Material solutions for the next generation of rail vehicles

JOE CARRUTHERS reviews how NewRail, the railway research centre at Newcastle University, is collaborating with industry to develop new concepts for rail vehicle components and structures based on advanced materials and manufacturing processes.

As the expectations of passengers, operators and indeed wider society continue to evolve, rail vehicle designers and manufacturers face an ever-increasing array of technical challenges that must be reconciled. Such issues include safety, security, capacity, energy efficiency and interoperability to name but a few. These are all challenges that are currently being addressed by NewRail, the railway research centre at Newcastle University, through a range of materials-led research programmes in collaboration with rail vehicle manufacturers.

One of the areas in which NewRail has particular expertise is in the development and application of structural composite materials for rail vehicle applications. The aerospace industry has increasingly exploited the lightweighting benefits of composites over the last 30 years, with the recently developed Boeing 787 having a composite share of around 50 per cent. However, the lower weight premiums of the rail industry make it difficult to justify the use of costly high performance carbon fibre reinforced composites. As such, the mainstream application of composites in rail vehicles has typically been limited to semi-structural or aesthetic glass fibre reinforced composite mouldings for applications such as fairings and interiors. Sandwich constructions, in which two thin stiff facings are bonded either side of a thicker low density core material, are perhaps the best prospect for producing affordable composite rail vehicle structures, although a number of ambitious composite sandwich bodyshell development programmes in the 1990s failed to achieve significant market uptake. Customer confidence in the longer-term performance and durability of the new materials proved to be a significant barrier.

NewRail’s engineers take a pragmatic approach towards the development of composite structures. Firstly, there is an acceptance that composites are not best suited to every application. When designing a new component, materials should be specified on the basis of their performance in relation to the requirements and constraints of the given application. Sometimes an application will favour composites. Other times it will not. Importantly, NewRail has the tools and expertise to manage material selection decisions in a systematic, robust and optimised fashion. Secondly, NewRail focuses its composite development efforts on applications that have a realistic prospect of short-to-medium-term acceptance by industry. The uptake of composites within the rail industry is more likely to happen by evolution rather than revolution, as illustrated by the all-composite bodyshells mentioned earlier.

A good example of NewRail’s approach to the development of new composite applications is the lightweight crashworthy driver’s cab that it completed recently in collaboration with Bombardier Transportation. Conventional rail vehicle cab structures are typically based on welded steel assemblies, often with a thin non-structural fibreglass cover. They are therefore relatively heavy. Furthermore, current cab designs tend to be very complex, high part count assemblies with fragmented material usage. This is because they must meet a wide range of demands including proof loadings, crashworthiness, missile protection, aerodynamics and insulation. Assembly costs are high, and there is little in the way of functional integration.

By contrast, NewRail’s cab is an innovative modular design based on advanced sandwich material technology. It provides all the required functionality within a single lightweight integrated package. Furthermore, the reduced mass and integrated nature of the cab’s design yields savings in assembly and outfitting costs, as well as in-service reductions in energy consumption and operational costs. As well as the development and prototyping of specific railway applications, NewRail also performs more fundamental research to improve our general understanding of material and process behaviour. One such example of this work is the FIRE-RESIST project, a four-year, 7.8 million euros initiative led by NewRail that brings together the rail, aerospace and marine industries to look at...
the development of innovative solutions for improving composite material fire performance. For many applications, one of the biggest factors currently preventing the more widespread use of light high-performance polymer matrix composites is their poor fire performance. This is due to the organic matrix resins, which first soften on heating, causing a loss of mechanical properties and then, at higher temperatures, decompose. Decomposition results in the production of smoke and toxic or flammable decomposition products. These products are not only hazardous in terms of lack of visibility and toxicity; they can also burn, releasing heat, which can lead to flame spread and exacerbate the fire. Furthermore, loaded composite structures often collapse in a fire within a period of minutes, depending on the magnitude of the load and heat flux. FIRE-RESIST, which commenced in autumn 2010, aims to address these issues through the development of a number of novel material technologies and improved simulation capabilities. The project will conclude with the design, prototyping and testing of a number of full-scale demonstrator parts drawn from the three transport sectors to evaluate the technologies developed.

Other examples of projects to which NewRail has lent their material expertise include ALJOIN, which provided a series of recommendations for improving the performance of welds in aluminium rail vehicles in the light of the concerns raised by the Ladbroke Grove inquiry, and SECUREMETRO, a current project that aims to improve the resilience of metro vehicles to terrorist attacks by explosives and firebombs. Further details of these, and indeed NewRail’s full portfolio of research activities, can be found on their website – www.newrail.org.

By maintaining an application-led approach to their research activities, and by seeking to work closely with their industrial partners, NewRail intends to maintain its position as one of Europe’s leading centres of excellence for rail vehicle materials engineering.

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Further information


Both of the above publications are available for download at http://eprint.ncl.ac.uk.

Dr. Joe Carruthers is the manager of NewRail’s Vehicles Group.
Tel: 01246 281634
Email: joe.carruthers@ncl.ac.uk
Web: www.newrail.org

NewRail has a well-equipped fire test laboratory to support material development and application-led research.