Computational vamadecum of the coupled mechanical/thermal behavior of composite materials during ultrasound curing

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ABSTRACT

Recently, composite material forming processes have been an active research topic, aiming faster and more reliable end products. Therefore, innovative processes are being designed and studied, such as ultrasound curing of thermoplastic composite materials. In fact, ultrasound curing of thermoplastics shows many advantages over classical curing methods. For example, it ensures a volumetric heating of the composite part through the propagation of the mechanical waves through the thickness of the composite laminates. However, because of the coupled physics and the complex behavior of such materials, ultrasonic heating of composite materials is not mastered yet and requires further investigations.

Thus, simulation of ultrasonic heating becomes compulsory for optimizing the process. Therefore, in this work, we propose to model the process from a dynamical viscoelastic model in the frequency domain. Later on, this model is coupled to the transient heat equation to give the temperature and heat flux in the simulated part.

On the other hand, the result depends strongly on the chosen experimental and material parameters such as the thickness of the part, its viscosity, the modulus of elasticity, the imposed frequency and displacement... Which makes the optimization of the process a tricky issue requiring a new solution for each choice of the process parameters.

Using the proper generalized decomposition (PGD), we are defining a coupled viscoelastic/thermal model where all the parameters mentioned above are included as extra coordinates of the problem. The resolution is moreover done within a realistic timeframe by using the PGD which alleviates the curse of dimensionality. In fact, the PGD acts by performing a separation of variables which reduces the solution dimensionality [1].The result is thus a computational vamadecum that we can use to obtain in real time the solution of the problem for any choice of the process parameters, fact that speeds-up its optimization [2].

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