

Optimization of die-temperature in pultrusion of thermosetting composites for improved cure

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Abstract

In this work, we will present a swarm optimization based approach to optimize die-temperature and pull-speed in pultrusion of thermosetting composite. Pultrusion is a composite manufacturing technique for processing continuous composite profiles with a constant cross section. The materials which are used for pultrusion in the industry are continuous glass fibers with polyester or epoxy resins. During composite processing, the reinforcing fibers are impregnated with a liquid resin in an injection box or resin bath, fibers and resin are preheated in a mold in which the curing process takes place. High productivity and low operating costs are the main advantages of this processing method. During processing, the heat flux provided by the mold must be sufficient to promote the polymerization reaction of the thermosetting matrix (curing). Furthermore, curing of a composite should be uniform and sufficient in order to provide a good quality of the end product. The exothermic character of the curing reaction induces, inside the composite, exceed temperatures. This temperature rise can cause degradation of the final product. Also, in pultrusion process, transport phenomena are involved and mathematical models are necessary to predict the physico-chemical behavior of the process. For such studies, the region enclosed by the mold is usually considered the main part of the process in which the curing reaction occurs and heat is transferred. Thus, the optimization process is quite important for the prediction of die-heating temperature and pull-speed.

To compute the die-heating temperatures and pull speed that give the best degree of cure of the composite we will use the function, given in [1], relating die-heating temperatures and pull speed to the degree of cure of the composite. A particle swarm based approach (see [2]) will be used to optimize this function. The best die-heating temperatures and pull speed found will be used again (as initial boundary condition) to compute the degree-of-cure profiles in the composite (at the exit section of the mold). This optimization step will

be executed several times until a measure of uniformity attains a certain threshold (the same measure as in [1] will be used).

As computational results, the die-heating environment will be optimized for few cases (different geometries) with different initial temperatures for a glass/epoxy. A general-purpose finite element software, ANSYS-16.2, is used in order to perform three dimensional conductive heat transfer analysis and the MATLAB PSO solver will be used to compute the die-heating temperatures and pull-speed. The solutions obtained using the PSO solver will be compared (when it is possible) to the exact solution of the optimization problem.

References

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