Exploring structural carbon fiber composites for mass-less energy and actuation

Johannisson, Wilhelm

KTH, School of Engineering Sciences (SCI), Aeronautical and Vehicle Engineering, Lightweight Structures. KTH, School of Engineering Sciences (SCI), Engineering Mechanics.

Abstract [en]

The energy consumption in transport is today a large contributor to global greenhouse emissions. One way of reducing these emissions is by electrification, which is an ongoing journey for the vehicle industry. The aeronautical industry has started investigations but are limited by the relatively low specific energy of batteries.

One way to improve the specific energy of batteries is by making them multifunctional by combining them with other functions of the vehicle. When the battery is combined with a structural material, the resulting material is referred to as a structural battery. This structural battery ultimately performs the fundamental function of mechanical rigidity and the battery function provides almost mass-less energy. The idea of structural batteries has been around for a while, but its actual construction has not yet been understood.

This thesis is focused on exploring the design and implications of structural batteries made from carbon fiber composites. The first section is focused on the construction of the structural battery. Specifically investigating a structural carbon fiber negative electrode with regards to its manufacturing, electrochemical properties and mechanical properties. The results show that the construction of a negative electrode for structural batteries is achievable. The next section is using the findings from the first section in exploring the implications of implementing a structural battery into vehicles with regards to weight saving and life cycle characteristics. The findings show that the structural batteries have the potential to decrease both weight and life cycle burdens. The last section presents the use of the structural carbon fiber negative electrodes as a morphing material controlled by applied electrical power. The morphing deformations are large and stationary when power is removed but the morphing rate of the material is limited. Additionally, it is solid state, lightweight and has an elastic modulus higher than aluminum with large morphing deformations.

The long-term outcomes of a thesis are hard to predict, but the findings herein conclude that the technology of structural batteries have the potential to disrupt energy storage in transportation, as well as traditional actuation and morphing technologies.