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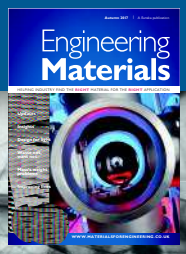

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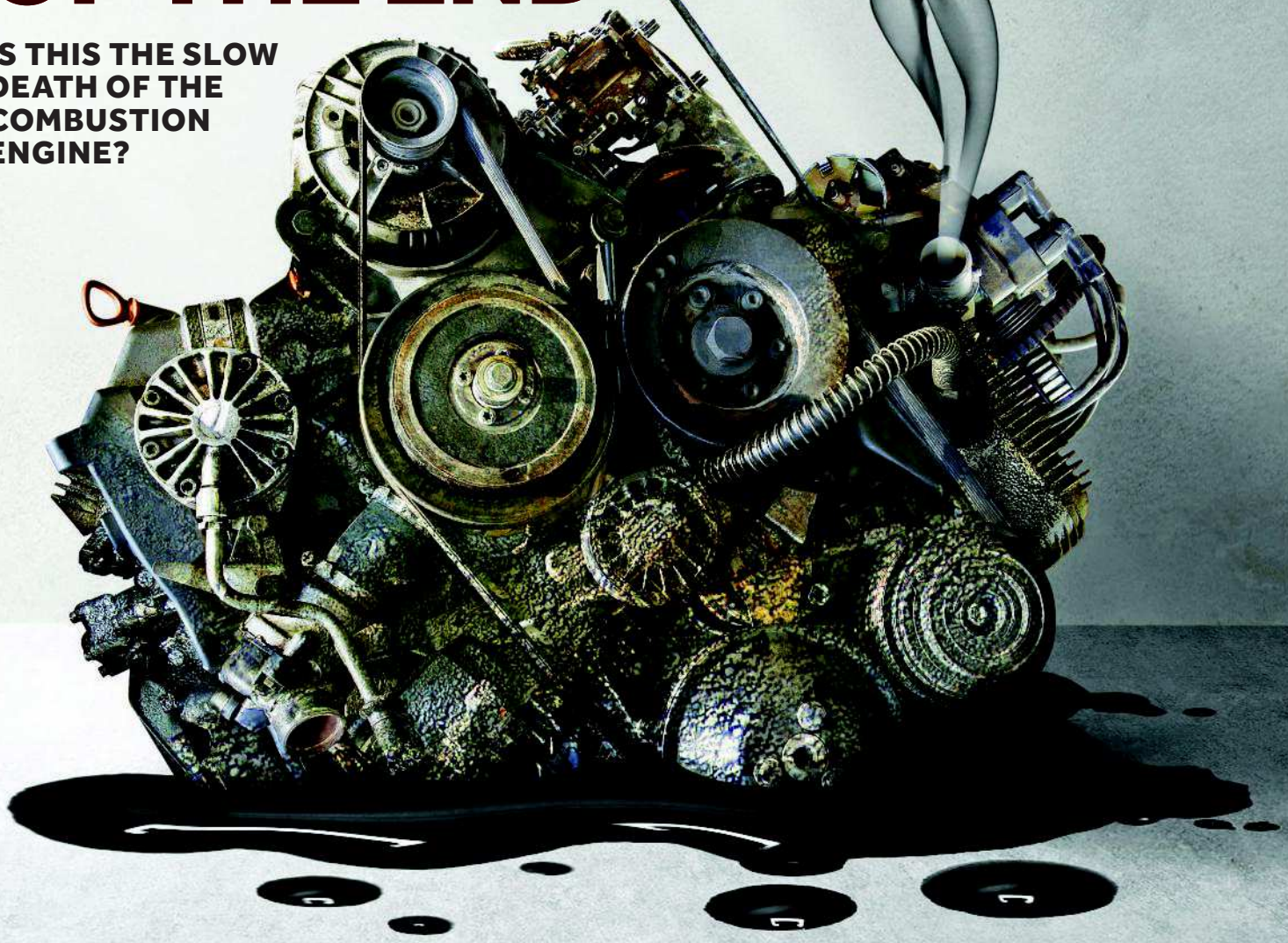
DESIGN | INNOVATE | ENGINEER

Eureka!

THE BEGINNING OF THE END

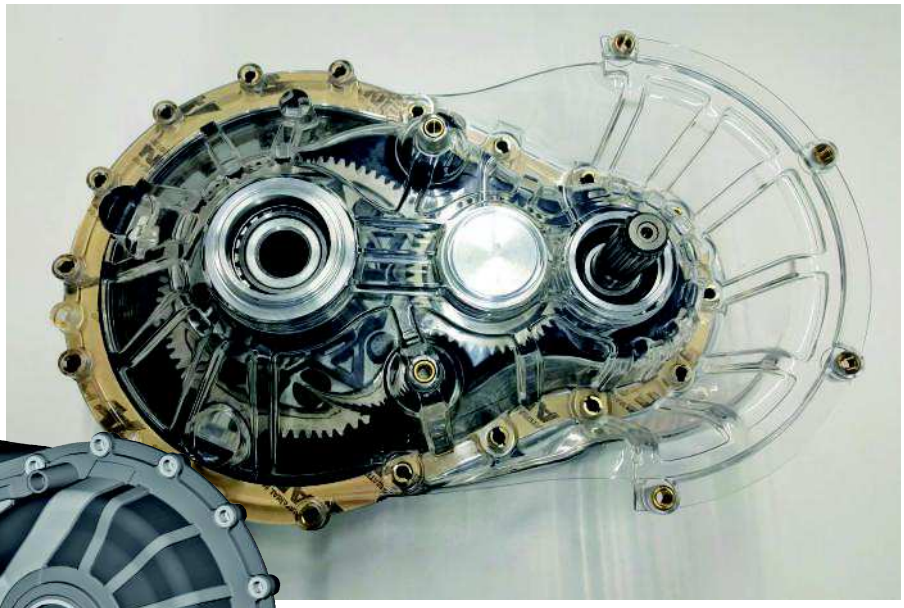
IS THIS THE SLOW DEATH OF THE COMBUSTION ENGINE?

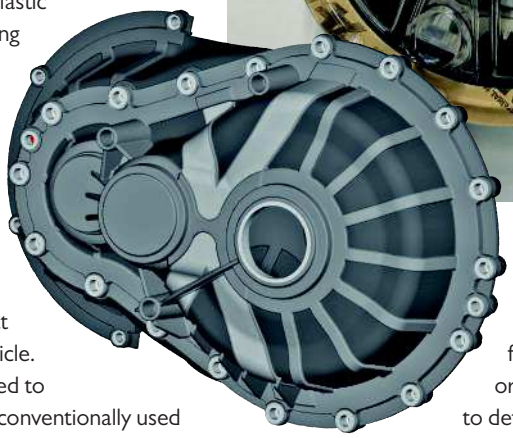


IN THIS ISSUE

Design for LIGHT

A composite gearbox housing has been made with layer-optimised organic sheeting. By optimising the design, the resulting component is set to soon replace aluminium.





When it comes to electric vehicles, keeping weight down is paramount in ensuring long range. In addition to the bodywork, drive components such as the housings, typically used in double reduction gearboxes, are of interest in terms of materials substitution and metal replacement.

The challenge, however, is maintaining the required rigidity levels at higher operating temperatures. In a recent project exploring the possibilities, ARRK Engineering produced a fully functional thermoplastic composite gearbox housing with the first half already implemented as a prototype.

The composite gearbox housing features a thermoplastic matrix and was the first component of its kind that could be installed in a vehicle. Those involved also aspired to match the profitability of conventionally used materials.

Dr Thomas Schneider, head of technology and innovation at ARRK Engineering says: "The minimal investment and the use of tried-and-tested technologies make long-fibre-reinforced components with thermoplastic matrices very interesting from a cost perspective."

Target values

The project time was divided into three phases: the rough concept was set out in the first, the second dealt with the final draft and the third phase looked at the fine details. In order to be able to determine the 'technical specifications' the target values – which was the minimum outcome to be met – were first calculated by re-engineering an existing aluminium housing.

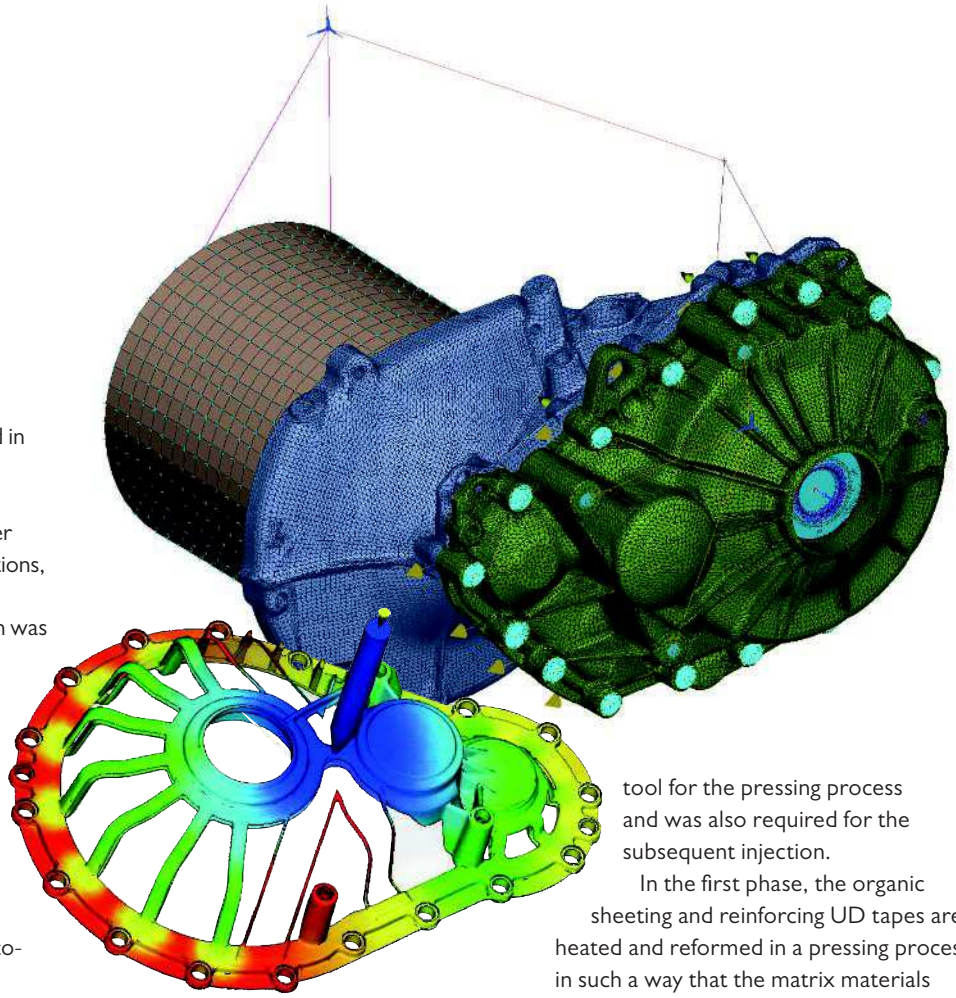
As rigidity has a significant effect on the performance of a gearbox, geometric design was given careful consideration. The development was driven forward with a reliance on simulation methods, which were used for testing all approaches and trialling solution concepts in a virtual environment.

Monika Kreutzmann, head of the center of competence for composite at ARRK Engineering, says: "Due to the short cycle times and high quantities involved, we opted for a thermoplastic material that was to be extrusion-coated using short-fibre-reinforced plastic.

"Our knowledge of the relevant failure models and our expertise in injection moulding processes also proved useful."

Recasting the organic sheeting, however, was a different matter entirely: the team possessed little prior knowledge of cycle times or temperatures.

In order to design the installation space, the force profiles in the housing first had to be determined on the back of an optimised topology – taking the traction and tension areas into account. The resulting concept served as an indicator of where the material was to be positioned and how the layers of



the organic sheeting had to be optimised in order to achieve the required rigidity.

Furthermore, the deformations that could potentially arise when placed under load were examined in extensive simulations, allowing the torsion of the housing to be derived as a dimensioned variable, which was countered with 45° layers. Additionally, it was necessary to identify localised weaknesses in order to specifically minimise them and reduce the resulting strains.

"In addition to FEM optimisation, we also manually sought out specific strengthening methods which involved as little additional weight as possible," explains Raik Rademacher, engineering co-project leader.

Crossed unidirectional (UD) tapes proved to have a particularly positive impact here: the thickness of the organic sheets was subsequently reduced from 5mm to 4mm, not only saving weight but also facilitating the sheet's remodelling process.

The draft included the use of aluminium inserts, which transmit the loads discharged into the bearing onto the organic sheeting, allowing the reduction of shaft tilt.

Rademacher adds: "As the bearing seats have to be precisely adjusted to 30µm while incurring as little reworking as possible, the corresponding process parameters and their effects on, for example, warping, were examined."

Alongside the UD tapes, injection moulding ribs on to the organic sheeting ensured rigidity targets were achieved. A positive side effect of the use of injection moulding technology is that it can be implemented on the final contour and requires no additional drilling, meaning reduced reworking.

Short glass fibre-reinforced injection also prevents contact between the carbon fibre and the metallic inserts: this galvanic isolation prevents corrosion, meaning no additional coating is required.

Production process

Manufacturability was ensured by the close involvement of 'shapers', the tool manufacturing specialists within ARRK, and through simulations of the pressing process using the software of cooperative partner ESI.

As the prototypes for the first half of the housing were created in a two-step process, the new development served as a tool for the pressing process and was also required for the subsequent injection.

In the first phase, the organic sheeting and reinforcing UD tapes are heated and reformed in a pressing process in such a way that the matrix materials are combined and the desired preform is created, which is water jet cut to size.

In the second phase, the preform is heated again and moulded with the injection moulding tool, creating the final geometry including ribs and other functional surfaces.

Kreutzmann says: "This proved to be difficult due to the high temperatures and mechanical strain before and during the pressing process for the organic sheeting."

The gearbox housing was made 30% lighter through the use of fibre-reinforced thermoplastic. The prototype is then subjected to hardware tests later this year for functional control purposes while the second half of the housing is created.

Kreutzmann concludes: "The interest from a range of different industries is a testament to the development's potential. We believe that the cost-efficiency of this process will increase as the use of its automation potential rises. If, for example, the two process steps could be combined, the production costs would sink significantly."

"Due to the short cycle times and high quantities, we opted for a thermoplastic that was extrusion-coated using short-fibre-reinforced plastic."

Monika Kreutzmann, ARRK Engineering