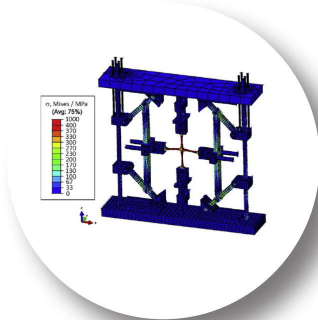
Case Study

diamond

Stresses in Steel During Manufacturing

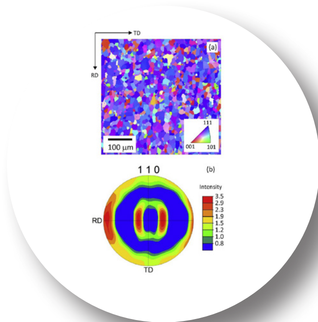
The Problem

The automotive industry typically uses steel sheets for the bodywork of cars which is cut to the size of the part (i.e. roof, door or bonnet) and then stamped into the precise shape required. Although steel is a commonly-used material, the exact behaviour of the metal's crystalline structure during these forming processes has yet to be fully mapped. By understanding how the 'steel crystals' react when undergoing stamping, new alloys could be created that offer greater flexibility and strength which might allow more complex shapes to be formed.



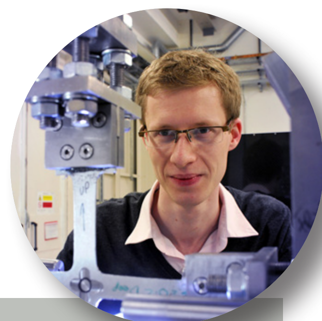
The Challenge

The stresses exerted on sheet metal during stamping are difficult to study. The metal is typically deformed along two axes (termed 'biaxial'), but previous efforts by material scientists have only studied stress along a single axis. The various strains and stresses exerted on a material as it undergoes deformation are known collectively as a strain path; consequently, replicating a strain path is vital in order to accurately recreate the events in a factory. A high resolution, non destructive technique along with specialist equipment to replicate the strain path was required to provide data to validate theoretical approaches.



The Solution

The team of scientists from the University of Oxford, The University of Sheffield, and Diamond Light Source designed a bespoke cruciform rig to support a section of sheet steel provided by BMW-MINI in order to recreate the stresses exerted on sheet steel during car manufacturing. X-ray diffraction on beamline I12 allowed the team to track the metal at a high angular resolution as it was deformed using the rig, to recreate the biaxial strain path experienced by sheet steel in a car factory. These observations were shown to closely match theoretical computer simulations of the stamping process.



The Benefits

The X-ray diffraction studies allowed the team to accurately visualise the effect of biaxial stresses on sheet steel so that the results could be fed back directly to the car manufacturer. The experimental results successfully validated the existing theoretical models of steel crystals during the forming process. The team saw that the biaxial strain ratio affected the distribution of strain across the crystal lattice. This lattice strain accumulated more rapidly in the direction of the axis that was exerting the greatest load, but the distribution became uniform at high loads.

"Only by having access to the unique facilities offered at Diamond were we able to replicate a real manufacturing process whilst collecting X-ray data. The insights were invaluable; they are now allowing us to develop new methods for metal forming by exploiting the revealed microscopic material behaviour. This approach will allow us to use new materials that are currently impossible to fabricate using traditional methods."

Dr David Collins, University of Oxford

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