Ford Led Team Develops Lightweight Suspension Using VR&D Genesis

Ford Motor Company, in collaboration with WMG, University of Warwick, Gestamp and, GRM Consulting have developed a lightweight composite rear suspension knuckle for a C-segment vehicle with Innovate UK. A combination of unique carbon fibre deployment, optimisation techniques, and a bespoke manufacturing process have resulted in a potential 50 % weight reduction compared to the current fabricated steel component.

By combining advanced processing technology with GRM's simulation techniques, the team has developed a design which is the first of its kind. The design of the part is complete and manufacturing trials of the component are currently ongoing to develop the full scale mass production process.

Introduction

The global automotive industry is pushing for tighter mass targets in order to satisfy the ever increasing and stringent regulations over emissions and the customer's demand for extended ranges of electric vehicles. Ford chose to start the development cycle by picking a serial steel suspension component and reworking the design as a producible composite lightweight part. The selected component presented conflicting structural requirements with minimum and maximum stiffnesses, buckling and strength targets. The weight savings in this specific un-sprung component increases the relative effectiveness of the springs and dampers, leading to enhanced passenger comfort and driver handling. This newly developed composite part proved appropriate for a high performance C-segment vehicle. A delicate and perfect balance obtained between the material and process selection led to a total cycle time as low as 5 minutes. This short cycle time is comparable, or in most cases, outpaces the processing times of older manufacturing technologies

Collaboration is Essential

This success story is the result of a 2 year project partially funded by Innovate UK and executed by a cluster of organisations including Ford Motor Company, Gestamp, WMG, University of Warwick, and GRM Consulting. The project was titled *Composite Light weight Automobile Suspension System* (**CLASS**). The technology of composite materials has had to evolve from both academia and the aerospace industry to reach mainstream automotive engineering practices to offset weight increases inherent in electrical and autonomous vehicles. The complexity of composite material behaviour still remains a challenge to be overcome for the mainstream automotive industry as a whole. Although a vast amount of research has been dedicated to understanding composite materials in both industry and academia, the art of prediction of composite material behaviour is still in its infancy. GRM Consulting, who have decades worth of experience in developing predictive tools for carbon fibre structures in Motorsport, have made a significant contribution to the project by circumventing traditional approaches as well as reducing the amount of physical testing required. Using VR&D Genesis a FEA and design optimisation software, GRM has taken an optimisation based approach to reduce cost and engineering time without forgoing performance. This has been required to understand the failure points of mechanisms for an infinite number of

combinations of fibre orientations across strength, stiffness and buckling load-cases. WMG, University of Warwick was able to use their extensive knowledge of material behaviour and state of the art manufacturing cells to enable Gestamp, a global leader in automotive chassis manufacturing, to play a vital role in designing a component that meets the necessary functional requirements.

Design approach:

During the two year development of the project, the design of the composite part evolved from a single material part to a multi-material design, challenging the manufacturing and optimisation teams. Initial surveys based on various articles indicated that the idea of a composite light weight knuckle could be realised by a single material Sheet Moulding Compound (**SMC**). However, a long engineering timeline ultimately led the design engineering team towards a multi-material system; where layers of prepreg gave the required planar mechanical properties and over moulding of SMC allowed the complicated geometric details and out-of-plane stiffening. The approach of combining uni and bi-axial prepreg with SMC suggested that the composite component could achieve the mechanical strength, stiffness and buckling targets. Other design challenges have meant that further innovations have had to be introduced whilst staying within the design brief without affecting the manufacturing. The design was finalised only after the completion of extensive simulation and experimental work. This has optimised and refined the design to meet OEM durability and NVH targets.

The final weight saving achieved by the project is a minimum of 30% with potentially an outstanding 50%, with equal functionality.

Figure 1: Steel Knuckle-Tie Blade

Figure 2: Prototype Composite Knuckle-Tie Blade

Innovative manufacturing technology:

A compression moulding manufacturing process has been developed capable of mass manufacturing this high strength and complex shaped suspension knuckle. A demonstration part is due for manufacturing and physical testing in the second quarter of 2017.

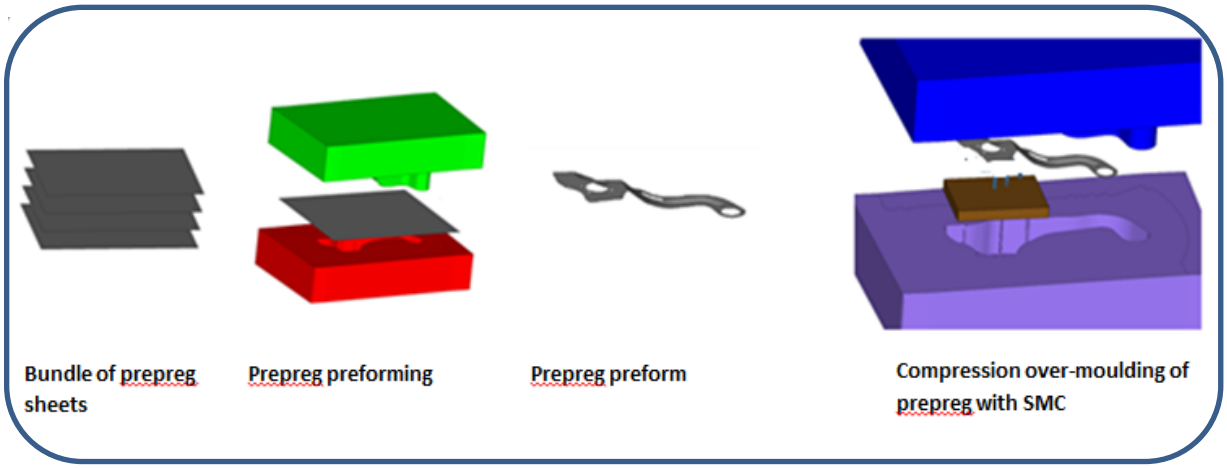

Figure 3: Steps in the manufacture of composite part

With material supplied by the Mitsubishi Rayon Corporation, an illustration of the basic tooling is shown in Figure 3. Prior to embarking on manufacturing of the composite knuckle tie blade, CLASS candidate carbon fibre materials were moulded at Ford Research and Innovation Centre based at Dearborn in the USA. This experience helped the project to optimise the process parameters so that the maximum mechanical performance and geometrical accuracy can be obtained.

Lessons learned

Through the combined efforts of GRM Consulting and the firms involved, the structural and weight saving targets of this project were met, while the experience gained during the project helped engineers understand how to strike the best balance with multi-material designs. As it progressed, the optimisation methodologies within VR&D Genesis were refined and material selection methods modified to support design and manufacturing engineers in delivering to stringent requirements.

Ford challenged the project team to deliver a highly complex and heavily loaded component, suggesting that if this could be delivered then many other vehicle components would be relatively simple. Indications are that this has been achieved with a weight saving that offers huge opportunities throughout a vehicle.