QUB - Mechanical and Aerospace Engineering
PhD Project Description

Development of lightweight composite helmet using auxetic materials

Project Description:

The use of military helmets has greatly reduced injuries and saved lives of many soldiers. A helmet's protective capabilities are evaluated on the basis of two primary test measures: resistance to penetration (RTP) and back face deformation (BFD). Many factors are considered during ballistic helmet design, including comfort, weight, fit, and maintainability. Especially, being light in weight for military helmets is very important due to long-term operations.

The ubiquitous use of lightweight composite materials in protective structures has created a formidable challenge in ensuring the same level of protectiveness as their metallic counterpart. Different approaches towards the development of more efficient materials has led to an interest in auxetic structures. Auxetic refers to a negative Poisson's ratio which is a meta-material property. Consequently, when a compressive load is applied to an auxetic, the material will contract in the direction orthogonal to the applied load, creating a denser region. This densification makes auxetics suited to severe loading conditions such as impact (Fig 1). This research programme will examine their effectiveness in the design of lightweight composite helmets.

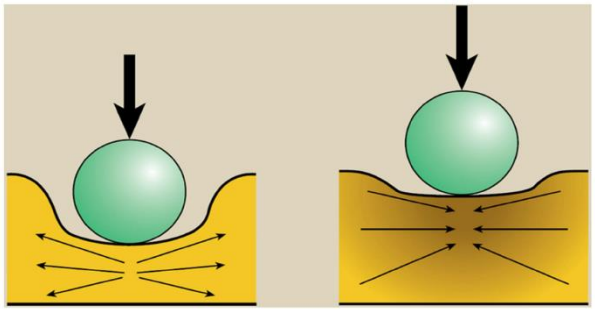

Figure 1. Impact resistance of non-auxetic and auxetic materials [1]

In order to decrease design cycle times and ensure that safe design standards are met, virtual tests are usually performed by numerical simulation. The virtual impact test data are subsequently used as part of the development of a new design. These numerical simulations produce results without building a physical model, and can be performed relatively quickly and inexpensively. This permits optimization of the design before an actual prototype of the helmet has to be built.

Aims and Objectives:
The aim of this project is to develop an optimum composite helmet using auxetic core structure, to deliver the lightest possible military helmet with improved ballistic efficiency. A new finite element model will be developed to analyse the impact response of composite sandwich panels using auxetic cores. The effect of helmet shell material, shell thickness, impact velocities, and impact types (with hemi-spherical and flat anvils) on the performance will also be studied.

[1] Alderson A 1999 A triumph of lateral thought, Chemistry & Industry, 17 May 1999, pp 384–91.

Key Skills Required for the post:

Candidate should demonstrate knowledge/experience/skills in at least one of the following areas:

- Structural analysis and testing
- Numerical modelling (primarily finite element analysis)

Key Transferable Skills that will be developed during the PhD:

These will include an ability to effectively communicate research outcomes to academic peers and industry, independent analytical thinking and problem solving, time management, and leadership.

Lead Supervisor	Dr Zafer Kazancı e-mail: z.kazanci@qub.ac.uk webpage: go.qub.ac.uk/kazanci
Second Supervisor	Prof Brian G. Falzon FRAeS e-mail: b.falzon@qub.ac.uk
Funding mechanism:	Yet to be secured
Application closing date:	-
Guaranteed stipend:	-

PhD students in the School may have the opportunity to apply to be demonstrators on undergraduate modules. Compensation for this can amount to in excess of £2,400 per year.

Queens University Belfast is a diverse and international institution which is strongly committed to equality and diversity, and to selection on merit. Currently women are under-represented in research positions in the School and accordingly applications from women are particularly welcome.