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Modelling and optimisation of rapid tow shearing for composite reflective mirrors in space-based laser communication systems

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ABSTRACT

This study focuses on the modelling and optimisation of a composite primary reflective mirror for a Schmidt-Cassegrain telescope, intended for laser communication systems in low Earth orbit. A novel manufacturing process employing rapid tow shearing (RTS) is developed to fabricate the mirror from aerospace-grade Hexcel 8552/IM7 carbon fibre prepreg. Process modelling includes forming and curing simulations, post-process distortion prediction and dynamic analysis to assess the mirror's performance under operational and launch conditions. Thermomechanical and hygrothermal models are incorporated to predict the behaviour of the mirror under thermal cycling, outgassing and launch acceleration. Optimisation aims to minimise mass and thermal distortion while maintaining a resonance frequency above the launch limit and ensuring structural integrity under launch loads. Comparative analyses are performed between the RTS-fabricated mirror and a conventional straight-fibre counterpart, demonstrating the capability of RTS for weight and distortion reduction. Additionally, the ability to tailor deformation fields through local variation of fibre orientation is investigated as a means of achieving enhanced optical performance. This research aims to validate RTS as an innovative manufacturing process for lightweight, high-performance space optics, paving the way for future technological advancements in space missions.

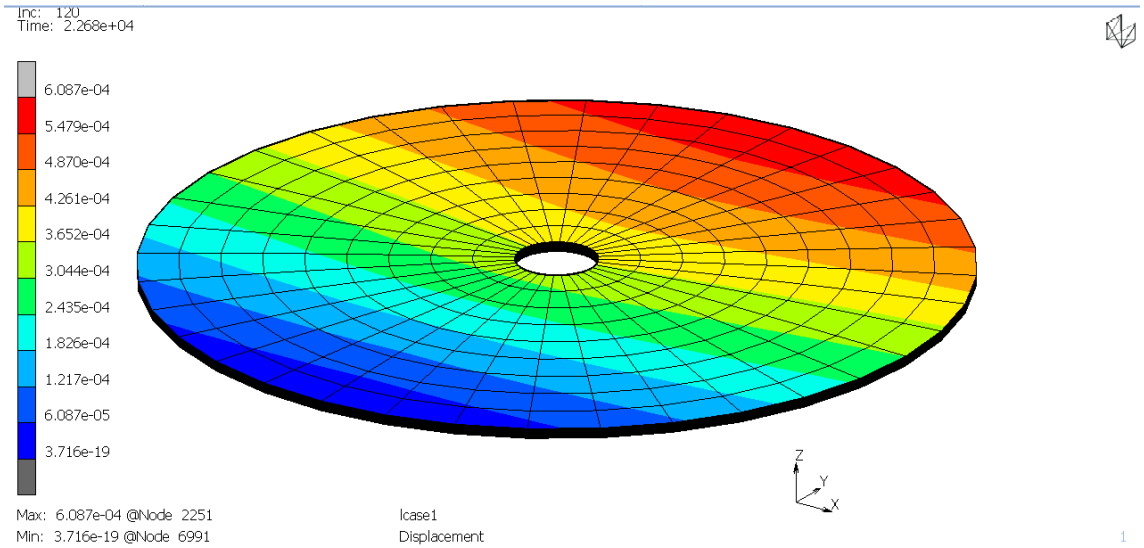


Figure 1 Post-curing displacement contour for straight-fibre mirror (Unit: m).

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