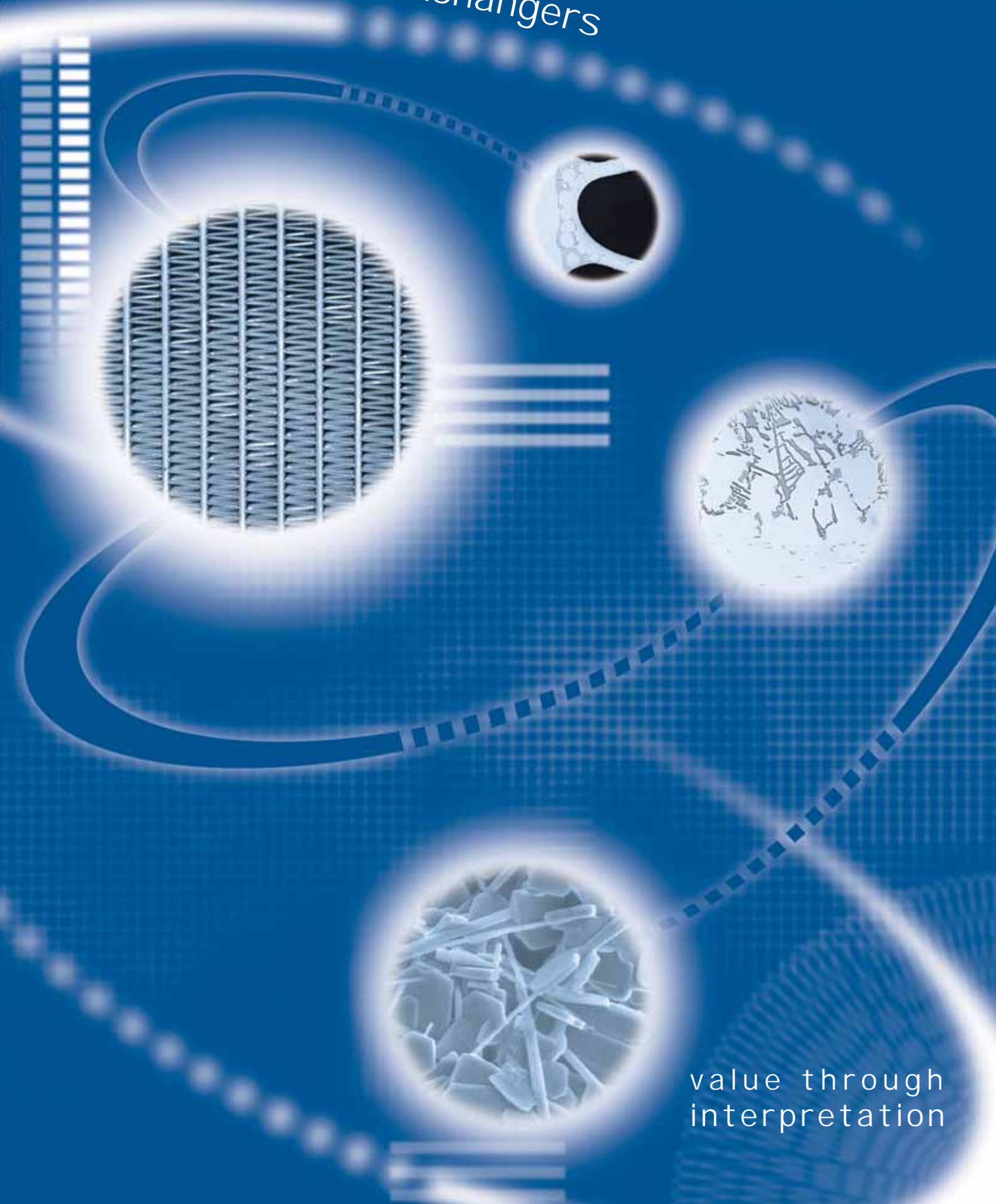


innoval
technology

Aluminium Heat Exchangers



value through
interpretation

Innoval Technology – Your Technical Partner for Heat Exchanger Development

We are committed to providing world class expertise in aluminium alloys and brazing technology. Our experts have unique knowledge in materials characterisation and performance, coupled with extensive product and process experience.

Innoval Technology is an independent company active in all stages of the Heat Exchanger supply chain. We have a unique view of the industry, and we can supply information on market trends, new materials and processes, and new techniques to keep you up to date with the latest developments.

Together we can ensure you stay at the forefront of your industry.



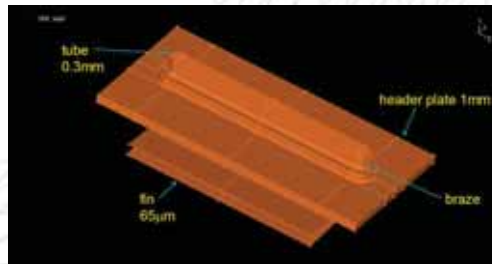
Mechanical modelling for enhanced durability

Our modelling team can create a header plate and tube model of your product which will allow you to identify regions of high stress for different types of deformation. For example, the model can illustrate the effect of deformation due to pressurisation and thermal tube expansion. It can then be used to explore how gauge, fin location, braze dimensions, etc. affect regions of stress. By using our mechanical models in your product design, in-service failures can be avoided.

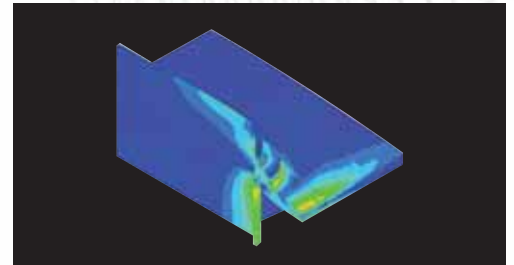
The modelling group is supported within Innoval by metallurgists and surface scientists who are themselves experts in the production and processing of aluminium. For heat exchanger materials, there really is nowhere better than Innoval Technology for your modelling requirements!



Header Plate



Header Plate Model



Contours showing stresses upon 1mm tube displacement (1/4 model)

Residual carbon measurement – how clean is your aluminium surface?

Brazing sheet suppliers – the cleanliness of the aluminium surface you supply to your customers can impact on their first time through rates. Therefore, ensuring your residual carbon levels are the lowest in the business could lead to significant competitive advantage.

At Innoval we can help you achieve this by firstly monitoring your residual carbon levels, and then using our thermal modelling techniques to optimise your annealing process to ensure all traces of lubricant are removed from the strip before *in-situ* oxidation occurs.



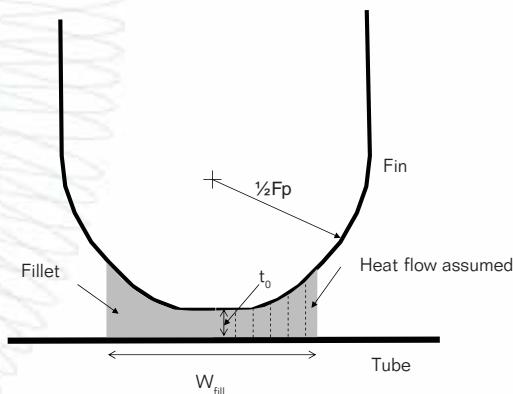
Thermal modelling for effective down-gauging

Our thermal modelling expertise will enable you to make your products smaller and lighter without reducing their performance. We will use our sophisticated thermal models to explore the relationship between key dimensions of your product and heat transfer performance. Specifically we will focus on:

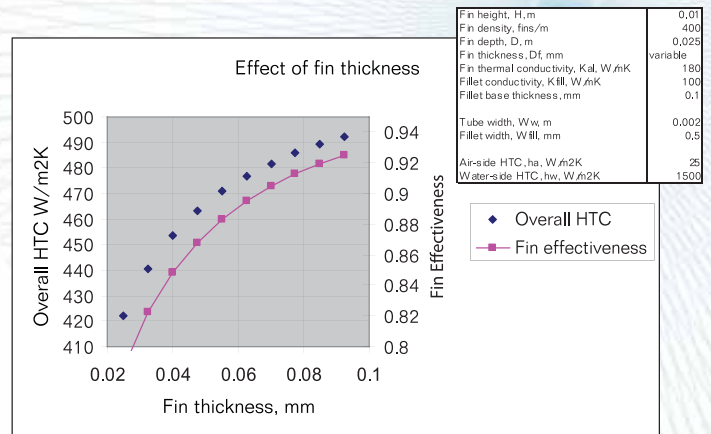
- Fin gauge and conductivity
- Fin height
- Fillet width

Furthermore, we will explore each of the above with different fin chemistries to obtain a perfect balance between mechanical properties, thermal conductivity and corrosion resistance.

We are confident that our modelling tools, coupled with our extensive product and process knowledge, will reduce the development time and cost of your new products.



Model results: effect of fin thickness

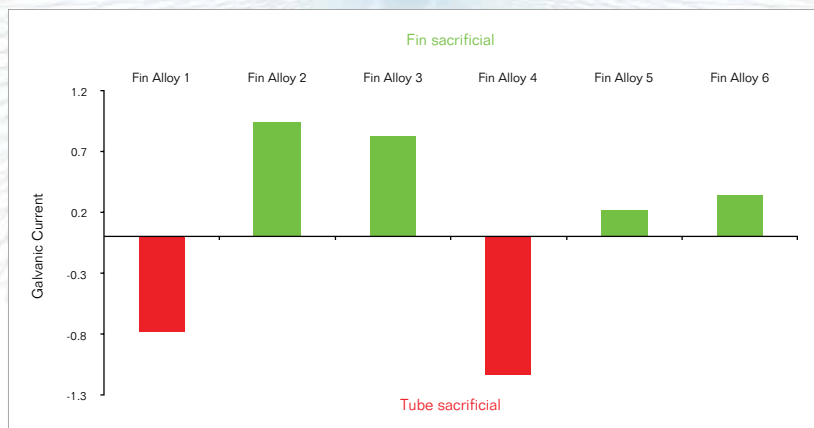


Modelling the braze fillet

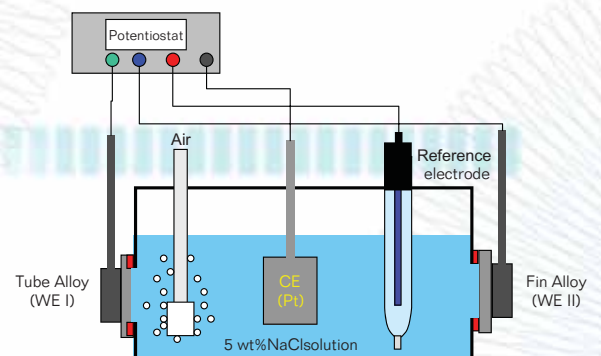
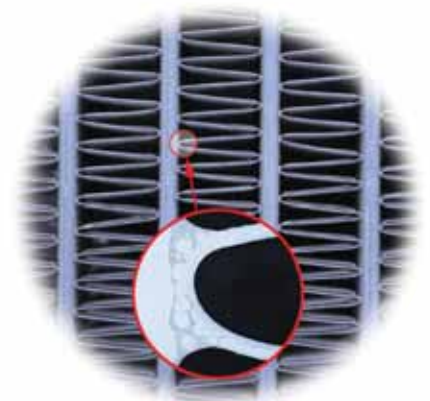
Is your system galvanically compatible?

As tube stock continues to be down-gauged, it is becoming increasingly important to ensure your finstock remains sacrificial to your tube alloy, thereby maximising the durability of your heat exchanger. Furthermore, your finstock must remain sacrificial irrespective of supplier. This is an important point to consider because it is the process route at your supplier which influences galvanic compatibility. Two alloys with the same composition can behave very differently when in a heat exchanger system.

We can ensure you have the best combination of finstock, tube-stock and header plate. We use a ZRA (zero resistance ammeter) to measure the galvanic compatibility of your whole system in accordance with ASTM G71. We will test all suppliers of each component to ensure that there isn't one combination which could let you down.



Total galvanic charge of fin alloys against extruded tube for 6 hours coupling in SWAAT solution



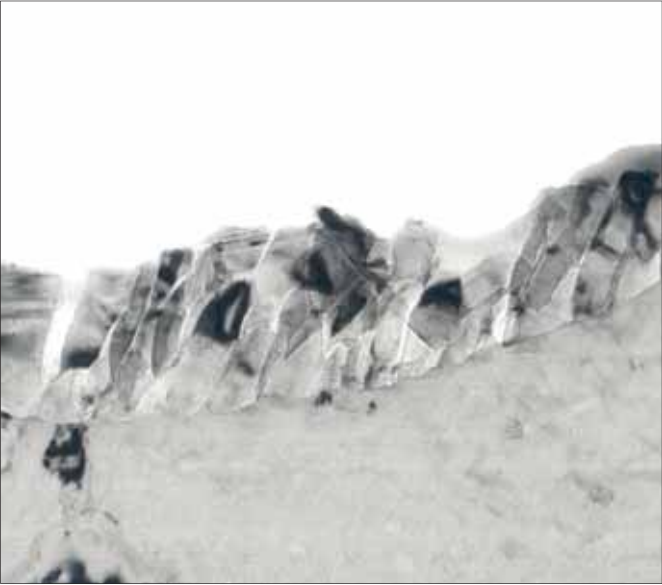
Schematic of a the ZRA configuration

Ultramicrotomy

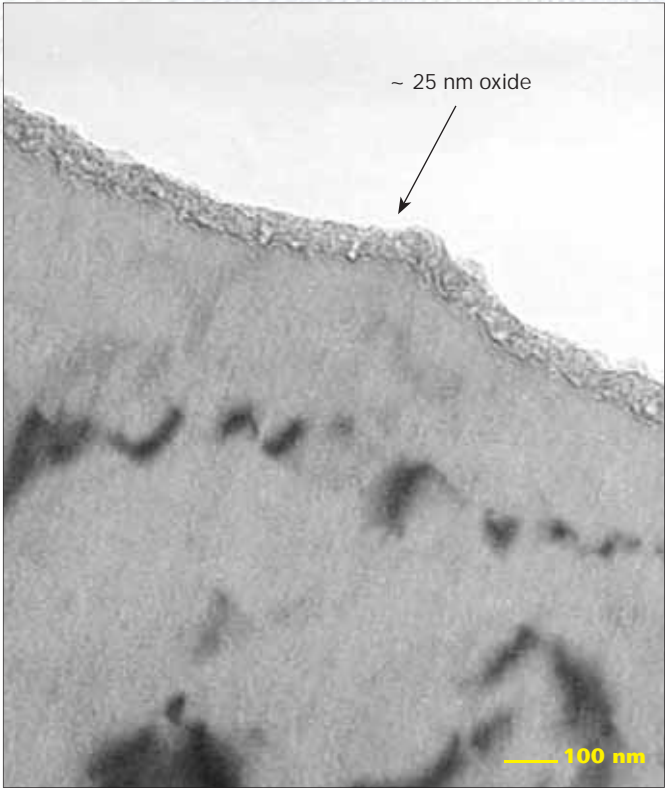
The surface chemistry of your brazing sheet is critical to your first time through rate. A thick oxide layer can adversely affect brazeability irrespective of the process being used eg. CAB or VB. We use microtoming and transmission electron microscopy to analyse the surface of your brazing sheet in minute detail to tell you:

- the thickness of the oxide layer
- the chemical composition of the surface layer
- the surface morphology

Furthermore, we can interpret the findings and, taking into account your process parameters, advise you on how your brazeability might be affected.



Microtomed section through residual flux layer



Microtomed cross-section through heat exchanger alloy

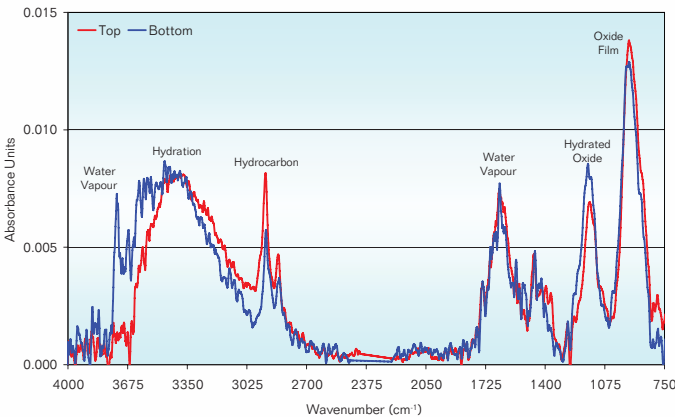
Oxide thickness measurement

The thickness of the oxide film on your brazing sheet can affect its brazeability. The oxide layer is affected by your suppliers' process routes, and consequently varies from supplier to supplier. Ideally the film thickness should be less than 75 Å, and it should be uniform across the width of the strip.

At Innoval we can measure oxide thickness by Fourier Transform Infra Red (FTIR) spectroscopy using an in-house technique accredited to ISO 17025. It is as accurate as x-ray photoelectron spectroscopy (XPS or ESCA), but is considerably faster and cheaper. Furthermore, FTIR can show the level of hydration of the oxide layer, and whether there are any residual hydrocarbons present on the surface.



Oxide thickness comparison between FTIR and XPS



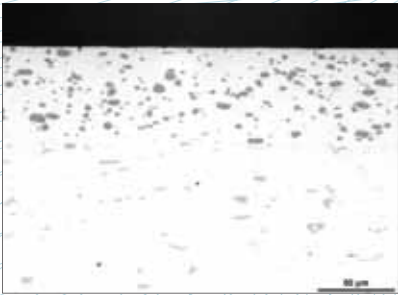
FTIR analysis of brazing sheet surfaces

Silicon particle size analysis

The shape and distribution of the silicon particles in your cladding affect its fluidity once molten.

Generally, large silicon particles and those with a plate-like morphology inhibit the movement of liquid into the joint. The silicon particles can therefore have a significant effect on brazability. There are often variations in silicon composition within the brazing sheet itself, as well as between suppliers.

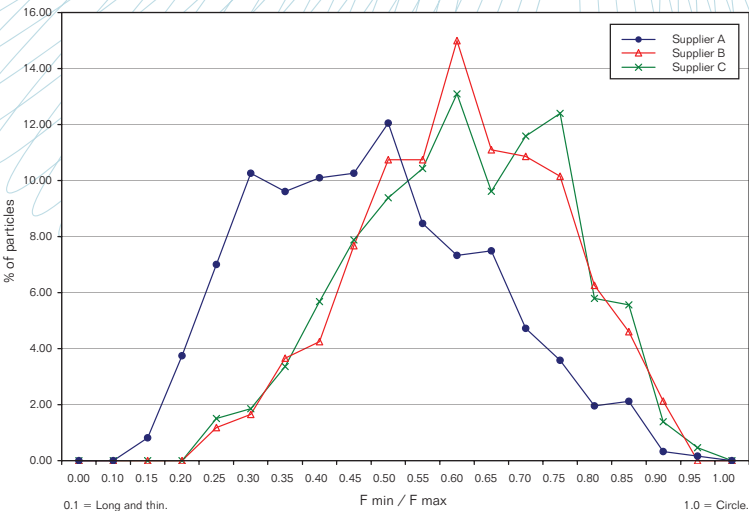
At Innoval we can analyse the silicon particles in samples from each of your suppliers so you can be confident you are selecting the best material for your products. We use optical metallography, together with image analysis, to give you critical information such as Feret ratio, size distribution and equivalent circle diameter of the silicon particles.



Good silicon particle size and distribution



Poor silicon particle size distribution



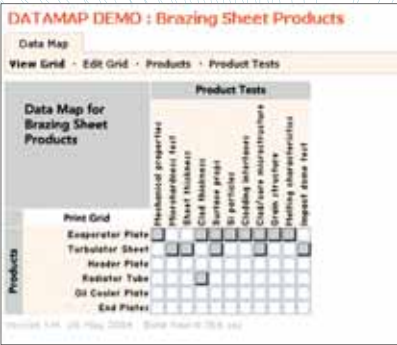
Feret ratios of Si particles (longitudinal)

The Data-Map (D-Map™) the tool for efficient data capture and dissemination

When you embark on a material characterisation programme either in-house or with Innoval Technology, a large quantity of data is generated which gives you invaluable information about your products. However, this information is almost useless unless it is accessible at all times to all parts of your business, irrespective of location. To help you manage this data, and to allow effective dissemination, we have developed the Data-Map, or 'D-Map™'.

The D-Map™ is a software tool consisting of a matrix with the axes defined as product tests vs products. Behind each intersection in the matrix there is a table of results for each test, together with any relevant charts or photographs. It is also possible to display the results graphically.

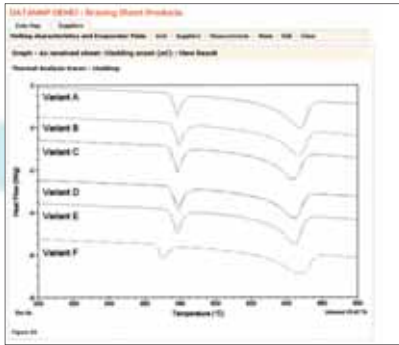
The D-Map™ is designed to be held on your intranet so the results can be viewed by anyone with appropriate access. As more characterisation programmes are completed, your D-Map™ provides a user-friendly results archive to track changes in your materials over time. Furthermore, it is very easy to add new products or new tests to the D-Map™ as your product portfolio increases.



Level 1 map



Level 2 results table



Level 3 result chart

Capabilities

- Metallographic laboratory, sample preparation etching and anodising techniques
- Digital image capture for microstructure and grain structure characterisation
- Micro-hardness measurement
- SEM/EDX - imaging, analysis and element mapping
- Microprobe – imaging, analysis and element mapping
- Transmission electron microscope (external)
- Microtome – sample preparation (TEM)
- FTIR (ATR, FT80, drifts, microscope and transmission modes)
- Surface properties – microbalance and goniometer
- Thermal analysis (TMA/DSC)
- Heat treatment furnaces (up to 1000°C)
- Gas chromatography
- Paint and lacquer testing – adhesion, hardness and degree of cure, etc.
- Electrochemical and salt spray corrosion testing
- Mechanical testing – static and fatigue

Who are Innoval?

Innoval Technology is an *independent* materials technology provider specialising in aluminium and other light metals. We provide technical expertise, contract research, analytical and testing services.

The Innoval team has extensive industry experience. We are equipped with the multi-disciplinary skills, knowledge and latest technology to solve your materials problems and process development needs.

Innoval's range of services

- Materials science
- Process Development
- Simulation & Software Development
- Knowledge Management
- Materials Characterisation & Analysis
- Training

A recent selection of our papers

- The Development of Corrosion Resistant Extrusion Alloys for Heat Exchanger Applications
AFC Holcroft 9th Brazing Seminar – October 2004
- Magnesium Diffusion and Flux Interactions During Controlled Atmosphere Brazing (with Solvay Fluor)
AFC Holcroft 9th Brazing Seminar – October 2004
- Low Temperature Brazing for Aluminium Heat Exchangers - Fact or Fiction?
AFC Holcroft 10th Brazing Seminar – October 2005
- The Growth of Aluminium in Automotive Heat Exchangers
Aluminium, vol. 81, March 2005
- The influence of silicon particle morphology on the melting mechanism of aluminium brazing sheet (with Dana, Oakville)
VTMS 7, May 2005, Toronto

For more information contact:

Innoval Technology
Beaumont Close
Banbury
Oxon
UK OX 16 1TQ

Tel: + 44 (0) 1295 702800
Fax: + 44 (0) 1295 702898/9
Email: enquiries@innovaltec.com
<http://www.innovaltec.com>

