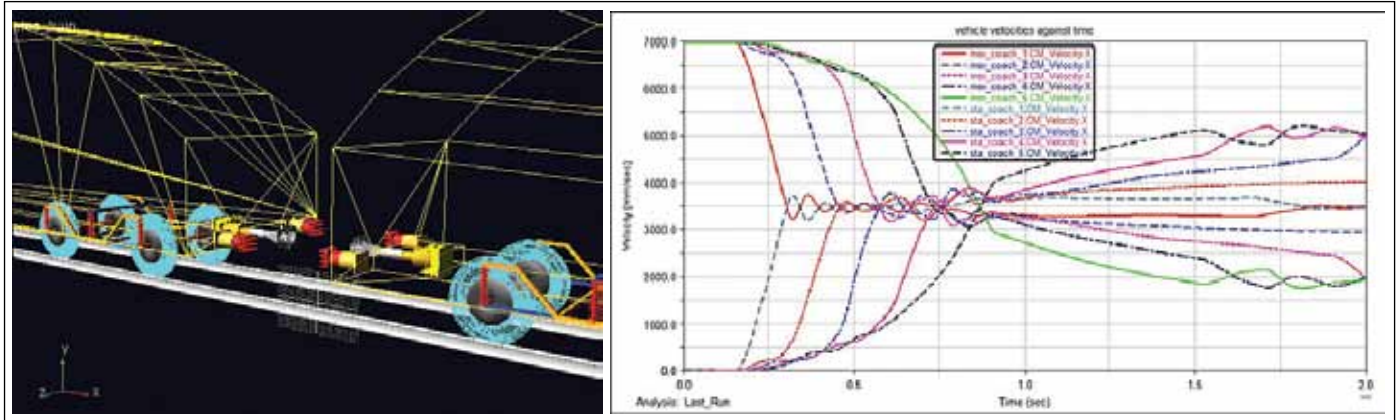# Define crash energy management needs early in procurement

MODELLING Wider access to multi-dimensional simulation tools could help to reduce the cost of incorporating tighter crashworthiness standards into rolling stock procurement.

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The development of tighter crashworthiness standards in Europe, centred on the Euronorm EN15227, has led rolling stock designers to place more importance on energy absorption and vehicle protection measures. EN15227 applies to new locomotives, multiple-units and other passenger vehicles, and it is intended to protect occupants through the preservation of structural integrity. It mandates the provision of a level of protection by addressing the most common types of collision that cause injuries and fatalities.

This renewed emphasis on vehicle structural integrity has led Oleo to develop its range of simulation and modelling tools to enable designers, component suppliers, rolling stock owners and train operators to gain a more profound understanding of the issues surrounding crashworthiness.

Oleo has supplied gas hydraulic energy absorption equipment to the rail industry for many years, and we are frequently asked to run simulations looking at various train impact scenarios when the train design is well established. This can, on occasions, give rise to a situation where the rolling stock procurer finds that its vehicle specification cannot be met from the crash energy management options available in late-stage design.

Oleo has regularly been asked to help unravel such complexity.

Simulate early, simulate often

Broad engagement from the various parties involved in train design and procurement into the specifics of energy absorption at an earlier stage should help to mitigate these issues. We have a range of modelling options from one-dimensional simulation through to multi-body dynamics analysis in three dimensions.

Our 1D Rail software package has been in use for a number of years, but our current focus has been to redevelop the application to enable customers to access the application via a secure login. This gives end users from various disciplines the potential to evaluate absorption characteristics at each interface of a vehicle in various shunting and collision scenarios.

Each vehicle in a trainset can be modelled as a single mass with a stiffness value, and allocated a separate coefficient to model braking or rolling friction. The gas-hydraulic crash absorption modules can be selected from a library of customisable designs. The static and dynamic performance of these library models has been verified by full-scale component testing.

The piecewise linear characteristics of rubber or elastomer springs and the characteristics of permanently-deformable elements such as tubes, crush boxes and shear-out mechanisms can also be selected. Specific dimensions for couplers, buffers and anti-climbers can be entered so that the physical space required to house the crash energy management system is known from the outset.

The approximate crush behaviour of the vehicle ends can be entered as force versus displacement data generated from separate finite element analyses. Once the train and its energy management behaviour have been modelled, it is possible to run various collision scenarios including:
- train into sliding or fixed end stops;
- moving train into stationary train, with or without brakes applied to either train;
- moving trains at different speeds and directions.

Oleo is working with specialist translation company Comtec to launch 1D Rail internationally, having already introduced it to the Chinese market via a bespoke web portal and at a number of trade exhibitions.

Multi-body dynamics

Multi-body dynamic simulation can also be offered by 2D Rail, which uses the established Adams software platform in conjunction with Oleo's proprietary modules.

Detailed three dimensional models of vehicles are created, including geometric details of key components, suspension characteristics and CEM elements including couplers, buffers,

Oleo is developing its three-dimensional multi-body dynamic simulation models.

Users can access the Oleo 1D Rail online portal via a secure login.

Rapid analysis to optimise the crash energy design then assists in the selection of key components and the assessment of their space requirements, which in turn can indicate if the proposed CEM design will work for the given vehicle or if more customisation is required. Such an approach can be used at the start of a procurement process to indicate the likelihood of achieving a desired collision performance. This reduces the risk that customised couplers or other components might need to be sourced, or — worse still — the vehicle's internal or external layout revised.

We are now extending this concept to include three-dimensional multi-body dynamic simulations that analyse vertical and lateral effects on straight or curved track. These simulations require the provision of complete 3D characteristics of vehicle suspension and track geometry. The resulting simulations can model the components of the train's CEM design, including the force stroke characteristics of couplers and buffers to show over-riding and lateral movement.

Vehicle manufacturers often perform the final validation of the crashworthiness of their trains using structural finite-element analysis. This requires the production of a detailed mesh of the vehicle structure for use with established software programs such as LS-Dyna or Radioss-Crash. Such analysis is costly in terms of pre-processing and execution times given the large number of elements required to model a full rail vehicle.

Early use of Oleo's 1D and 2D Rail platforms allows vehicle designers to be confident that when final validation is performed much later in the design process, they will achieve the desired outcome. Furthermore, we can provide bespoke elements for use with both LS-Dyna and Radioss-Crash which contain the characteristics of specific energy absorption devices used in the original simulation. This avoids the need to approximate the often highly non-linear behaviour of CEM components in finite element analysis, leading to a more accurate validation process.

anti-climbers and crush zones. Oleo's 2D Rail can create models, including vehicle misalignment, to simulate the vertical movement to analyse vehicle over-riding tendencies.