New bonding technology of composites, inspired by the silk joints of spider webs

Highlights
- Bonding/joining of fibre or polymer-based composites
- Static and dynamic measurements of the silk joints of spider webs
- Modelling the ultra-lightweight structure with resilient joints

Overview
Airbus is now trying to design a new composite material and structure for the future aircraft frame by using synthetic silk biopolymers (https://www.airbus.com/innovation/Strong-as-a-spider-web.html). Bonding/joining of fibre or polymer-based composites is very critical to guarantee the structural and mechanical performance of the products. Spider webs are highly optimized and sophisticated architectures that exhibit exceptional material and mechanical properties. The viscous joints between the radial thread and sticky spiral thread are sturdy, also with high resilience. The joints also play important roles in energy attenuation when the webs are subject to dynamic forces, such as vibration excitation and transient impact.

Therefore, this unique joint would provide special inspiration to the solution of the welding challenging of the composite material structure. This study will use advanced instruments to explore the scientific interpretation of the resilience and damping merits of the joints under static, quasi-dynamic and dynamic loading conditions. Meanwhile, we expect to develop an analytical/numerical model of lattice/net geometry with proper joints. The model will lay the foundation for the development of the new bonding/joining technology of novel fibre composite material.

Methodology, Critical Skills and Training and Development
A couple of real spider webs will be provided by the spider lab at the University of Nottingham. The student will use the 3D laser vibrometers in the new “Dynamics, Vibration and Acoustics” Laboratory (DVA Lab) in the Engineering Department and the various advanced material analysis equipment in the Mechanics of Materials Research Group to experimentally study the static, quasi-dynamic and dynamic properties of the silk joints of spider webs. Tensile tests will be carried out to investigate the static mechanics of the joints. The energy absorption and transmission at the joints will be precisely recorded by the laser vibrometers when the webs are subject to transient collision forces. On the other hand, the DVA lab is equipped with the latest vibration analysis system, Siemens/LMS Test Lab. Therefore,
after exciting the silks by multi-frequency excitation forces, we can record the wave motion by the laser vibrometers, and the wave’s propagation and reflection properties at the joints will be studied in the advanced software.

Meanwhile, the student will mathematically study the static and dynamic (linear and non-linear) properties of the silk joints in the net structure (with the help from the co-supervisor), next the net structure with joints will be modelled in advanced simulation packages, such as COMSOL. Finally, based on the experiments and numerical models, the student will explore the application of the silk joint in new bonding/joining technology of composites. Last but not least, there is a feasibility to extend this research by the first supervisor’s application for a larger EPSRC project in the near future.

The key skill development and training opportunities for the student include:

- laboratory experiments and data analysis (static & dynamic mechanics)
- field work
- internship in industry
- numerical modelling training
- teamwork in a multi-disciplinary environment

Further Reading


Additional Entry Requirements

- Degree in Engineering, Material Science, Physics or Biology
- Willing to work with industry
- Experience in laboratory tests/analysis

Funding

This research project is one of a number of projects in the College. It is in competition for funding with one or more of these projects. Usually the project which receives the best applicant will be awarded the funding.

Home/EU Applicants

This project is eligible for a fully funded EPSRC studentship which includes:

- A full UK/EU fee waiver for 3.5 years
- An annual tax free stipend of £14,777 (2018/19)
- Research Training Support Grant (RTSG)
Studentships are available to UK/EU applicants who meet the EPSRC Residency Criteria; if you have been ordinarily resident in the UK for three years you will normally be entitled to apply for a full studentship.

If you are an EU student and do not meet the residency criteria, please contact csepgr@le.ac.uk for more information on the funding options available.

International Applicants
- Unfortunately, there is no funding for international students on this project.

Application Instructions
The online application and supporting documents are due by Monday 21st January 2019.

Any applications submitted after the deadline will not be accepted for the studentship scheme.

References should arrive no later than Monday 28th January 2019.

Applicants are advised to apply well in advance of the deadline, so that we can let you know if anything is missing from your application.

Required Materials
1. Online application form
2. Two academic references
3. Transcripts
4. Degree certificate/s (if awarded)
5. Curriculum Vitae
6. EPSRC Studentship Form
7. English language qualification

Applications which are not complete by the deadline will not be considered for the studentship scheme. It is the responsibility of the applicant to ensure the application form and documents are received by the relevant deadlines.

All applications must be submitted online, along with the supporting documents as per the instructions on the website.

Please ensure that all email addresses, for yourself and your referees, are correct on the application form.

For more information, please visit our website at:
https://www2.le.ac.uk/colleges/scieng/research/postgraduate-opportunities/epsrc-2019/instructions