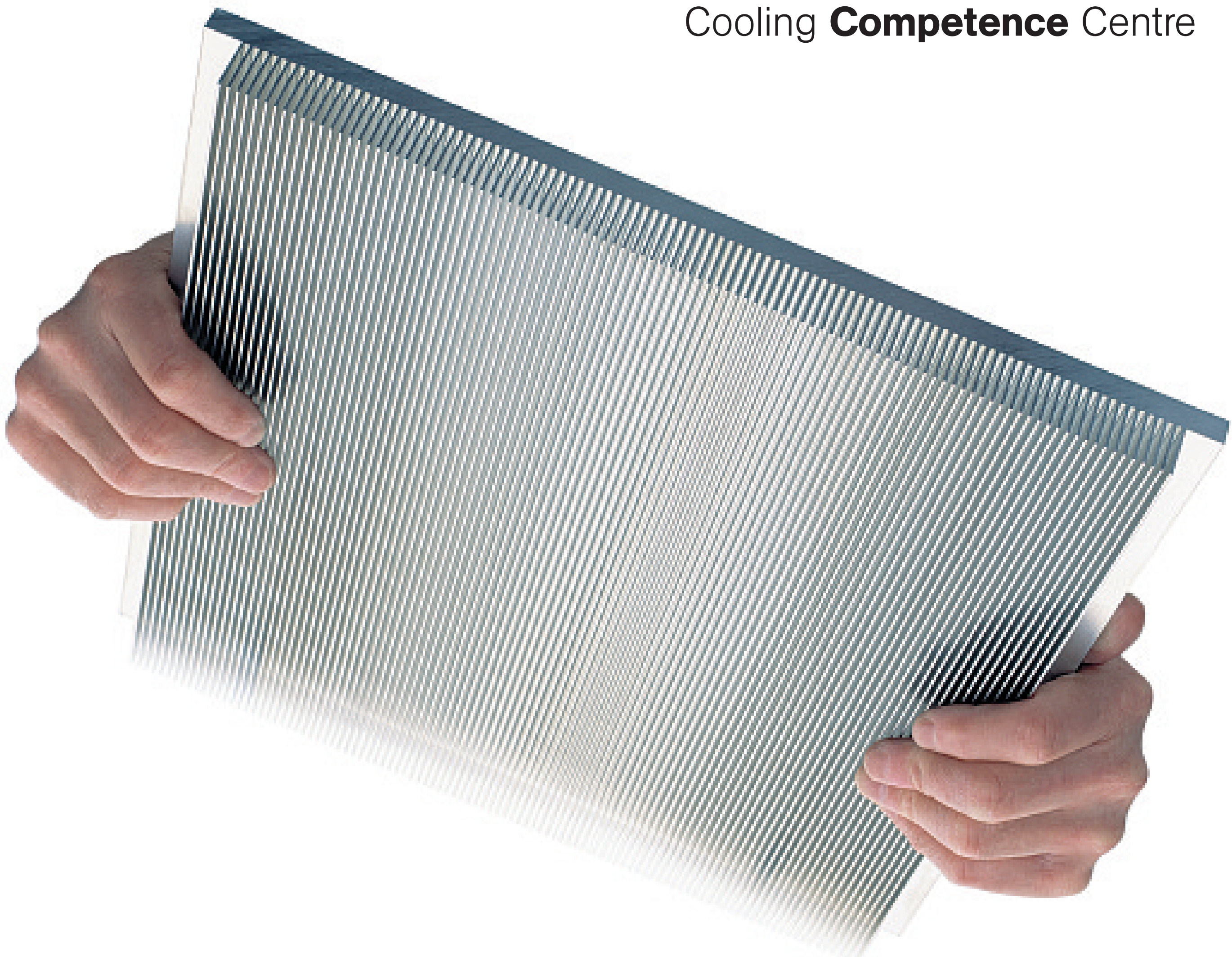
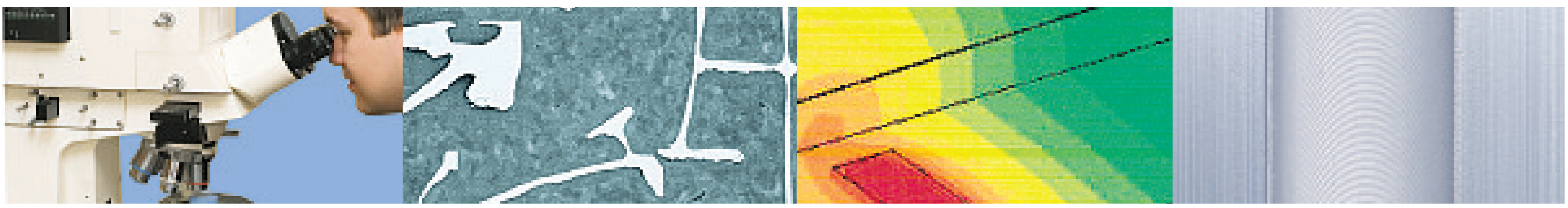
Faster **product development** at lower cost: Cooling **Competence** Centre



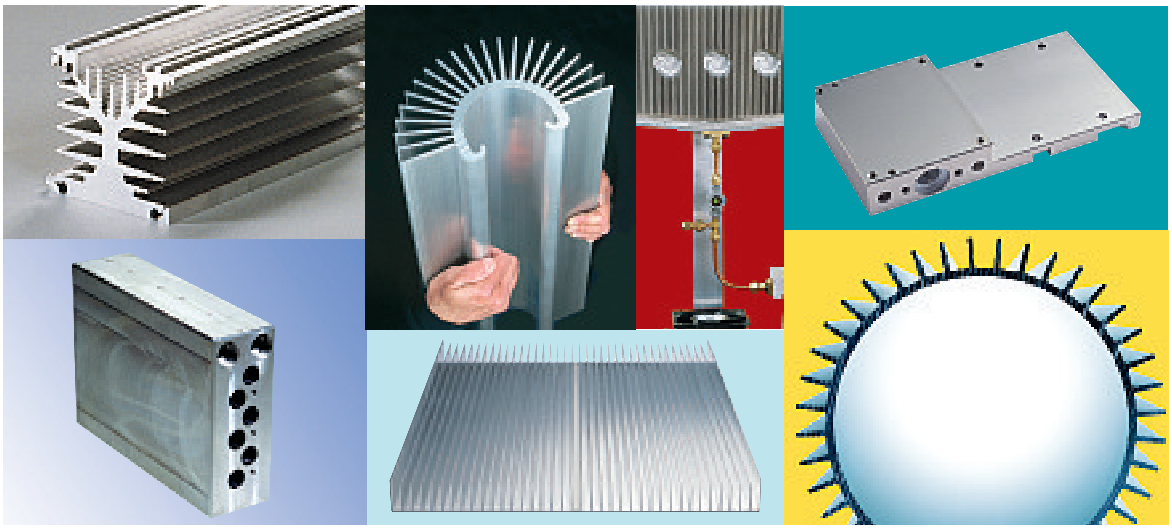


The Cooling Competence Centre is a joint venture between Sapa Profiler and Sapa Technology, Sapa's research and development centre.

We have specialists with in-depth knowledge of manufacturing and using aluminium. This covers everything from controlling the alloy content to adapting manufacturing processes to meet the customer's wishes – including choice of materials, design solutions, strength, joining method, surface finish, recycling, etc., etc.

What does the Cooling Competence Centre **want**?

“Our aim is simply to optimise cooling characteristics, create cost-effective solutions, simplify production for the customer and improve the end product.”



Look on the Cooling Competence Centre as a source of knowledge and experience in a very specific area: cooling solutions based on aluminium profiles.

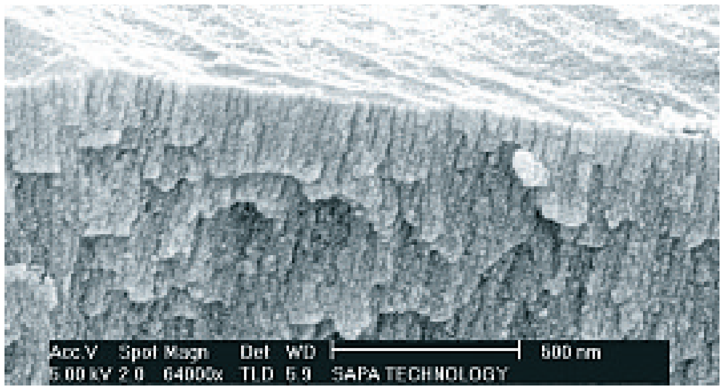
We can offer:

- advanced equipment for simulation, measurement and materials technology investigations.
- metallurgists, chemists, metallographers, physicists, designers, mechanical engineers and workshop technicians, all specialists in aluminium.
- contacts with universities, colleges and research institutes around the world.

Quite simply, we have a combination of experience, expertise and ambition that you can draw benefit from when you want to improve your company’s competitiveness.

What can the Cooling Competence Centre **do**?

Alloy development: Understanding the properties of a material and how they are affected by composition and production processes requires a knowledge of the building blocks that make up the material. It calls for knowledge from the atomic level upwards. The structure of the material determines its properties. This is the area where Sapa focuses its main research, on properties such as strength, ductility, corrosion resistance and, not least, thermal conductivity. Among other things, we have developed a variant of a standard alloy that conducts heat so well that we can guarantee a thermal conductivity of 210 W/mK at room temperature.

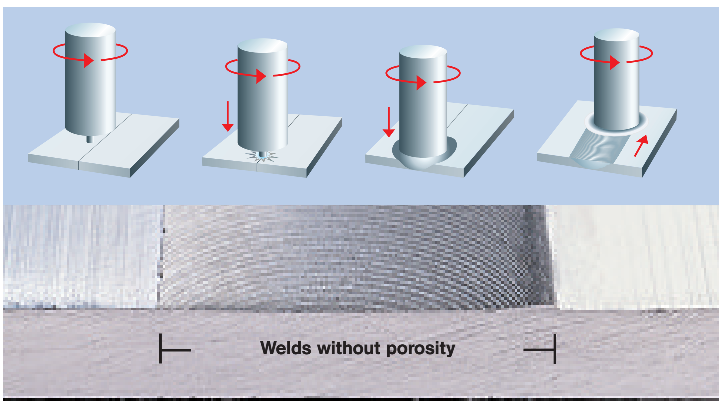


The Scanning Electron Microscope (SEM) allows us to magnify up to 100,000 times and at the same time get large depth of field. Energy Dispersive X-ray Spectroscopy (EDS) lets us determine the composition of the metal in very small areas – around 1µm (0.001 mm) across. The photo shows a cross-section through a fractured anode layer. Magnification: 64,000x

Friction Stir Welding: Sapa has played an active role in the process of transferring theory and laboratory trials into full-scale production.

We began serial production back in 1996 and to the present day we have produced more than 1000 kilometres of friction stir welds, considerably more than anyone else. This gives us a unique level of experience.

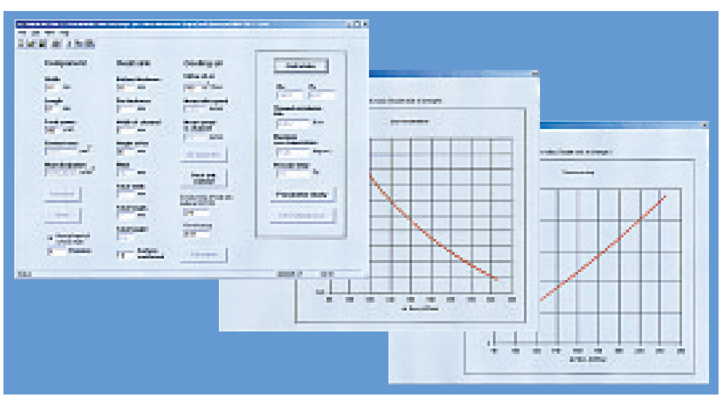
The method is based on subjecting the metal to extreme plastic deformation. As the rotating tool is pressed into the metal (see illustration) it generates heat through friction. The high pressure exerted by the tool results in extensive mechanical deformation, forcing the clean joint surfaces together and creating a homogenous structure.



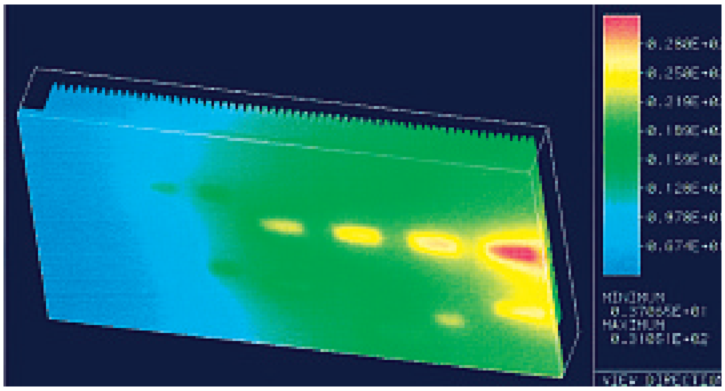
Compared with fusion welding, the benefits of Friction Stir Welding include higher strength and fewer leaks. The joints are completely free from pores and leaks, and are stronger than fusion-welded joints. This method is particularly suitable for liquid cooling devices (see also Case 1 on next spread).

RapidCool: In the course of developing coolers for, and in collaboration with, our customers, we realised there was a need for a quick and easy method for simulating the performance of a cooling device. The programme we developed, RapidCool, begins with the warmest point on a cooling device and designs the rest of the component on the basis of that point. This means that the number of calculations required is much smaller than with Computational Fluid Dynamics (CFD) and Finite Element Methods (FEM). The programme is also used to get an idea of the performance of existing cooling devices.

RapidCool has been shown to produce very good results in verification tests in our wind tunnel, for example.



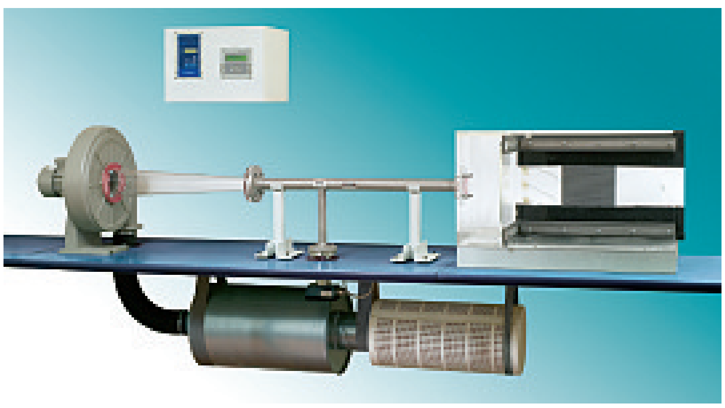
The advantage of RapidCool is apparent from its name. A simulation, including data entry, does not even have to take an hour. The programme is easy to use and the information it provides is easy to interpret.



The image shows the results of a CFD analysis. It is relatively easy to see where the problem lies. The redder the area, the hotter it is. Displaying sophisticated calculations visually makes it easier to interpret results and find a solution. Sapa has several licenses for a variety of software for carrying out thermal calculations.

CFD/FEM: We have long experience of using computer simulation to understand and optimise manufacturing processes such as extrusion, rolling, bending and hydroforming. The same tools are particularly effective for carrying out detailed studies of new products at an early stage of the design process, such as simulating the flow of air, liquids and heat around cooling devices.

CFD/FEM simulations demand extensive resources but generally give very reliable results. This makes it possible to reduce both the development time and costs.

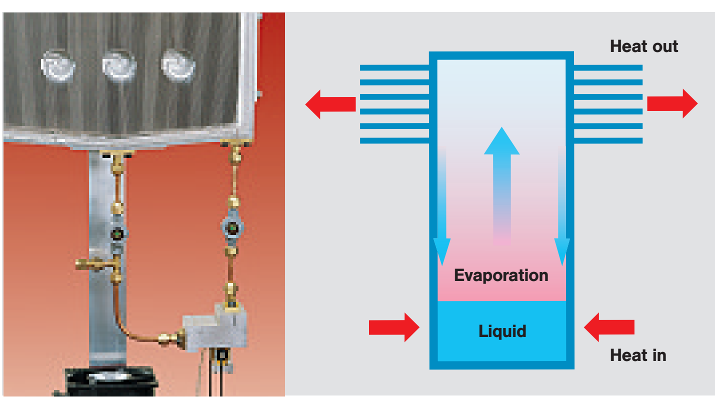


The wind tunnel makes it possible to verify calculations carried out using RapidCool and/or CFD analysis, and hence check the actual performance of the cooling device.

Our technical equipment is often highly specialised, and in some cases unique. It includes instruments for analysis, microstructural investigations and mechanical testing, as well as specially built furnaces for developing new materials and methods for brazing.

Our **wind tunnel** is another example. This is where we verify the simulations obtained from RapidCool and from CFD/FEM calculations.

The tunnel can accommodate cooling devices measuring up to 500 x 500 mm.



The thermosiphon. On the left: part of a prototype for a long-term study. On the right: the principle. Sapa has started manufacturing working prototypes in order to test the cooling concept of the future. When Sapa combines the benefits of aluminium extrusions with those of the thermosiphon we get a solution with enormous potential.

Sapa takes an active part in the development of technology and production methods – all the way from the research laboratory, through innovative high-tech solutions to mass production. When the market is ready for the next development we are already there.

Take **heat pipes** and **thermosiphons**, for example: we have now taken the step from small production runs for exclusive products to cost-effective solutions and efficient production.

Sapa's thermosiphon solution (patent pending) has potential as a solution that can be extended to high-volume products.

What can the Cooling Competence Centre **show**?

Case 1
– liquid cooling device

The liquid cooling device (top photo) was previously manufactured using a conventional welding method (Metal Inert Gas – MIG) in automated robot cells. But because fusion welding is a complicated process the results often vary. In this case fusion welding led to too many leaks, which resulted in a large number of rejected cooling devices.

During fusion welding a filler metal is added. This gives a weld with a different grain structure to the rest of the material. There is also the risk of inclusions and porosity in the weld.

Sapa and the customer began a development programme that included a trial of the FSW method.

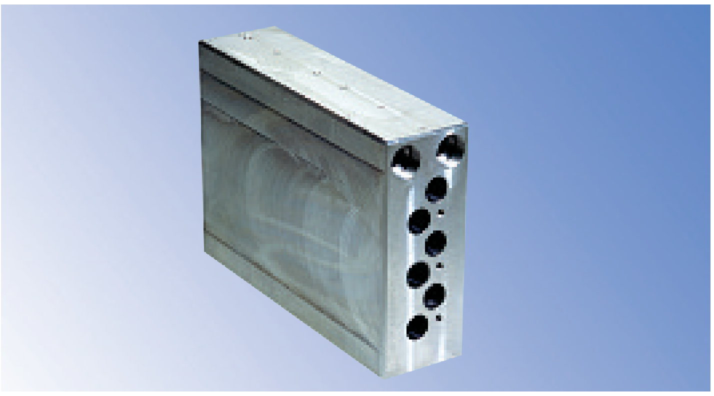
Evaluation of the welds included leak testing with helium, which showed no leaks due to welding defects. The FSW joints were also pressure-tested with water. The results were clear-cut: the FSW process ensures a joint that can be used in components that require maximum freedom from leaks.

The robot welding process was replaced by FSW. This led to higher product quality and reduced overall costs.

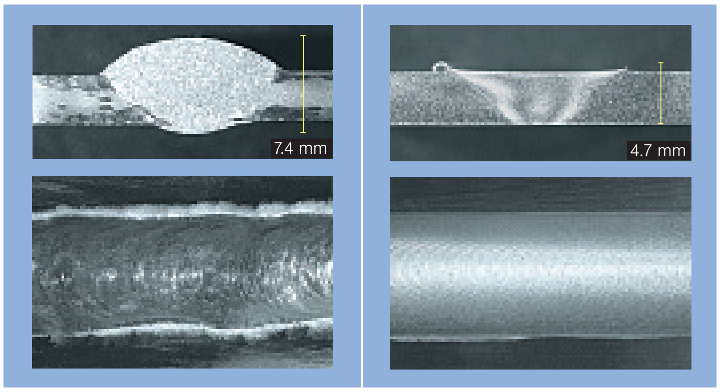
The FSW weld is formed without filler metal. Joining takes place as a result of friction heating and extreme plastic deformation. The result is a homogenous weld that is free from porosity or inclusions.

Development of smaller liquid cooling devices
The thermal deformation that occurs during fusion welding can be a big problem. Because the FSW process takes place at a temperature that is lower than the melting point of the metal it results in very small changes in shape. This has made it possible for customers to manufacture considerably smaller cooling devices (bottom photo).

Ongoing product development
Sapa's development work is now focused mainly on the design of cooling channels and other factors that will further improve the capacity of cooling devices and reduce their manufacturing cost.

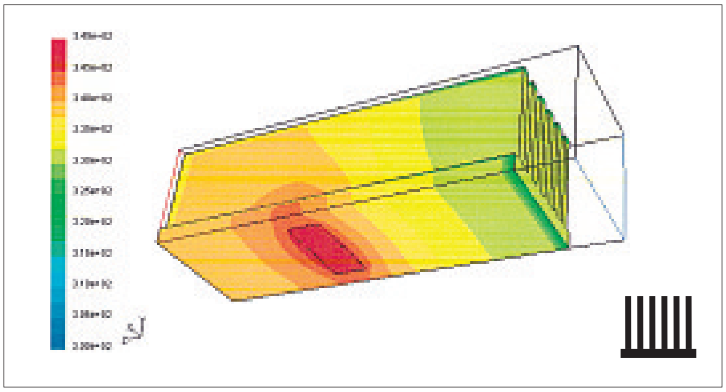


A liquid cooling device that is now welded using the FSW method. This process has just a few variables that are easy to control. It gives the same results weld after weld. Fusion welding is a more complicated process, which means that results often vary.

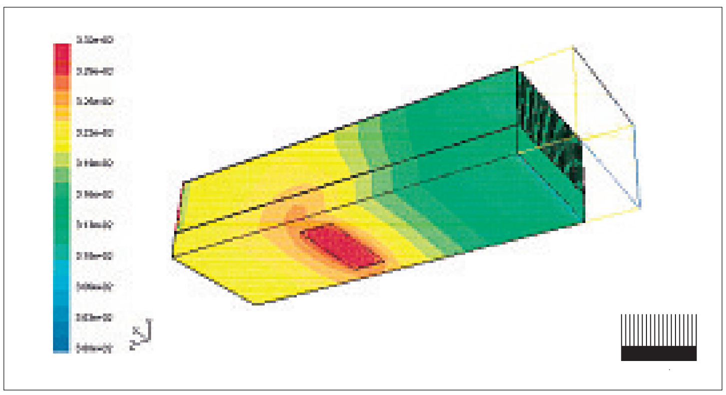


Welds viewed from the side and from above. **MIG** (on the left): the weld has a different grain structure from the rest of the material. There is also a risk of inclusions and porosity. **FSW** (on the right): a homogenous, pore-free weld without inclusions. The appearance of the metal in and around the weld has also changed as a result of deformation and the influence of heat. However, the composition of the metal has not changed.

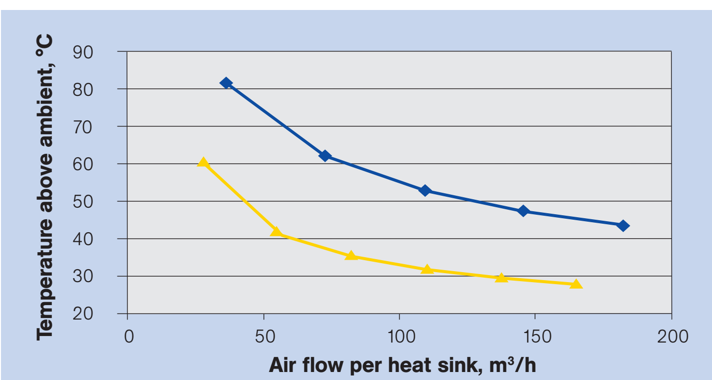
Dimensions of cooling device: 180 mm long, 95 mm wide and 30 mm high. The starting material is a solid section that has been CNC machined. The machined area is concealed with a cover.



Customer's existing profile: the CFD analysis clearly shows that the profile's cooling capacity is unacceptable. The problem that faced Sapa's engineers: is it possible to improve the cooling capacity and at the same time reduce the weight of the heat sink?



Sapa's recommendation: a profile with considerably thinner fins (see cross-section) than the profile above. We have the technology to extrude even thin fins such as these cost-effectively and to close tolerances. The result: around 40% better cooling performance and around 30% reduction in weight. On the way to production the profile can be further refined by producing a prototype. This can be done quickly and at low cost.



The graph shows the maximum temperature above ambient. The customer's profile (blue curve): fins 4 x 35 mm, pitch 8 mm. Sapa's solution (yellow curve): fins 0.7 x 21 mm, pitch 2.72 mm.

Case 2
– heat sink

Sapa has worked closely with a large number of customers to optimise their heat sinks. The heat sink in question sits inside an electronics housing in which space is limited. It also has to be light in weight.

The customer's heat sink, a simple, extruded solution (illustration 1), was too heavy and did not have sufficient cooling capacity.

The engineers considered the available space inside the product, the customer's existing fan and the desire to reduce weight. The solution: an extrusion with thinner fins (illustration 2).

The next stage in the process was a simulation of the performance of both heat sinks.

In this case a CFD analysis (FEM) was used. The analysis showed that Sapa's suggestion has around 40% better cooling effect. And this had been achieved with an extrusion that was around 30% lighter.

During product development we use a faster analysis procedure – RapidCool. This is a unique method that gives the product developer an answer the same day – a valuable tool when you want to evaluate your ideas.

Sapa's contribution to the customer's product development

The Cooling Competence Centre offers:

- Optimisation: design solutions that solve the customer's cooling problems cost-effectively.
- Effective tools for simulation.
- Fast production of prototypes at very reasonable cost.

And when production is underway

- Low tool costs.
- Short lead times.
- The ability to extrude complicated profiles to tight tolerances.
- Capacity: with around 40 presses in ten or so countries we have the capacity to handle large production series even when the pressure is on.

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Sapa is an international industrial group and one of the world's leading manufacturers of high value-added aluminium products.

With around 7,800 employees in companies throughout Europe and in the US and China, the group has a turnover of around SEK 14 billion.

The core businesses are Profiles, Building System and Heat Transfer.

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Shaping the future