

# Finite Element Modelling of Automated Tape Laying of Thermoplastic Composites

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## Abstract

Automated tape-laying (ATL) is a technique for manufacturing thermoplastic composite components, in which the material is laid down and ideally consolidated in one step. It shows great promise for replacing expensive autoclaves in the aerospace industry but there is still some research and development needed before the final parts are of autoclave quality. The University of Limerick has just purchased a €1M laser-heated ATL system for research purposes and the first material of interest will be Carbon Fibre/PEEK. In ATL, a pre-impregnated composite (“pre-preg”) tape with thickness of the order 0.1 mm, is laid down by a robot, initially on a tool, and then, on subsequent passes, on top of previously laid layers (the “substrate”). The tape and substrate are heated to the melting point of the polymer via the laser, and pressure is applied via a roller. Ideally the final part can be lifted from the tool at the end of the process and no further processing is needed; however, presently industry practice is to autoclave the part after it has been laid down by the ATL machine, as the quality of the part is not good enough for use in primary load-bearing structures.

In this project, a micro-mechanical finite element model is being developed to simulate the deformation of the composite under heat and pressure, in order to predict the development of intimate contact between the two initially rough surfaces, and the compression of voids within the material. An automated method is being used to generate a representative volume element (RVE), containing randomly positioned fibres in a polymer matrix. Extremely fine meshes are required to model the flow of the polymer (a non-Newtonian fluid), and the movement of the fibres at melt temperature, and contact between all fibres and the matrix must be tracked, all of which leads to very high computational demands. This is an advance on most previous models which do not take the microscopic detail of the material into account, and approximate how the non-Newtonian polymer melt responds to shear strain rate.