Newton’s Laws and composite fibre - Lightweighting Technology Clinic, Toyota, Melbourne, 21 March 2013

The International Fibre Centre and Technical Textiles and Nonwoven Association, in association with Toyota, proudly hosted the recent Lightweighting Technology Clinic. Speakers from CSIRO set the context of ‘lightweighting’ - or product weight optimisation - for manufacturers by examining societal trends that impact potential markets; and lightweighting R&D, highlighting the significant potential of fibre, textiles and composite materials to transform Australian manufacturing.

With the aerospace and automotive sectors the current international leaders in lightweighting, the venue for this Technology Clinic at Toyota Australia’s Altona plant was most apt. Toyota generously provided a tour of the plant, where participants witnessed the latest Camrys roll off the production line.

CSIRO speakers included: Ms Sarah King, of the Future Manufacturing Flagship; Dr Tony Pierlot of the Fibre Science & Engineering Program (Materials Science & Engineering); and Dr Niall Finn, a Senior Research Scientist investigating nonwoven textiles, advanced fibrous materials, nanocomposite fibres, fibre reinforced composites and textile processing.

Lightweighting is not just the latest “buzz word”, it is a necessity driven by some very important, but complex, issues – including global warming, carbon emissions, resource scarcity, sustainability.

Simply put, lightweighting is about achieving “more with less” ..... 

To put some structure around that very broad concept the CSIRO speakers provided a logical, and thought-provoking path for all of the participants.

Sarah King challenged our current view of the world with her presentation on CSIRO’s “Global Megatrends” – the trends that will change the way we live, work and play.

The CSIRO recently released its latest version of its Global Megatrends study, which presents a view of the future from six
interlinked megatrends that are anticipated to impact us over the next 20 + years. A megatrend is defined as a significant shift in environmental, economic and social conditions that will substantially change the way people live in the future. http://www.csiro.au/Portals/Partner/Futures/Our-Future-World-report.aspx


In thinking about the future, the CSIRO have used some key words – “probable”, “plausible” and “possible” - as descriptors to cover a range of scenarios. “Probable” is well supported by evidence or data. Here historical data can be used to make reasonably accurate forecasts – an example would be population growth. “Possible” is really about imagination, where scenarios cannot be substantiated by data. Finally, “plausible” sits between the two extremes – where there is a balance between evidence and imagination. The plausible future is the domain of the CSIRO megatrends study.

In thinking about the 6 megatrends, Ms. King stressed the need for current decision-makers to consider how these concepts could shape strategic thinking and product planning within organisations.

1. “More from Less” focuses on the increasing demand for the world’s limited resources, such as food, water, fossil-fuels, and minerals;
2. “Going, going, gone” explores the perilous situation of the world’s ecological habitats and biodiversity;
3. “The silk highway”, acknowledges the global economic shifts occurring and the trade opportunities created, especially with China and India;
4. “Forever young” considers our aging population and both the opportunities and challenges this presents to governments, companies, communities and families;
5. “Virtually here” recognises that people, businesses and governments are rapidly moving into the “virtual world” to transact, obtain information, shop, work and interact with each other;
6. “Great expectations” recognises the growing demand for more personalised, better and faster products in keeping with the communications revolution. In-person social relationships will still hold great value; while concurrently there will be impoverished communities throughout the world with far more basic needs.

Elements of these megatrends are everywhere – as such it may be necessary to step outside of your existing industry sector to gain a better perspective on the impact of change.

Finally, Ms. King shared some thoughts on possible opportunities for the textile and composites industries:

- Mass customisation of garments;
- 3D polymer printing of garments;
- On-line shopping, using visualisation and body scanning;
- Lightweighting options in textile designs;
- New and interesting uses of fabrics in environmental protection;
- Lightweighting in composites for mobility devices;
- Augmented worker / person devices – robots and actuators.
Dr. Niall Finn took the audience from the future, and back to the present with a comprehensive presentation on the advantages of Lightweighting; how textiles and fibre properties enable a lightweighting strategy; and the science supporting it.

Lightweighting, or reducing the mass of a product (with textiles and fibres), has numerous advantages. Reduced material consumption – “more from less” – has both direct benefits such as reduced material cost; and indirect benefits related to reduced waste; reduced consumption of related input materials (labour, chemicals, energy, etc.).

Reduced weight is significant when the product moves or needs to be moved, Newton’s law of motion simply states that for a given force the acceleration will depend on the mass. Arguably the most critical example is in aerospace where weight saving directly relates to a saving of fuel, or increase in capacity, or both. The much vaunted Boeing 787 Dreamliner airframe is 80%, by volume, constructed from fibre composites – delivering a fuel saving of some 20% compared to similar sized aircraft.

![Figure 2: http://bintang.site11.com/Boeing_787/Boeing787_files/Specifications.html](http://bintang.site11.com/Boeing_787/Boeing787_files/Specifications.html)

Consider something closer to home – your daily drive. By far the most significant cost over its life is fuel, which in turn is directly related to its weight.

In industry and infrastructure weight is also significant – particularly where goods need to be transported, or machines (weaving machines, robot, etc) need to operate efficiently.

To optimise advantages of lightweighting it may require redesign of a product. This will give designers an opportunity to innovate, select most appropriate materials, improve functionality / performance and reduce waste.

The unique properties of textiles and fibres were explained. This presentation made it clear, even to the numerous non-engineers in the audience, that lightweighting using textiles and fabrics has excellent potential for businesses in our industries.

The light weight, high strength and stiffness of carbon fibre have seen it specified in applications where light weight is considered a premium. Aerospace, wind energy and automotive are market segments already using this amazing fibre – with demand forecasts into the immediate future very strong.

But it is not all about the fibre. Dr. Finn shared work done by CSIRO on an automotive seat using a 3D knitted fabric. In this example the shape, fibre selection and textile
design were critical parameters that resulted in a hollow seat frame, significantly lighter than seats made from metals. Additional advantages claimed are reduced labour and energy in construction; low capital investment and reduced shipping costs (the knitted shape can be flat packed to plant, reading for moulding).

The final presenter, Dr. Tony Pierlot, provided an extensive overview on a range of existing applications and emerging opportunities where textiles and fibres have been used to advantage in lightweighting.

In the field of Composites, examples of innovation were seen in Sports, Automotive, Aerospace, Infrastructure and even Agriculture.

Some excellent examples from within Victoria included:

- Racing Skulls using a mixture of glass, carbon and aramid fibres to optimise performance;
- one-piece Carbon Fibre car wheels that have a 40-50% reduction in unsprung mass, improved performance on a number of measures and reduced fuel consumption;
- Westgate Bridge renovation, where more than 10,000 m² of Carbon Fibre fabric was used to strengthen the structure. The light weight, high strength and minimal labour cost and traffic disturbance were critical decision factors.

While much focus has been given to aerospace and automotive, there a number of innovative infrastructure projects, where textiles and fibres have been employed. A number of pedestrian bridges have been constructed, in China and Spain, where carbon fibre has been instrumental in the construction of lightweight bridges, with minimal disruption to the communities.

Examples in textiles and fabrics are equally as impressive, covering a wide range of applications including:

- Coated fabrics:
  - with great design flexibility and ability to be joined using a variety of welding techniques;
  - bladders and onion tanks – light weight, foldable and transportable. Wide range of applications for water and fuel storage in disaster zones, remote locations and military deployments;
  - air-supported structures, for architectural / building applications.
(e.g. hotels, sporting stadiums;
  o architectural features, such as building facades and screens;
  o air-beams – pressurised inflatable tubes that become rigid when inflated, have a wide range of applications

- Body Armour
  o To reduce carrying load of soldiers

- Light Weight High Strength Ropes
  o UHMWPE and p-aramid fibres for marine and industrial applications, where light weight adds to ease of use

- Pipe refurbishment
  o Textile “socks” to repair pipes “in situ”. Light weight enables long lengths of pipes to be repaired

These are just a few examples that clearly demonstrate that textiles and fibres are essential materials in lightweighting. While they may add additional cost, they provide innovative designers, engineers and manufacturers with opportunity for improvement from enhanced design/manufacturability, functionality and performance, and “more from less”.

**Clearly lightweighting is not a “light weight topic”!**

Each of the CSIRO speakers provided the participants with both information and inspiration to encourage them to implement strategies - to realise the opportunities that lightweighting presents to the textile and fibre industries.