# Reprocessing of Recycled Aerospace Materials

## Introduction

$CO_2$ emissions and pollution are causing damaging consequences for the planet and mankind. Without major changes, global temperatures can rise by to 2°, leading to severe weather conditions, such as droughts and floods, to become more frequent and aggravating health related conditions. To prevent this people, industries and governing bodies are pushing to adopt more sustainable practices. Governing bodies like the EU are committed to cutting down on GHG emissions and adopting a more circular economy.

To achieve such a feat, recycling and reprocessing materials is vital, as it increases the life span of products, prevents waste and can cut $CO_2$ emissions. It is for these reasons that thermoplastics are currently seeing large increases in demand, as opposed to its non-recyclable counterpart, thermosets.

## Background

In the aerospace industry, polyetheretherketone (PEEK) is commonly used due to its high mechanical performance, as well as its resistance to heat, radiation and chemicals. However, sometimes PEEK alone is not strong enough. To strengthen the PEEK parts, fibre reinforcement, usually in the form of carbon fibre (CF), is added thanks to its high specific strength. Apart from their exemplary performance, PEEK and CF are also used due to their recyclability. Through mechanical recycling both the fibres and matrix materials can be recovered to be reprocessed.

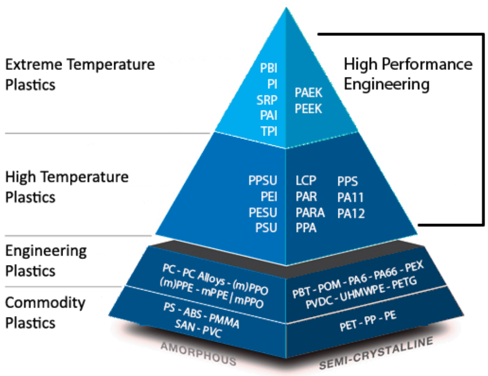


*Figure 1. Thermoplastic performance pyramid (Polymers International Australia)*

When mechanically recycled, fibres are shredded and grinded down resulting in discontinuous fibres (figure 2).

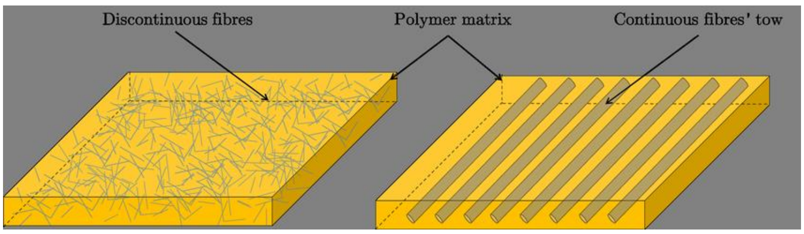


*Figure 2. Discontinuous vs continuous fibres (Simon, 2022)*

Due to their discontinuous nature, the fibres are more chaotic in alignment and inconsistent in distribution, which results in lower mechanical properties compared to their virgin counterpart. However, literature suggests that there are methods to optimize the design of recycled fibre reinforced thermoplastic composites (FRTCs).

## Approach

The purpose of this design is to determine how do various design elements affect the properties of compression moulded, recycled, FRTC products. To do this research questions pertaining to mechanical properties, fibre properties, rheological properties and processing properties were formulated and how they can be affected by varying different parameters, dimensions or geometries.

## Result

The final design (figure 3) ends up being a flat plate with eight branches each testing one or more research questions, each with their own hypotheses.

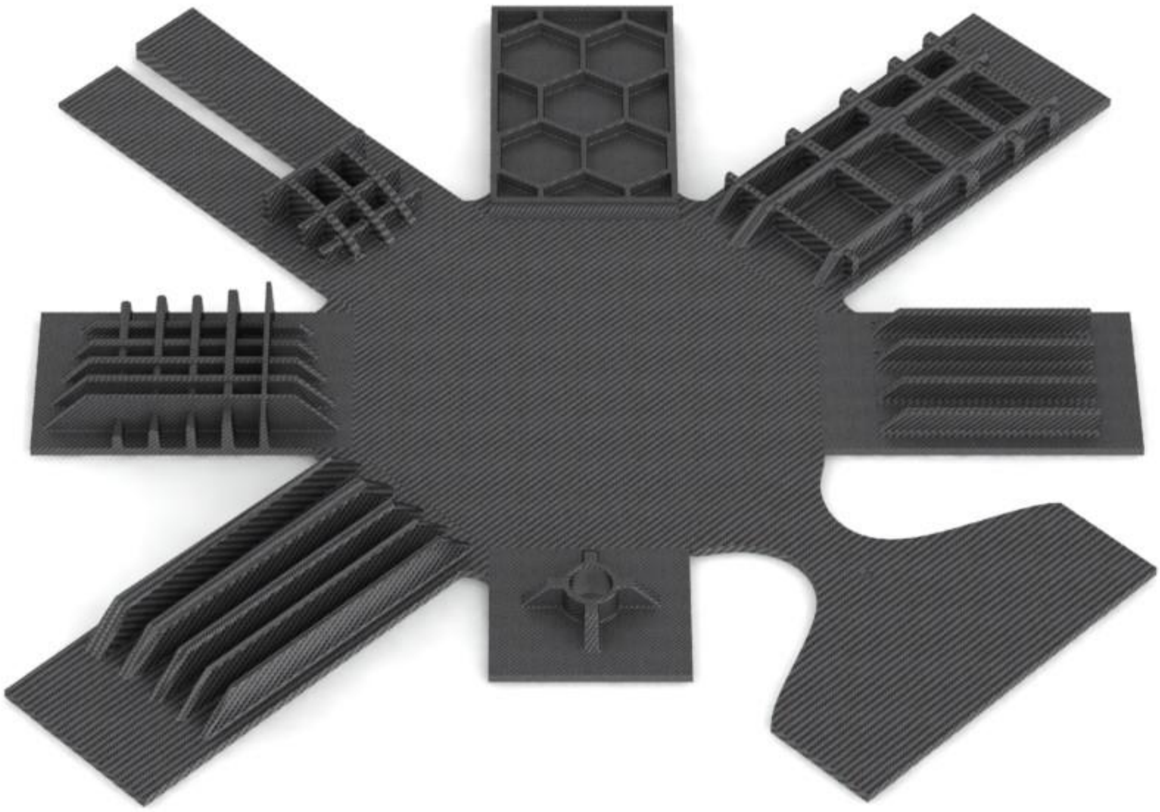

*Figure 3. Final CAD model*

Each branch was designed to produce favourable characteristics, like consistent fibre orientation alignment, or to determine the formation of unfavourable characteristics, such as air traps or weld lines. These properties were examined in simulations. The simulations performed were for injection moulding and not compression moulding due to inaccessibility at the time. However, taking into account some considerations, the injection moulding simulation can still provide valuable insights into the outcome of the compression moulded part.

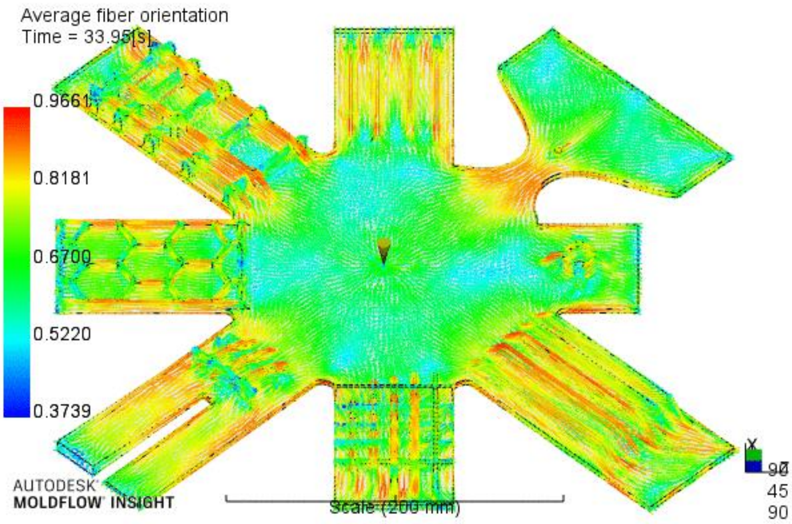


*Figure 4. Fibre orientation results*

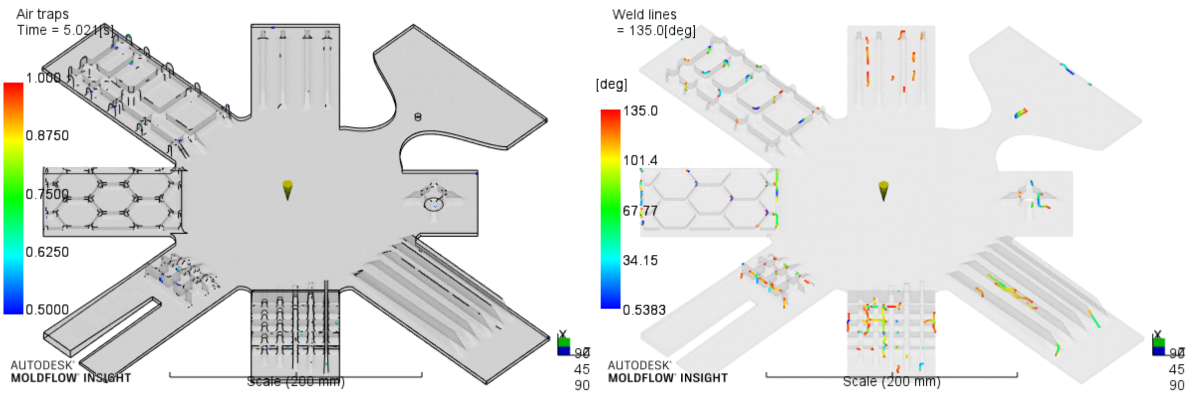


*Figure 5. Air traps (left) weld lines (right) results*

The simulation results suggest that the designs used resulted in strong alignment in some sections, mostly those parallel to flow direction, whereas geometries and sections angled to flow require specific design to demonstrate a noticeable degree of fibre alignment.

Furthermore, the simulation results of air traps and weld lines provide insight into the formation of these defects, with some sections displaying higher densities of defects (intersecting geometries) than others. This suggests specific design approaches can limit the formation of these defects.

## Conclusion and Recommendations

A compression moulded, recycled FRTC part was made analysing how mechanical properties, fibre properties, rheological properties and processing properties can be affected by different geometries, dimensions and parameters. While testing is required for conclusive evidence, simulations demonstrate the influence design has on these properties.

Continuation, in determining how these properties affect the final result, can be done by investigating more on intersections of the geometries, as those are where the densest areas of deformations can be found. Furthermore, varying pre-processing parameters like total fibre content will provide significant insight into determining further applications of recycled FRTCs. Finally varying the compression moulding processing parameters, heat and pressure, will provide interesting insights into many of the investigated properties.

# Bibliography

Simon, J. (2022, June). *Numerical simulation and experimental investigation of the forming of tailored fibre placement preforms : a mixed embedded-ALE finite element formulation.* Ph.D. dissertation.

Polymers International Australia. (n.d.). *Thermoplastics*. Retrieved July 24, 2024, from https://polymers.com.au/thermoplastics/