Aluminium Extrusions for Automotive Applications

Background:

Engineers in the automotive industry, like engineers everywhere, have their problems. These include, demands for lower weight, choosing the right materials, joining the materials together, manufacturing components in large quantities and to high quality... and the list goes on. Among those coming to the engineers' aid are aluminium extrusion manufacturers, who are continually improving their processes and products to offer effective automotive engineering solutions. Recent specific successes include the Audi A8 spaceframe and the Lotus Elise chassis structure, and in general the use of aluminium extrusions is important in the drive for lean weight vehicles. Manufacturers are using extruded aluminium sections in increasingly demanding structural applications, which means that novel design solutions are needed to give components the desired structural functionality, and also that alloy microstructures must be carefully designed and controlled.

The Challenge for Extrusion Manufacturers:

The interaction between design and microstructural control is critical in optimising the manufacturing process by which a component is made. Extrusion makers must produce repeatably high quality products through the development of improved fabrication and assembly techniques. For example, as part of the SALVO programme for developing the next generation of passenger vehicles, British Aluminium Extrusions are contributing to research aimed at optimising methods of attaching lightweight polymer and composite components to extruded aluminium structures. Such research and development of extrusion and fabrication techniques supports the needs of a range of automotive markets. The work fits into four key areas:

- developing alloys and their microstructures to allow the production of materials with accurate and repeatable physical and mechanical properties. These alloys are mainly based on 1xxx, 6xxx and 7xxx materials.
- developing near net shape extrusion and final shape fabrication and assembly techniques.
- developing design and manufacturing systems, along with implementing quality systems such as QS9000.
- developing engineering solutions for component parts and structural assemblies, including joining and assembly techniques.

There are many examples that demonstrate how aluminium extrusion manufacturers are meeting the demands of automotive manufacturers. Some of these are highlighted below.

Applications:

Sunroof Channels:

Aluminium extrusions, are excellent for producing sunroof channels, figure 1. The material is particularly good for manufacturing complex parts with multiple features, which can help reduce costs through easier assembly and a lower number of parts. Sunroof channels form part of a sliding system and so require a smooth, low friction, hard wearing surface. Manufacturers achieve this by making mill-product extrusions with a high quality surface finish, obtained through close process and tooling control. The extrusions are then anodised to give a layer of aluminium oxide on the surface, which is harder than the metal alloy.

In order for the sunroof channels to fit with the rest of the assembly they must meet tighter tolerances than normal for extruded products. Extrusion makers closely control the properties of the materials through alloy design, optimising strength and formability. Using such tailored materials contributes to good product performance throughout subsequent fabrication. Section shape is also tightly controlled, through die management, to give a consistent product shape. With quality materials, section dimensions and fabrication, there is very low variability in the components entering the assembly line.

Figure 1. An extruded aluminium sunroof channel.
Roof Rails:

Other components such as roof rails, figure 2, prove how aluminium extrusions can be used to produce aesthetically pleasing and functional parts for vehicles that add very little to the total weight. These parts, like most automotive components, must be of repeatable quality and supplied in large numbers. Extrusions makers achieve this through optimising alloy composition, accurate process control and suitable heat treatment, the product then has the structural capability required while at the same time lending itself to being formed consistently into a 'sweep' bend.

As with sunroof channels, variations cannot be tolerated as the roof rail forms part of a multipart assembly. Consistency is vital, as the large 'sweep' bends through which the extrusion is manipulated can be influenced by relatively minor material property variations. In the bending of roof rails, a yield stress variation of ±5MN/m² results in a positional variation of ±0.75mm in the final bent section. Tight control of extrusion die manufacture and the extrusion process itself are therefore essential. These enable material property and tolerance controls to considerably higher levels than normal.

Side Intrusion Beams:

Customers now expect safety features, such as side intrusion beams, to be supplied as standard. However, increasing the number of safety features increases the mass of a vehicle. Aluminium side intrusion beams, figure 3, minimise this weight gain but still enable safety performance requirements to be met. OEMs increasingly expect to buy sub-assemblies, rather than individual parts or materials, and so the side intrusion beams are manufactured as fully fabricated assemblies ready to fit straight into the vehicle door.

By combining optimised extrusion design with tailored alloy design, heat treatment and controlled extrusion conditions manufacturers can achieve single stage manufacture of these side intrusion beams, which have enhanced strength and ductility. All parts closely match the specified design, which achieves stable arc deformation during impact, maximising energy absorption and safety of the vehicle occupants.

Heat Exchangers:

Efficient, low weight heat transfer appliances, such as radiators and air conditioning systems, can be made using micropore aluminium tubing. As well as being a low density material, aluminium has high ductility and high thermal conductivity, making it ideal for forming products such as condenser tubes, figure 4. The exact requirements of product integrity and formability can be tailored by the development of product specific alloy compositions.

The intricate, multi-chambered, hollow sections needed for condenser tubes can be made thanks to the development of precision die technology. The dies feature novel die insert technologies developed in partnerships between suppliers and OEMs, which have significant reduced tooling costs.

Crush Cans:

As the products described above show, aluminium extrusions offer advantages over other materials because of their relatively low density. Another property of aluminium is its ability to absorb energy, which is greater than steel. This makes it an ideal material for energy absorbing components, such as in crush cans, figure 5. Special heat treatment practices for standard alloys can be used to produce the necessary high performance tailored materials. Then, by manufacturing a simple section that has high extrusion throughputs and material recovery rates and enhancing the section with basic features, a structure can be obtained that collapses in a controlled manner. Co-ordination of the design process enables physical design and material adaptation to be combined to give a final product that has enhanced energy absorption for maximum occupant safety.
Benefits of using Aluminium Extrusions:

The aluminium extrusion process offers benefits other than weight savings. Multi-functional chassis parts can be extruded incorporating additional features such as channels to carry wiring or sections to attach to body panels. These features can even be incorporated so that they enhance the structural strength of the assembly.

The use of aluminium extrusions in combination with novel fabrication techniques can be a low-cost tooling solution. British Aluminium Extrusions' development of novel laser cutting and welding technology, in conjunction with Coventry University's Centre for Advanced Joining, will prove an important part of a versatile and low cost manufacturing route. In terms of capital costs, a typical extrusion die costs less than US$1500. Prototype costs can also be significantly reduced during design, and the manufacturing technology is easily transferred into full production. Design optimization through incremental manufacturing improvements can ultimately provide the best solution for a particular application. This design and manufacturing methodology was used in the Jaguar XJ220 demonstrator and similar, patented technology that has been developed in conjunction with British Aluminium.

Summary:

Clearly, aluminium extrusions can play key roles in integrated engineering solutions for automotive structures and component parts. To get the most out of the materials, the versatility of aluminium extrusions has to be taken into account at all stages of the process, from design through to production and assembly. The extrusion industry is working with automotive customers and their designers and manufacturers to ensure that this happens and that the full potential is realised.

Generally, the extrusion industry is changing from a bulk oriented industry into applications oriented suppliers, supporting and anticipating customer needs. The examples highlighted here give an indication of the range of products that can be made using extrusions, from structural assemblies to trim finished components, from simple shapes to highly complex intricate sections. All of these can either be manufactured directly to customer specifications or developed through working with the customer a full 'design and make' service. In other words, extrusions manufacturers are responding to the problems of automotive engineers, and by doing so are making aluminium extrusions an exciting alternative to traditional technologies in providing effective vehicle engineering solutions.