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An Investigation into the Engineering Design Philosophies for the Manufacture of Advanced Engineering Composite and Metallic Alloy Components.

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Introduction and Rationale:

Computer Aided Design software's drastic increase in accessibility shifted the responsibility of product design away from experienced engineers. Effective design requires comprehensive knowledge of a material's respective design philosophy. Designing with composite materials presents a distinct way of working, requiring deep understanding of the constituent materials and their properties. This report investigates the differences between traditional engineering philosophies and those of emerging composite materials—showing inherent software flaws and lack of guidance.

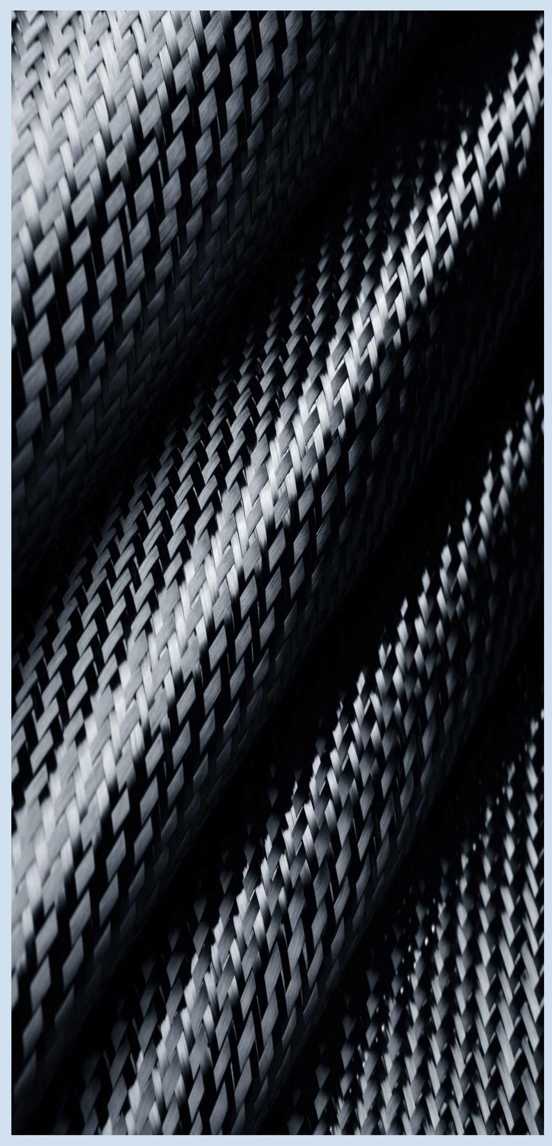
Project Aim and Methodology

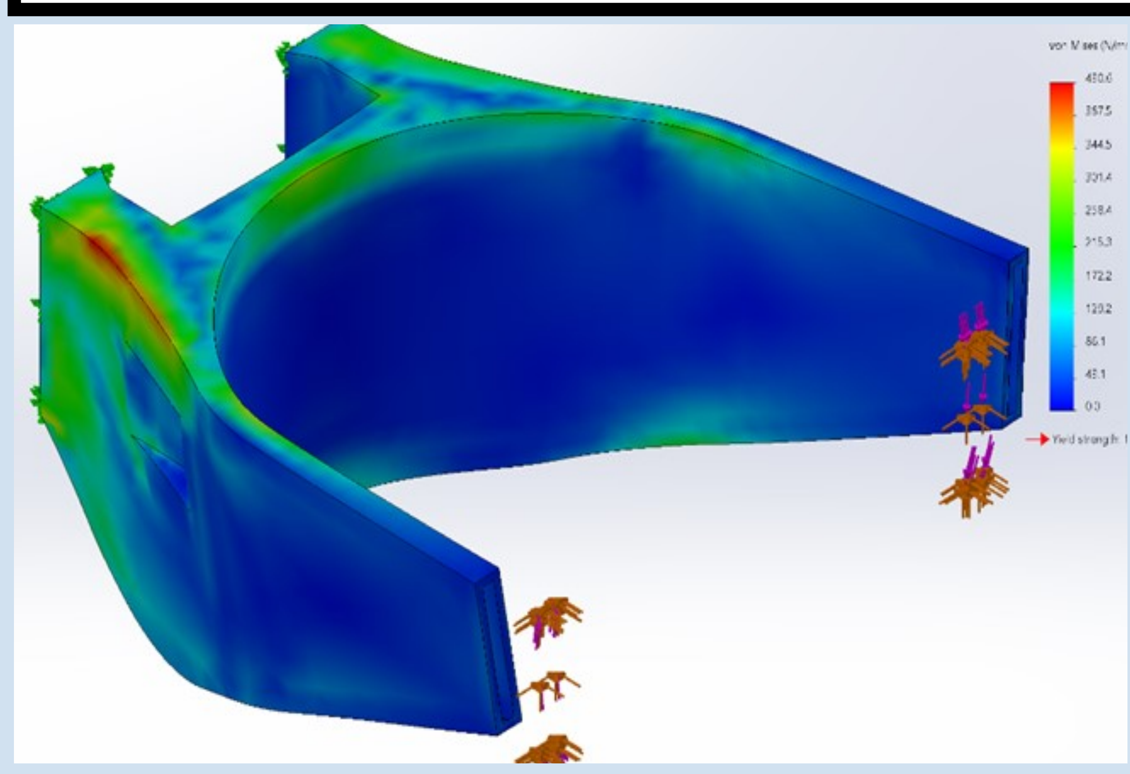
To investigate these difference in material design philosophies, the following methods were used:

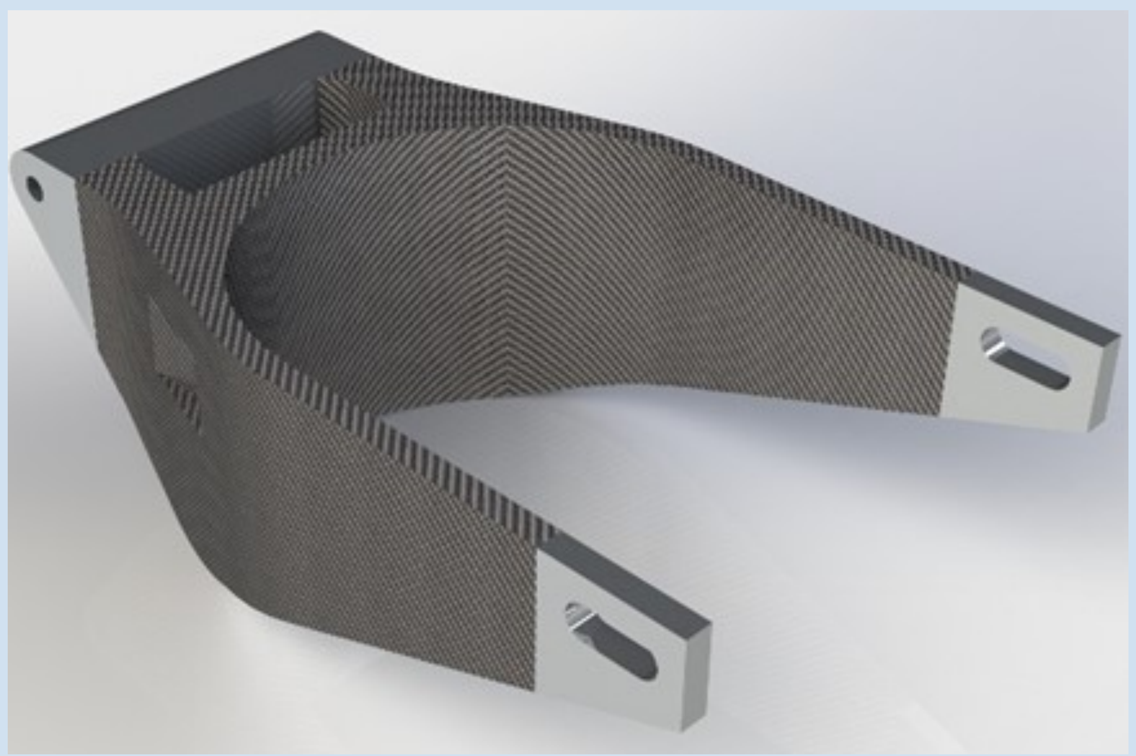
- Conduct a literature review of existing design guidance for both metals and composites, highlighting lack of composite support.
- Document the overall engineering design process.
- Investigate design philosophies utilised when adopting metallic and composite materials.
- Establish material specific guidelines for the design process.
- Highlight differences through a motorbike swingarm case study.

Review of Guidelines and Manufacturing Differences

- Composite materials require great numbers of design variables and decisions, increasing designer responsibility.
- Metallic part design must consider the manufacturing process—the distinct operation methods presents decisions early into product conception. Unique design guidelines have been detailed for each approach.
- Designer experience dictates composite design efficiency. The lack of accessible and applicable information often forces designers to treat composites like metals or 'black aluminium', failing to realise their potential.
- Widely available composite modelling and simulation is still in its infancy, lacking the optimisation present for metals. Composites require intricate definition of constituent materials and fails to consider the material and process idiosyncrasies. There is large disconnect between end-product and simulated composite performance.
- Engineering design educational resources lack composite inclusion, where often it is needed the most.
- Composite focussed software is becoming more available, but frequently lacks accessibility to smaller companies.







Case Study Analysis:

- The metal and composite swing arm requires drastically different design.
- SolidWorks featured multiple simulation features suited only for traditional materials, with drastically reduced support for composites.
- The composite design process was more complicated, requiring intricate material definition—the anisotropic properties were difficult to obtain.
- Additional metal inserts were required for the composite arm to prevent fibre damage and failure.
- Fillets could be used to reduce stress concentrations in the metal design.
- Multiple metal swingarms were designed utilising manufacture specific guidelines.

Conclusions and Recommendations:

Maintaining fibre continuity restricts shortcuts usually used with metallic materials. Designer responsibility is much greater when adopting composite materials due to the comprehensive knowledge requirement of the complicated failure modes exhibited—essential in high stress applications with catastrophic failure consequences. The developed guidelines provide a foundation for component design, however further, specific literature should be consulted before the design process is started. Increased composite education and software is required to bring understanding of composite design to the level present for metals for decades.