RAILWAY VEHICLE ENERGY ABSORBERS

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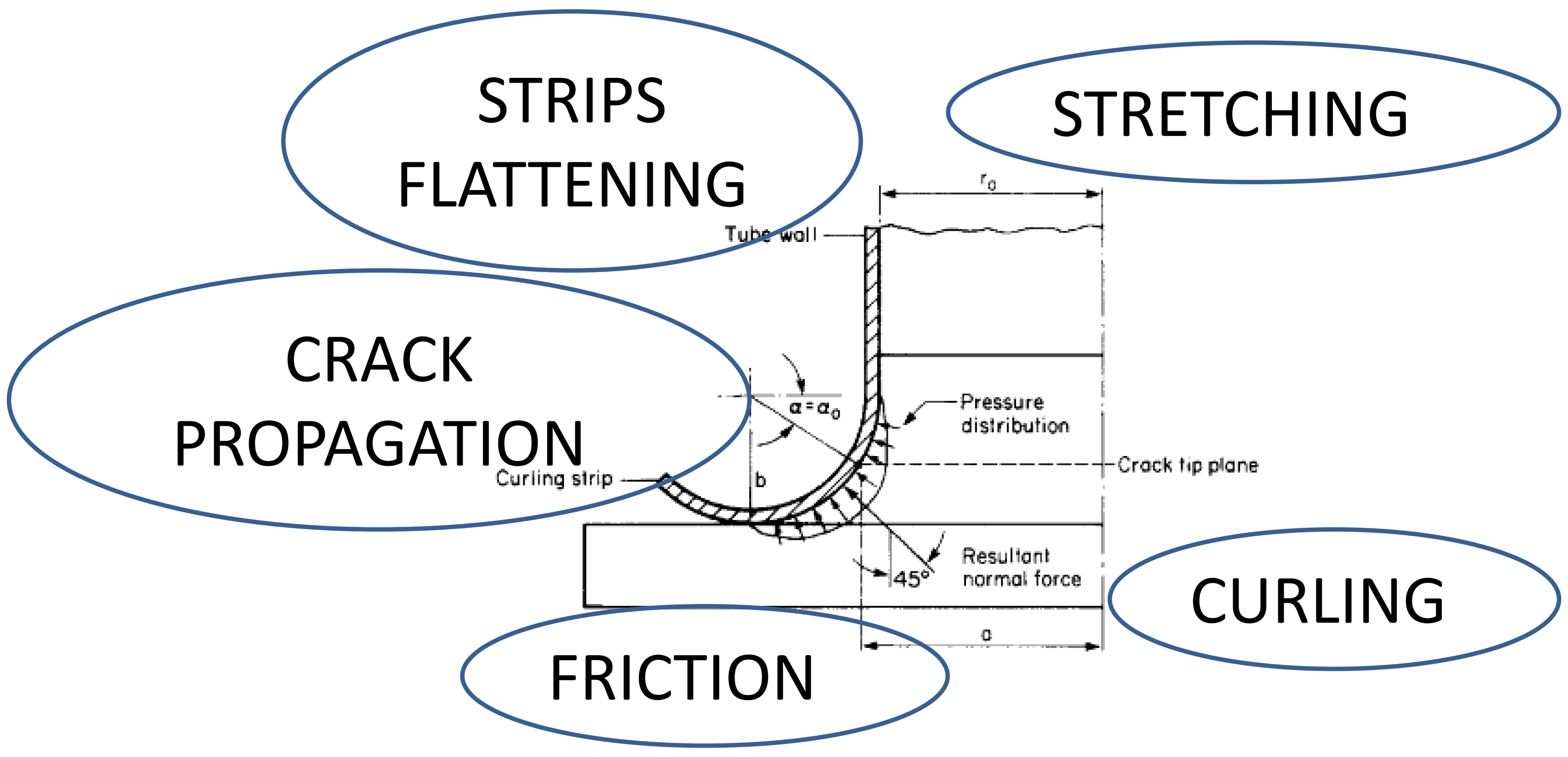
1. AXIAL SPLITTING OF TUBES AS ENERGY ABSORBERS

The axial splitting of tubes was proposed as a mechanism of energy absorption in the early 80's. It has been extensively studied and various analytical models have been suggested to predict the mean load response of the device .

The splitting mechanism absorbs energy through a number of ways including gross plastic deformation, ductile fracture of the material and friction between the splitting tube and the die.

Crashworthiness standards require that the energy absorbers must be tested, and the calibrated numerical model included in the railway vehicle crash simulation for approval.

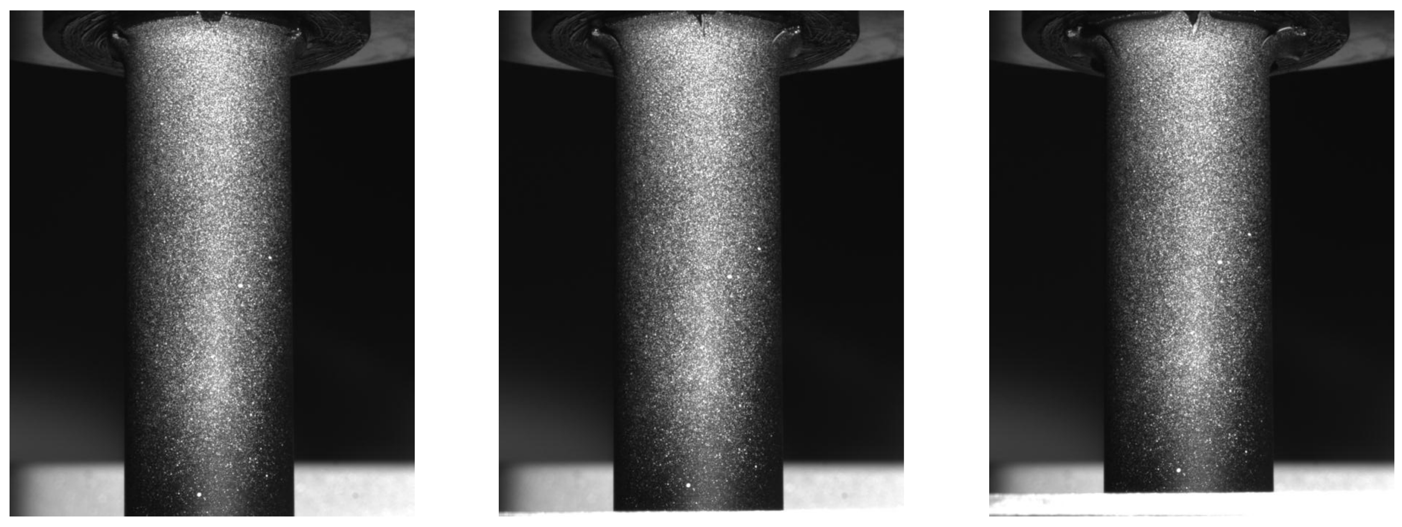
The key question is then, how accurate can simulations be to predict the behaviour of axial splitting tubes?



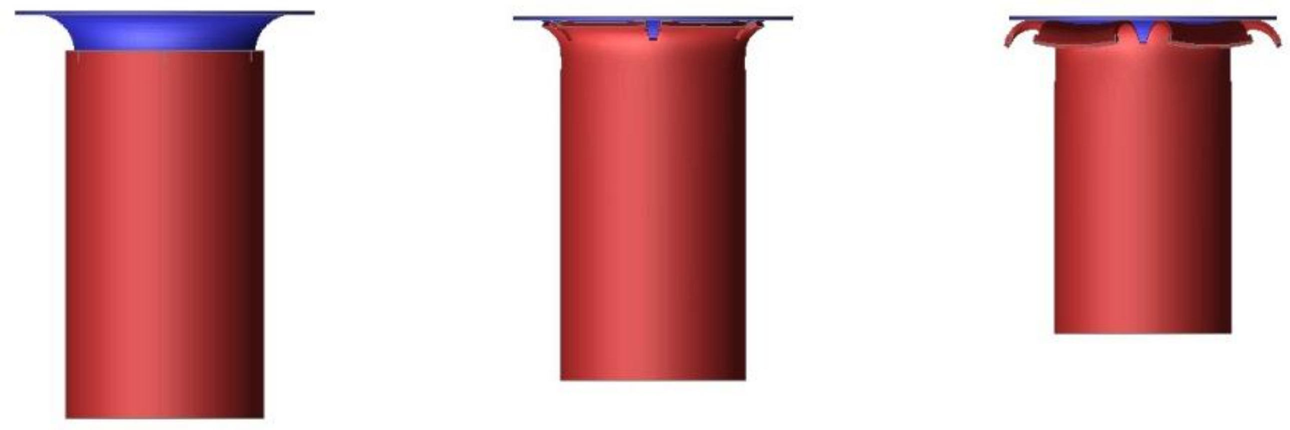
2. SIMULATION OF THE AXIAL SPLITTING PROCESS

A test has been created to calibrate a numerical model of the splitting tube. A scaled down dimension for the steel tubes, of 30 mm outer diameter and 2 mm wall thickness has been used. The splitting die features a flaring radius of 8 mm. The tubes are 200 mm long and have been crushed to a length of 160 mm.

Experiment

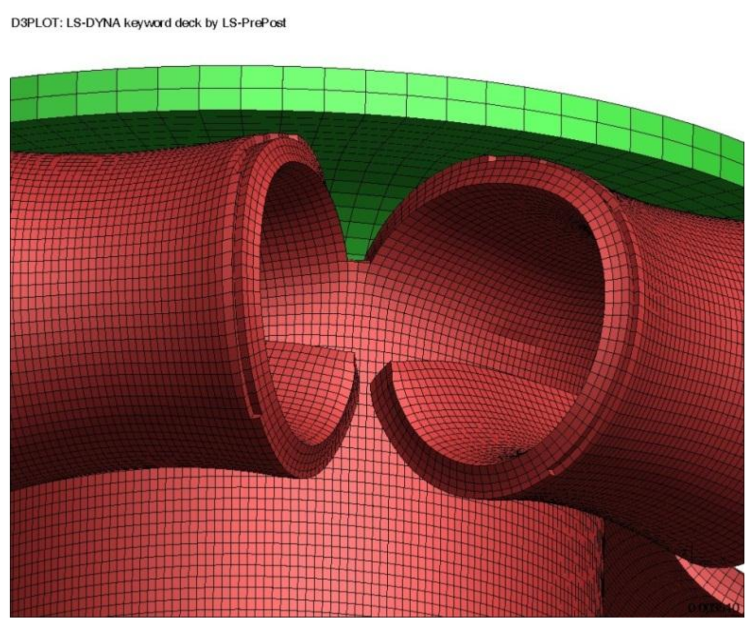


Simulation



The finite element analysis software, LS-Dyna has been chosen to perform the numerical simulation. The simulation needs to be able to capture the gross deformation due to the strips curling /flattening and the tube stretching ahead of fracture. It also needs to be able to implement accurately fracture and friction.

A preliminary simulation shows that the model deforms as observed during testing. The material model includes a simple constant strain fracture model. The elements are deleted when the selected constant strain fracture is reached.

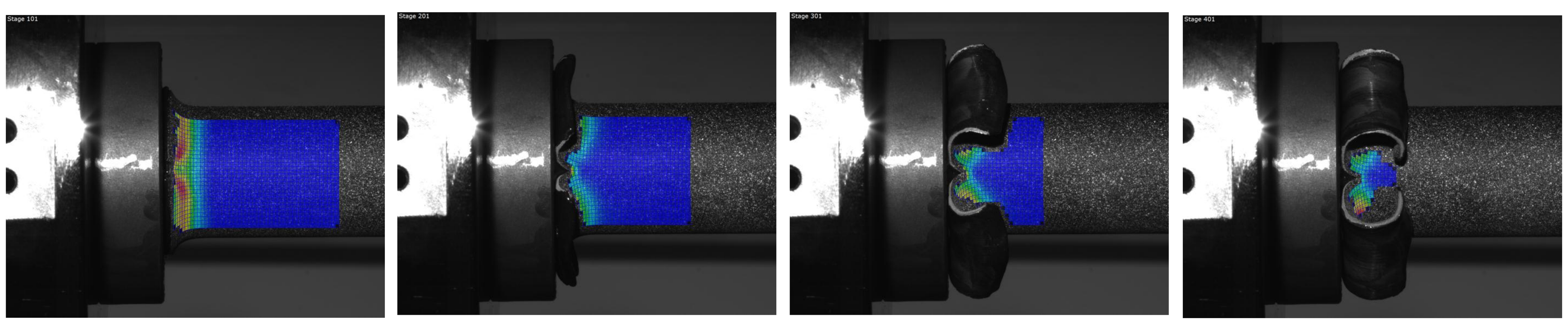


Knowledge of the fracture strain is essential to capture the correct fracture and deformation of the numerical model.

3. NUMERICAL MODEL CORRELATION

A digital image correlation optical method has been selected to assess the fracture strain. The GOM Aramis 3D commercial software has been used on splitting tubes with different initial number of notches to assess the fracture strain for different splitting processes.

It has been found that tubes developing different numbers of strips exhibit a different strain state at the crack tip. Therefore the fracture strain is slightly different for each case. The appropriate fracture strain has been introduced in the numerical model. The static coefficient of friction has been adjusted until the energy absorption of the finite element model agrees with that observed during test.



The load-displacement curve shows a good agreement between test and simulation. The energy absorbed by the test specimen is matched by the numerical model by including a static coefficient.

Qualitatively, the load response reproduces the events observed during testing. Therefore, the numerical simulation of splitting tubes is deemed as sufficiently accurate to be included in the crashworthiness simulation of a railway vehicle.