Science Bridges China Research Profile

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SUMMARY OF MY RELEVANT RESEARCH AREAS:

Finite element analysis of medical devices, composite materials (nano and micro-reinforced), sub-modelling. Solid phase polymer processing for the manufacture of shape memory and high stiffness materials. Solid phase mechanical testing using novel visualisation and alternative techniques for material characterisation.

医疗器械有限元素分析，复合材料（纳米和微观增强材料），分建模。形状记忆材料及高硬度材料制造中的固相聚合体加工。使用新型可视化和其他替代技术对材料特性的固相力学的测试。

Primary Research interests:

Finite Element Analysis

A range of finite element analysis experience ranging from the traditional linear and elastic plastic deformation of engineering components through to complex multi-scale analysis and non-linear bespoke constitutive equations. Recent analyses include the design of tibia tray implants (constructed from both metallic and polymeric materials) with bone geometry and material data constructed from CT images of cadaver tibia.

Mutli-scale analyses have been constructed so that micro-scale damage of short glass fibre – polymer interfaces can be modelled based on macroscopic deformation of a composite material during solid phase processing. This linked analysis seeks to predict cavitation initiation and propagation within the composite material but does not provide a feedback to the macroscopic deformation analysis. Feedback multi-scale analyses have been conducted on nano-reinforced materials using a novel RVE technique (which can be used to investigate particulate agglomeration, stress shielding and polymer matrix orientation)

Solid Phase Polymer Processing

Die and free drawing have been used to produce unfilled and filled polymer materials with significantly higher mechanical stiffness and fracture strength. Commercial applications of this technology have been launched in the civil engineering market and are being developed for high-end engineering applications and medical devices such as spinal implants. Oriented materials are also being investigated for fixation devices through their shape memory capabilities. Recovery of orientation is achieved by the application of energy in the form of heat (which can be tailored through material selection).

Solid Phase Mechanical Testing

Mechanical testing of polymer materials requires specialist skills and additional measurement techniques. A three-dimensional image analysis system is currently being developed (with an industrial partner) to provide accurate transverse, thickness and axial strain measurements. Biaxial and sequential deformation techniques are also being used to provide data for novel constitutive theories for finite element analyses.

Topics in which you would like to develop collaborative research:

Finite element analysis of medical devices

Multi-scale finite element analysis of polymer composites (through RVE or sub-modelling)

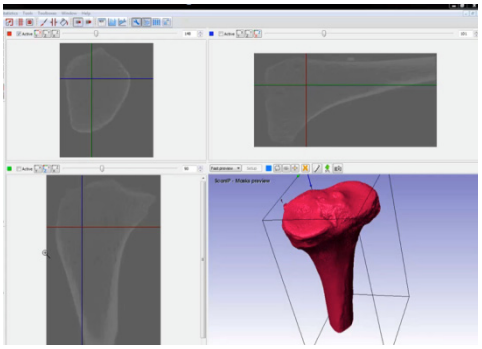
Oriented polymers for medical devices (fixation through SMP, enhanced properties, alternate production routes e.g. stents)

Polymer testing for improved material property acquisition (leading to constitutive model construction). Interest in thermal changes during deformation and the application of alternative measuring techniques (Ultrasound)

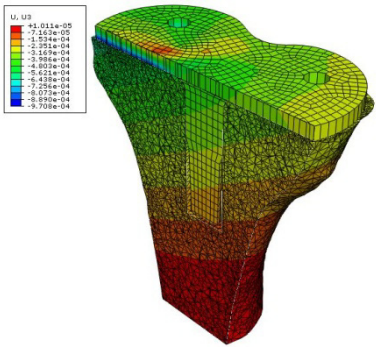
Relevant existing collaborations (academic/clinical/commercial) inside or outside China.

- Biodynamics, EPSRC, University of Leeds – Shape MP devices
- Sichuan University – Oriented PLA blends (Xiaowen Zhao), PP, SBS blends with nano-filler (Qi Yang)
- Autodesk – 3D visualisation techniques, improved fibre orientation predictions (injection moulding)
- Orthoplastics – high stiffness materials for medical implants
- Nylacast, TSB – high stiffness cast nylon for engineering applications
- University of Leeds – SMP materials, fibre orientation measurement, oriented polymers
- Eovations – Oriented polymer composites
- Jaguar Landrover – Improved finite element analysis of automotive components
- Sabic – materials analysis (processing and product)
- University of Warwick / University of Hull – microCT for finite element model construction

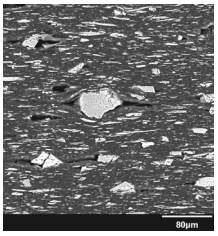
Relevant graphics, figures, pictures:



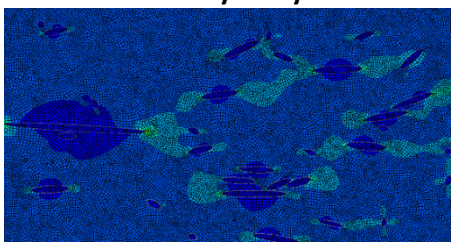
Knee reconstruction from CT images



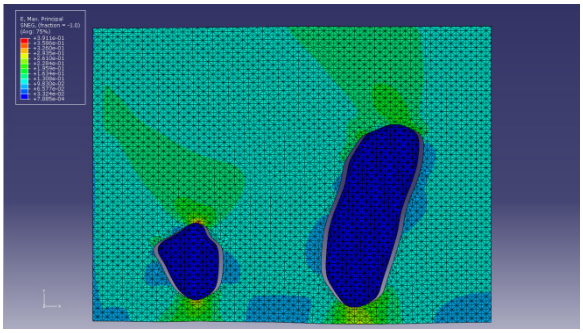
Tibia tray analysis



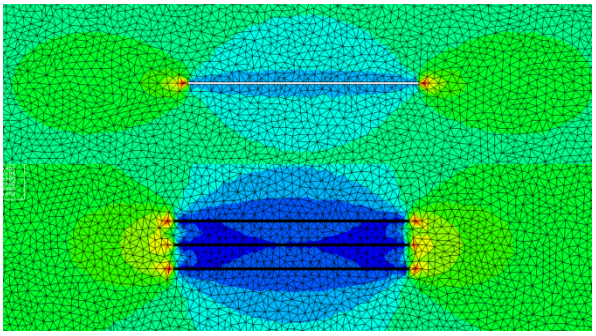
Cavitated oriented polymer sample



Micro-scale submodel of polymer composite



Partialy cavitated finite element model



Agllomeration analysis

Publications and other outputs relevant to your interest in this programme

1. Analysis of in die cavitation during the die drawing of composite materials, SPE Antec, Chicago, USA, 2009
2. Multiscale modelling of short glass fibre reinforced PP, Plasticity, St Thomas, Us Virgin Islands, 2009
3. Fibre orientation and mechanical properties predictions for short glass fibre reinforced injection moulding, PPS 27, Marrakesh, Morocco, 2011
4. Solid phase orientation processing of polymers, VIPPS meeting, Chengdu, China, 2009
5. High strength polymers – finite element analysis of fibre reinforced solid phase oriented materials, PPS 24, Salerno, Italy, 2008