachusetts
http://www.iec.org/events/2003/nanoengineering/

◄✧► **Aims for Future of Engineering Science** — **2-8 July**
Igalo, Montenegro
http://www.mia.org.ua/

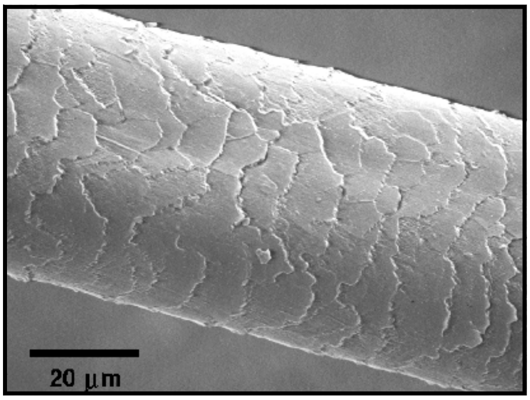
◄✧► **ICIAM 2003** — **7-11 July**
5th International Congress on Industrial and Applied Maths
Sydney
http://www.iciam.org/iciamHome/iciamHome_tf.html

Materials Grab Bag

Hair-raising adventures with the NYSF

It's amazing stuff hair. Super-strong (often as strong as steel), insulating, and comes in a range of colours. What's more, depending on how you analyse it, it can tell you a lot about the person it came from.

For example, five hairs from the French emperor Napoleon were analysed for arsenic and revealed that they contained 38 nanograms of arsenic (per milligram of hair) whereas normally hair has no more than 1 milligram. The conclusion was that Napoleon died of (undiagnosed) arsenic poisoning. (See http://www.cnn.com/2001/WORLD/europe/06/01/napoleon.poisoning/ for more information.)



▲▲ An SEM of human hair. It's amazing what you can discover if you look in the right way.

Then there's work by Australian researchers that indicated that it might be possible to detect breast cancer in women by scanning their hair with synchrotron radiation and studying the X-ray scattering patterns. (Though more recent work has thrown doubt on this finding; see http://www.iop.org/Physics/News/0430j).

So, it's a pretty remarkable material, and a perfect focus for visiting students from the National Youth Science Forum (NYSF) to learn more about the fascinating world of materials science and engineering.

NYSF is an opportunity for some of Australia's best and brightest year 12 students to come together in Canberra and visit many of our city's finest science institutions. CSEM, together with the ANU Electron Microscope Unit, hosted four groups and showed them the glittering world of cutting-edge materials science and electron microscopy.

CSEM gave each group a presentation on the value of materials science, how to get into it, why they might consider ANU as a place to study; and then tested their hair for tensile strength using the Department of Engineering's Instron tensile strength tester.

The EMU then gave the students a tour of the unit's many electron microscopes, and allowed them to take images of an insect.

The hope is that some of the NYSF students will choose to return to study at ANU. Clearly they were impressed by what they found at ANU.

CSEM would like to thank Aleks Cvetanovska and Jenny Campbell for their assistance in running the hair-strength testing sessions. (Aleks and Jenny are both recent engineering graduates at ANU. They also shared with the NYSF students what it was like for women to do engineering.)

For more information on the National Youth Science Forum see www.nysf.edu.au

◀◀ Two NYSF students test their hair strength.

Bigger than Ben Hur

At the recent Synchrotron Users Workshop the final design of Australia's new synchrotron was announced, and it seems to get bigger with every press release. It will now be twice as powerful as was originally proposed.

"The new design – known as Boomerang 20 – should guarantee that Australian researchers have access to world leading synchrotron technology," says Mr John Brumby, Victorian Minister for Innovation.

Mr Brumby said new funding arrangements had been adopted to accommodate the new design and boost investor confidence in the project. The Government will provide $157.2 million for the synchrotron building and machine, with consortia comprising universities, research institutions, other governments and the private sector to fund the cost of the beamlines. The total cost of the project will be $206.3 million.

Boomerang 20 will:

▷ Accommodate up to 95% of Australian research requirements;

▷ Generate light twice as bright as the previous design – brightness that is essential for the analysis of complex compounds such as the structure of proteins in cancerous cells; and

▷ Have a larger circumference (216 metres) to accommodate over 30 beamlines. The previous design was limited to around 24.

Stay tuned, more big news is sure to follow.

For more information see http://www.synchrotron.vic.gov.au/whats_new/media_release_item.asp?id=16

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CSEM

ANU Centre for Science & Engineering of Materials

Faculties
Department of Chemistry
Depart of Engineering
Department of Forestry
Department of Geology
Department of Physics

Institute of the Arts
Materials Workshops

Institute of Advanced Studies
Research School of Biological Sciences
Research School of Chemistry
Research School of Earth Sciences
John Curtin School of Medical Research
Research School of Physical Sciences & Engineering

MM webspotting:

Stamping Metal

- **Fabricator.com**
  http://www.thefabricator.com/xp/Fabricator/home.xml
- **Galling reduction through die treatment**
  http://www.thefabricator.com/xp/Fabricator/Articles/Stamping/Sta02/02web375.xml
- **Stamping Technology for Automotive Manufacturing Processes—**
  http://www.et.deakin.edu.au/stamp/Version3/introsframe.htm
- **Advanced Materials Manufacturing, Deakin Uni**
  http://www.deakin.edu.au/engineering/research/ammp/?62
- **Centre for Advanced Materials Technology, Syd Uni**
  http://www.camt.usyd.edu.au/introduc.htm
- **Advanced automotive materials in North America**
  http://www.newsletters.com/map/prod/858343.html

Magic metal

CSIRO's Elaborately Transformed Metals group have helped to develop a new low-cost, thin magnesium sheet and alloy ready for production lines worldwide. This will make it possible for manufacturers to successfully use magnesium for a host of everyday products from motor vehicle engines and body panels, to printers, mobile phones, DVDs, trains, batteries and even bicycles. **See:** **www.csiro.au/index.asp?type=mediaRelease&id=Prmagnesium**

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