MICRO/MESO-SCALE MODELLING OF MECHANICAL BEHAVIOR OF SHORT-FIBRE REINFORCED ELASTOMER COMPOSITES

Short fibre reinforced elastomer composites are an emerging and promising material class for the high-tech industry, although its applications are still limited. Short fibre reinforced elastomers have the potential of an excellent performance, such as high stiffness to density ratio and favourable tribological properties. However, the micro-scale mechanism that essentially determines the short fibre reinforcement in elastomer composites has not been studied in depth due to limitations of current experimental techniques. Micro/meso-scale finite element modelling is a valuable approach that can reveal the mechanism of short fibre reinforcement in elastomer composites.

Objective

Understanding the micro-scale mechanism of short fibre reinforcement in elastomers is greatly valuable to guide the development of new short fibre/elastomer composites. To satisfy this demand, a micro/meso-scale model of short fibre reinforced elastomer is required, to understand the mechanism and facilitate a parametric study of short fibre reinforcement in elastomers.

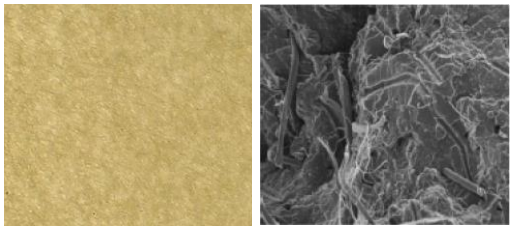

Figure 1 Short fibre reinforced elastomer composite; (left) optical image, (right) SEM image of tensile fracture surface

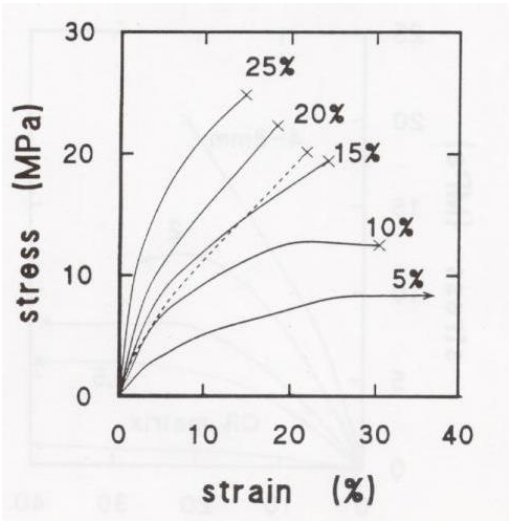

Figure 2 Short fibre reinforcement in elastomer composites.

Assignments

This project adopts an aramid short fibre reinforced elastomer as the research object, and requires closely collaborative work of two MSc students. Their research assignments are detailed as follows:

***Student 1*:**

(a) You are required to establish a micro/meso-scale model, via finite element method (FEM), to describe its mechanical behaviour. Mesh sensitivity and size dependence of the FE model should be minimized to ensure its representativeness.

(b) Together with student 2, you are required to validate the FE model by comparing to experimental data in references [1, 2] and that obtained by student 2.

(c) By using the FE model as well as the experimental data obtained by student 2, you will perform parametric studies to analyse the effect of fibre dimensions, distributions and fibre-matrix adhesion on the extent of reinforcement.

***Student 2*:**

(a) You will prepare samples of short fibre reinforced elastomer composites, whereby the volume fraction, distribution of short fibres in the matrix, as well as the fibre-to-matrix adhesion are varied.

(b) Experimental tests, such as uniaxial tension, will be conducted using the prepared samples. In collaboration with student 1, you will use the experimental results to validate the micro/meso-scale FE model.

(c) Based on the experimental results and with the help of student 1, you will use the FE model to simulate and analyse the

mechanism of short-fibre reinforcement in elastomer composites.

Report

The graduation report of student 1 should comprise the establishment of the micro/meso-scale FE model, validation of the model as well as the parametric analysis using the FE model.

The graduation report of student 2 should consist of the preparation of samples of short fibre reinforced elastomer composites, experimental tests and use of experimental data for validation of the FE model, as well as the mechanism analysis of short-fibre reinforcement.

Partners

This project will be technically supported by the Group of Production Technology. They will give suggestions on the detailed procedures of FE modelling.

Pre-requisite:

Experience of using ABAQUS to simulate mechanical problems (knowledge of ABAQUS Python scripts is preferred).

Fundamental mechanics of elastomers and elastomeric composites (ESE and PEE course).

Start:

Earliest: September 1, 2020

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References

[1] Morteza Sadat Shirazi, PhD Thesis, 2012, Aromatic polyamide short fibres reinforced elastomers: adhesion mechanisms and the composite's performance properties

[2] Nadia Vleugels, PhD Thesis, 2017, Short fibre-reinforced elastomeric composites, fundamental routes towards improvement of the interfacial interaction of short-cut aramid fibres in a SBR compound, to improve friction and wear properties.