Technology Challenges in a Changing Downstream Aluminium Industry

By Tom Farley, Managing Director, Innoval Technology Ltd.

Introduction

In this article, Dr Tom Farley, Managing Director of Innoval Technology discusses changes within the aluminium industry and their impact on research and development. Some critical technical challenges within the downstream rolling industry are highlighted, together with some potential step change technologies that could provide solutions.

Changes in the Downstream Industry

In recent years there has been a significant shift in the centre of gravity of the aluminium industry from developed regions such as North American and Western Europe to developing regions such as China, India and South America. The shift has been driven by the high economic growth rates in these developing regions leading to an increased local demand for aluminium products. The current economic climate has arrested this growth rate but once the recession has passed it seems reasonable to assume that growth will return to a pattern similar to that seen before the downturn, as shown in Figure 1.

R&D requirements are not uniform across the globe with different global regions needing different types of R&D. Developed regions need R&D to reduce costs, to support more specialised products and for new product innovation. The developing regions need support in achieving world-class product and process performance from newly installed capacity. Fundamentally, all regions need R&D to maximise returns.

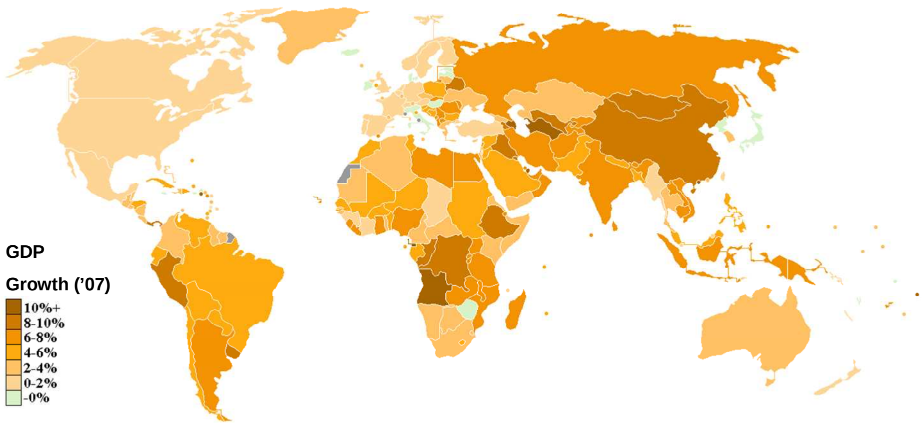

Figure 1: GDP growth rate in 2007 (source: CIA World Factbook 2009)

The past decade has seen many changes of ownership within the industry and this is still ongoing. Mergers, acquisitions and divestments may bring some financial advantage through synergies, but they have also resulted in the loss of important expertise through closures of plants and technical centres. The loss of vertically-integrated aluminium companies is also having an impact on the level of downstream R&D expenditure. Expertise takes decades to develop and can be quickly lost through such closures.

Figure 2 shows the extent of the downstream industry closures seen in the UK over the past decade and is an example of the decline in manufacturing industry experienced in most developed regions. There are now only three aluminium rolling plants remaining in the UK and the majority make specialised and technically challenging products such as aerospace and lithographic sheet.

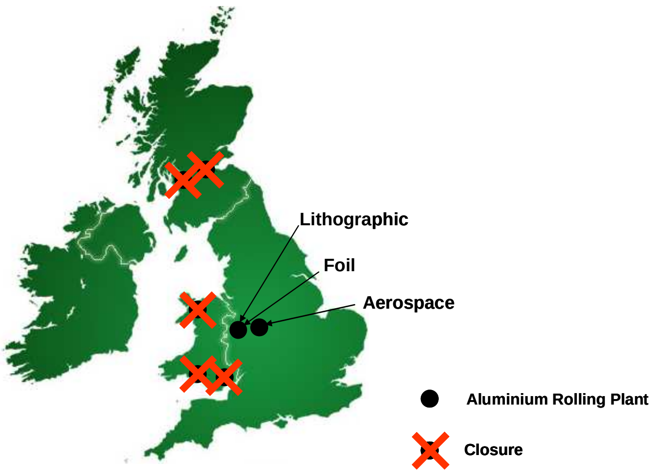

Figure 2: The extent of aluminium rolling plant closures in the UK over the past decade.

As the aluminium production shifts to developing regions and R&D expenditure in developed regions decreases, the new aluminium companies in the developing regions will need to increase their R&D expenditure to respond to critical industry challenges.

It is important to note that insufficient R&D expenditure will lead to a weak future for aluminium as other competitive materials eat into market share and aluminium is displaced from existing markets. Also sustainability challenges will become ever more important in the future and these will need to be addressed.

Technical Challenges in the Downstream Rolling Industry

Technical challenges in the aluminium industry are being driven by more exacting customer requirements and specifications; cost reduction; competition from other materials (substitution) and the increasing focus on sustainability issues. Some examples of these challenges are provided below.

Development of New Markets

Substituting aluminium for steel in automotive structures represents a huge potential market for aluminium and the history of this development goes back many decades. The favourable strength-to-weight ratio compared to steel has long been recognised, providing reduced CO2 emissions from the reduced weight.

The Audi A2 1.2 TDi (Figure 3) was a pioneering mass-produced aluminium vehicle weighing just 825kg. It was the first 4-door car capable of driving 100km using less than 3 litres of fuel (producing 80 g/km CO_2). This was achieved with non-hybrid technology and is still unmatched by many new hybrid vehicles today. Figure 4 shows the importance of vehicle weight reduction and choice of engine technology on emissions.

Figure 3: Audi A2 TDi was a mass produced aluminium intensive vehicle achieving 80 g/km CO_2 emission.

The higher price of aluminium autosheet compared to steel is holding back further application of this technology in high-volume, low cost cars. As a consequence much R&D is focused on reducing the cost differential. One potential solution is to increase the use of lower cost recycled aluminium in this product.

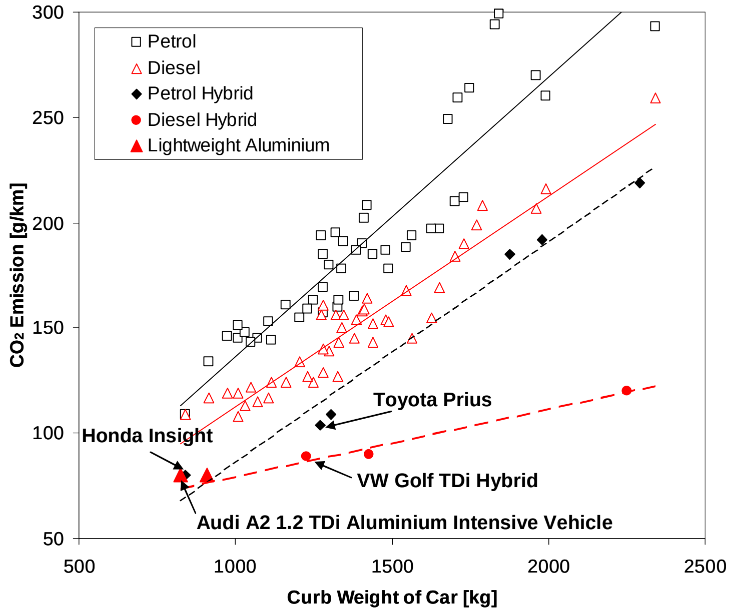

Figure 4: Impact of weight and engine on carbon dioxide emissions from cars

Protection of Existing Markets:

The use of aluminium in aerospace products provides a good example of an existing market under threat from new materials.

The new generation of wide body passenger aircraft from Boeing and Airbus will be 20% more fuel efficient than today's similar sized aircraft. Over half of this improvement comes from the use of advanced materials and the rest from improved engine systems.

The new Airbus A380 retains a significant use of aluminium, with approximately 61% of the structure made from aluminium alloys. However, ~50% of the primary structure of Boeing's 787 Dreamliner, including fuselage and wing, is manufactured from carbon fibre-reinforced plastic (CFRP). This represents a significant reduction in the use of aluminium in the aircraft structure, as shown in Figure 5. The aluminium industry has been responding to the increased use of CFRP and the use of other advanced materials (e.g. glass-FRP and titanium) as all represent a threat to the aerospace market.

Significant R&D effort is going into the development of next generation of Al-Li alloys and also glass-fibre reinforced aluminium (Aluminium-GLARE) which can be almost immune to fatigue.

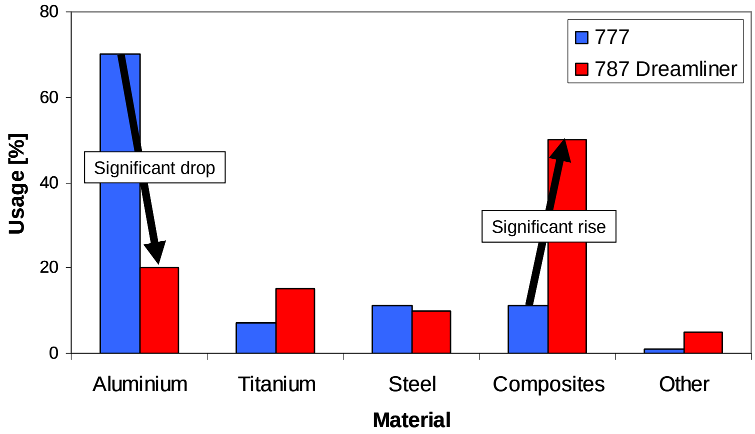

Figure 5: Material usage changes in 10 years (Boeing 777 vs 787)

Current and Future Sustainability Issues

Issues of sustainability present several major challenges for the aluminium industry. The industry must

- increase the use of recycled Aluminium
- reduce the energy consumption of its processes
- reduce the consumption of water in its processes
- reduce emissions including greenhouse gases
- reduce the volume of waste to landfill

In the future, the consumption of fresh water may become one of most critical issues in the world due to climate change and increases in world population.

Potential Step Change Technologies

The industry must continue to respond to these challenges and to develop new technologies with the potential to make step changes in the way we currently operate. These technologies may in themselves not lead to step changes but when combined together could result in a step change for the industry.

Example 1: Continuous Casting for all Products

Continuous casting offers many advantages over the more traditional direct chill (dc) casting and hot rolling process route. For example continuous casting saves the energy to reheat the dc cast ingot and for the hot rolling process itself. However, the process is currently limited to fairly dilute aluminium alloys, particularly to lower levels of the alloying element magnesium. The technical challenge is to remove these limitations or to find alternative alloys that can be continuously cast with sufficiently good properties for products such as automotive sheet, can body stock and others.

Example 2: Cladding Processes to Create Multi-layer Products

We are all familiar with aluminium brazing sheet used in heat exchanger products. It is made by cladding, on a hot reversing mill, two or more layers of different aluminium alloys. In their simplest form these products comprise a layer of low melting point aluminium-silicon alloy clad onto a higher melting point core alloy.

Making products from single alloys often involves a compromise in competing properties such as mechanical strength, formability, corrosion resistance, surface appearance, bondability, weldability, etc. Creating multi-layered structures using different aluminium alloy layers opens up a whole new world of opportunities in product design.

For example a surface layer of AA1050 on a high strength core alloy could be used to make lithographic sheet. Also, a high formability or corrosion resistant outer layer on a high strength core alloy could be used to make lower price automotive sheet with further potential for decreasing sheet thickness and weight. In both examples the core could be made from recycled aluminium to reduce product cost.

Traditionally, cladding on the hot reversing mill is not particularly efficient but there are many alternative technologies available to achieve the same final clad product. The layered structure can be created at any point in the process from casting to cold rolling. The further downstream this occurs in the process the better from the point of view of recycling and lean manufacturing. One new technology is Novelis Fusion^{TM} technology which combines the different alloy layers together during dc casting, as shown in Figure 6. Jaguar has recently announced its intention to use Novelis Fusion^{TM} sheet in part of its new XJ model.

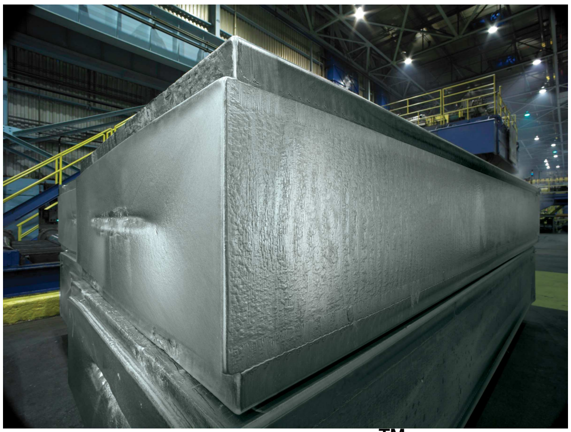

Figure 6: DC cast ingot using Novelis Fusion^{TM} technology (source: Novelis)

Example 3: High Shear Melt Conditioning of Aluminium Alloys

New process technologies are being developed to improve the properties of aluminium alloys. One such development is Melt Conditioning by Advanced Shear Technology (MCAST) at Brunel University (UK) in which Innoval Technology is a technical collaborator. The shear melt conditioning ensures a high survival rate of nuclei and the generation of fine grained uniform ‘as cast’ microstructures with no entrapped gas to cause porosity or macroscopic oxide film defects to devalue

mechanical properties. This means that aluminium alloys can be produced with fine uniform microstructures from the cast state and that subsequent thermomechanical processing can be minimised to provide cost effective high performance semi-fabricated products.
This technology offers the potential to upgrade the properties of existing and new alloys, including recycled alloys for applications in products such as automotive sheet.

Summary

There is no doubt that the current market and demand for aluminium is based on the successes of past technical developments made in R&D centres throughout the world. R&D is sometimes viewed as a costly expense that can be reduced during more difficult economic times, or perhaps as a synergy resulting from divestment, merger or acquisition activity. The positive value of R&D, be it short or long term, must be considered very carefully during these decisions because once expertise is lost it can be expensive and very time consuming to regain.

The aluminium industry must continue to develop new products and processes to combat the threat from other competitive materials and maintain aluminium's sustainable credentials. The emerging industry in developing regions must take on these challenges and for this they will need dynamic R&D departments with effective technology resources in place. The pool of aluminium product and process expertise in independent companies such as Innoval Technology can be used to help with these challenges.

Contact Details:
Dr Tom W.D. Farley, Managing Director,
Innoval Technology Ltd, Beaumont Close, Banbury OX16 1TQ, United Kingdom
tom.farley@innovaltec.com

Innoval Technology Ltd provides high quality consultancy and technical support to investors, manufacturers and end-users of aluminium, and other selected engineering materials, across a broad range of industry sectors. The company, based in Banbury, UK, and employing 26 people, holds ISO9001:2000 certification and ISO17025 accreditation.