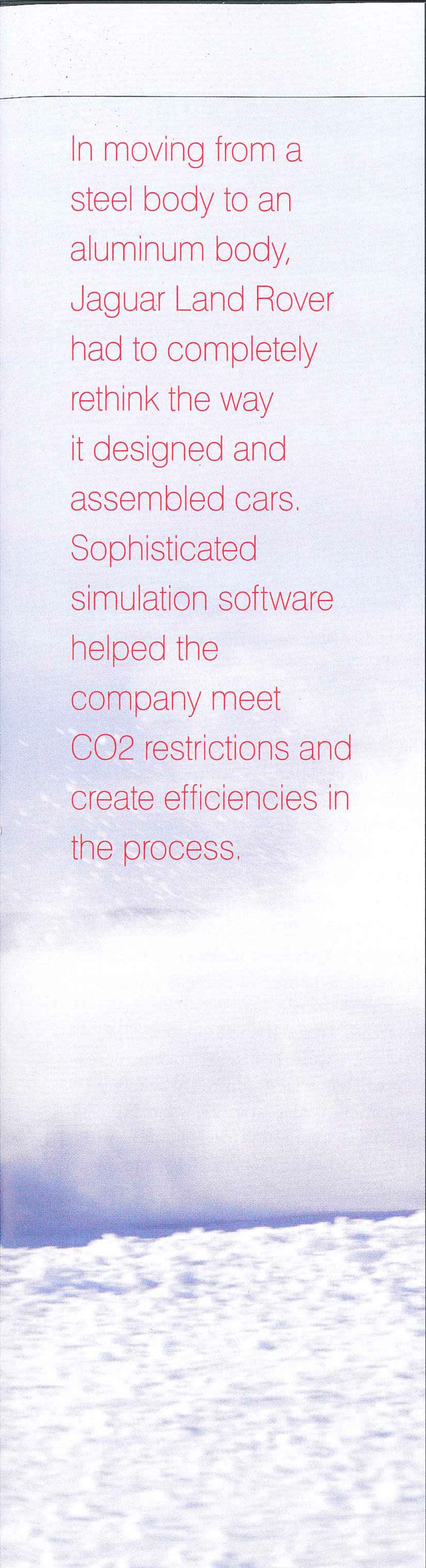
Jaguar Land Rover Switches to Aluminum Bodies and Saves Some Green

By Victoria Burt



In moving from a steel body to an aluminum body, Jaguar Land Rover had to completely rethink the way it designed and assembled cars. Sophisticated simulation software helped the company meet CO2 restrictions and create efficiencies in the process.

Jaguar Land Rover (JLR) has a long tradition as a manufacturer of premium passenger vehicles with internationally recognized brands, an exclusive product portfolio of award-winning vehicles, a global distribution network and strong research and development (R&D) capabilities. The company's strategy is founded upon three pillars: Customer First, Great Products and Environmental Innovation, supported by the development and application of advanced technologies and processes.

JLR's sophisticated customers demand the very best. That's why the company continuously assesses the quality of it vehicles and develops improvement actions to enhance its product offerings.

To ensure function and form, the company adopts an integrated approach whereby teams from design, engineering, process planning, manufacturing, supplier management and supply chain work together throughout the product creation process to deliver class-leading products. In addition, JLR is committed to minimizing its environmental impact and maximizing its wider contribution to society through a collaborative operating model focused on product innovations, resource efficiencies, closed-loop processes and community investments.

Recently, the company was recognized with an award for the development and implementation of its premium lightweight architecture design concept on the latest Range Rover vehicles. This article explores how JLR has leveraged advanced technology to deliver vehicles that meet customers' high expectations while decreasing the cars' carbon footprint.

A New Design Mindset

JLR's light weight vehicle (LWV) strategy involves moving from a steel body to an aluminum body. It includes meeting global automotive CO2 challenges while producing vehicles customers desire, including best-in-class performance for noise, vibration, harshness (NVH) targets as well as durability and safety. The result is reduced weight in the body and chassis systems as well as related secondary weight savings – in addition to maximized recycled material use and lower energy consumption during the body manufacturing stage.

While moving from a steel body to an aluminum body allows for weight savings, the complexity in producing and designing the parts increases. The holistic approach JLR took examined each design and manufacturing aspect, leveraging novel advanced simulation and manufacturing methodologies.

JLR set a goal to save at least 100 kg over an equivalent steel vehicle, and for the Range Rover SUV models, the target was 400 kg. "To do lightweighting, we want to make sure it's a significant savings so the customer can really feel the benefit," says Mark White, chief engineer, Advanced Body, Jaguar Land Rover Product Development.

Aluminum costs more than steel per pound, but using less and being able to recycle the unused metal offers significant savings and a new way of thinking about the manufacturing process. "We realized from early on, if you can recycle any in-process unused metal and get the maximum value back for that by segregating it into the alloy grades, then it can be turned back into good material fairly quickly at fairly low cost and fairly low energy," says White. "We've been working hard, first of all, solving the technical issues with going from steel to aluminum, but also trying to narrow the cost gap between steel and aluminum to make it more affordable for widespread applications."

Design Restrictions Lead to Design Bonuses

Replacing the steel body with aluminum required JLR to look at the entire design process. "If we duplicated the steel body in aluminum, we wouldn't have ended up with an optimum design. Instead we looked at what works well in aluminum, and what doesn't work so well," White says.

For starters, spot welding aluminum parts is challenging, so JLR instead looked at riveting. The riveting technique, combined with adhesive bonding, creates a joint that is actually stronger than a steel spot-welded joint. At the same time, the bonding substantially improves the long-term durability performance of the joints.

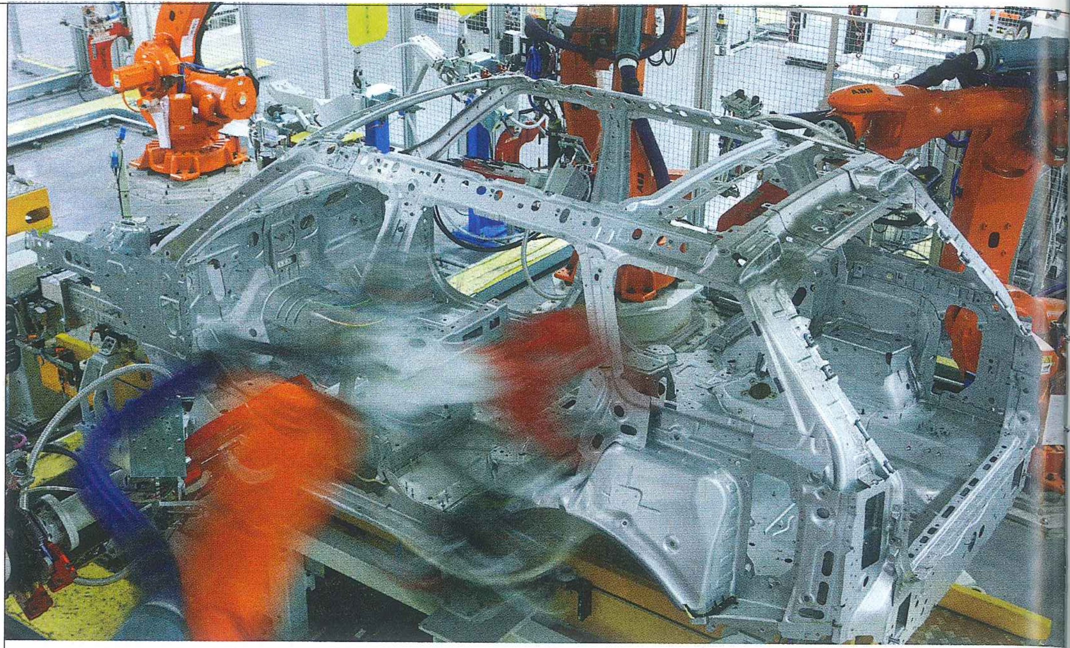
JLR used computer-aided engineering (CAE) tools, including a unique joining solution, to determine the best place to put both adhesive and rivets and how many to use. The rivets and the adhesives perform two different functions. The rivets are there for high strength, and the adhesive is there for stiffness, NVH and durability. "It helps in a crash, there's no doubt about it," says White. "It enhances the crash performance because having a continuous joint is always better than having a single-point joint."

By using riveting and bonding, JLR reduced the number of joints required in the manufacturing process. "For example, an average steel sedan will have between 5,000-6,000 spot welds. Combined with bonding, we only need about 3,500 rivets on the Jaguar XJ model," White explains. Although it takes slightly longer to rivet than to spot weld on a per-joint basis, because there are fewer rivet joints, the average time to complete the body-in-white for an aluminum car is less than for an equivalent steel car.

Another way JLR benefitted from rethinking the design was in reduced part count. Simply changing the material from steel to aluminum resulted in a design that potentially had more stamped aluminum parts than stamped steel parts. More parts translate into higher costs. "We said, if aluminum requires more stamped parts, is there another manufacturing technology out there we should explore to produce aluminum components that we can't produce in steel," White asked. "That's where we started to develop what we call thin-wall high-pressure die castings."

The team found it could integrate many parts into a single die casting and still join it to the rest of the structure using its riveting and bonding process. "With the front shock absorber, for instance, we were able to replace seven steel parts with just one aluminum part," says White. "When applied to the whole vehicle, we were able to replace 30 or 40 steel parts with about 10 in aluminum." And in turn, having fewer parts meant having fewer joints, reducing the number of rivets needed, as well.

Finally, the JLR design team aggressively applied optimization technology throughout the design of the Range Rover and other LWVs. Even though aluminum is lighter than steel, efficient use of the material results in even lighter designs and saves costs. "Advanced optimization software allows us to get the geometry and gauge right while removing unnecessary material where it is not needed," White adds.



Jaguar Land Rover, winner of the 2014 Altair Enlighten Award competition for vehicle lightweighting, developed new CAE techniques to simulate crash, durability, noise, vibration and harshness in the design of its Range Rover vehicles. In parallel, it created new manufacturing simulation techniques for stamping, casting and joining the lightweight vehicle structures.

Aluminum Alloys Deliver Green Benefits

In addition to lowering weight, thereby increasing MPG, there are other major environmental benefits in moving from a steel to aluminum body. For example, the aluminum sheets used to form the body panels can be made from recycled material.

Aluminum cars have been around for the last 15 years or so – and have been in the Jaguar and Land Rover DNA from the beginning. However, many of the aluminum vehicles are lightweight sports cars, with fairly low volume. "The focus had been on low weight rather than high strength and long-term durability," says White. An off-road SUV, such as JLR's Range Rover, faces a much tougher duty cycle than, say, a high-end sports car driven a few hundred miles a year on the track.

White explains, "When we started, we really wanted to make sure we developed alloys that were fit for purpose for any vehicle we make." JLR has developed several high-strength aluminum alloys over the last 15 years, including the following:

AC300T61. This is a 6000 series alloy that is very ductile, so it absorbs energy in a controlled manner rather than any real fracture of the material. When a material fractures, it starts to lose a lot of its strength. Unless the place of fracture can be predicted, it lacks controlled energy absorption. White says, "We wanted this material to have a high level of ductility to get good, what we call 'crash/crush performance.' We developed it for the Range Rover models."

AC170. This alloy is easily formable while maintaining a good level of strength. It bake hardens in the paint shop to the equivalent strength of a steel skin panel on a steel car. It is used to make fenders, door skins, body sides and other complex exterior skin panels.

RC5754. AA5754 is an industry-standard alloy. RC5754 has the same properties but is made from a high recycled content. "We spent about three or four years with one of our aluminum suppliers developing this new, what I would call, high recycle-content alloy," says White. "It acts just like a normal primary 5754 that you could buy from any aluminum supplier, but it consistently has large amounts of recycled metal in it. Our goal is to get to over 75% recycled alloy in RC5754."

JLR is looking at other alloys to add the recycled content prefix to, as well. "We're starting with this one because it's a fairly popular alloy. We know we can get segregated 5754 scrap supplies from the industry as a whole. It's a good place to start in terms of our recycling strategy," says White.

5754 is an industry-standard alloy with well-understood mechanical properties in terms of elongation and ultimate tensile strength. "We want to match all of those performance criteria, but what we've done is allowed for impurities in the alloy so we can tolerate a higher silicon level, a higher iron level in the alloy, etc." says White. "The customer will not notice the difference, but to us and the environment, it's a clear winner", he adds.

White says the carbon footprint of using a recycled aluminum alloy is also less detrimental on the environment. Depending on the process and how much recycled content is used, to make recycled alloys takes between 10%-25% of the energy used to make a primary alloy – up to 90% energy savings and subsequently 90% carbon savings from the primary alloys. "And, as we increase the amount of recycled content," says White, "in the long term we'll see a reduction in the cost of the metal, as well."

CAE Enables Fine-Tuning

JLR uses CAE tools for all design aspects on its aluminum lightweight SUV bodies. "Everything is done in the virtual world, and then we only perform validation tests," says White, which are still required by government legislation and consumer bodies. "We don't have to test as much as we once did. We work with them to make sure the car does everything it did on the virtual platform."

Beyond modeling the vehicles for crash results, JLR uses CAE to understand the mechanical properties of the materials used. "If we take a stamped part, for example, we will put it through the software and simulate the manufacturing process," White explains. "We'll get what we call the true gauge of the part in the model. Say we've got a panel that starts off as a flat sheet of material 1 mm thick. It may go down to as low as 0.85 mm in places where it thinned after it's been drawn. We can build that gauge model into our crash models."

That kind of detailed evaluation is repeated throughout JLR's design process. "We can record how much damage is done in the stamping process as we create the part because every time we put a sheet of metal into a press tool, not only do we thin it out, we also use some of its available energy, its inert energy, in the stamping process," White adds. "It no longer brings all of its strength into the crash because we've used some of that strength in manufacturing the part. We can also build that into the CAE model."

This type of simulation was unavailable even 10 years ago. In the past, "We'd have just taken a constant gauge and assumed that you get the maximum amount of work out of that constant gauge part. That's no longer the case," says White.

JLR is now using thermal modeling to look at the bake hardening response of the part, which will also change the mechanical properties over the life. "We can even model how much work hardening happens depending on where the part is located in the body. An outer skin panel will see the maximum amount of heat for the most amount of time while an interior reinforcement will see much less heat energy for much less time in the same paint shop oven. We are able to model that level of detail from a thermal point of view," he says.

Future Fidelity

JLR continues to build more sophistication into its models. "For every new product we design, we get a better level of fidelity, and we're able to do more in the virtual world than we were on previous models," says White. The company looks to improve techniques and partner with universities and research companies to identify areas for improvement. C2R

To view a video interview with JLR's Chief Technical Specialist and learn more about the 2016 Enlighten Award competition, visit www.c2rmagazine.com/W2016

***Victoria Burt** is a contributor to* Concept To Reality *magazine.*

Jaguar Land Rover Wins 2014 Altair Enlighten Award

The 2014 Altair Enlighten Award was given to Jaguar Land Rover for the development and implementation of its premium lightweight architecture design concept on the latest Range Rover vehicles. The award, presented in collaboration with the Center for Automotive Research (CAR), is the automotive industry's first award program created specifically to acknowledge innovations in vehicle lightweighting.

As an example of the premium lightweight architecture in action, the new Range Rover body weighs only 288 kg (658 lbs) in comparison to the previous model body weight of 498 kg (1096 lbs), a reduction of over 40%. Significant savings were also achieved for the chassis (70 kg, 154 lbs) and powertrain (130 kg, 287 lbs depending on engine derivatives).

"We would like to congratulate Jaguar Land Rover for winning the 2014 Altair Enlighten Award," says David Mason, vice president, Altair Global Automotive. "Their holistic approach to vehicle lightweighting and CO2 reduction has yielded an aggressive and highly impressive methodology that is enabling the creation of new and exciting vehicle architectures."

The Altair Enlighten Award is intended to honor the greatest achievements in weight savings each year; to inspire interest from industry, engineering, policymakers, educators, students and the public; to create further competition for new ideas in the industry; and to provide an incentive to share technological advances.