Reduction of the Mesh Size Influence on the Results of a Lagrangian Finite Element Machining Model

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ABSTRACT

Mesh dependence of the results of a finite element model are well known in many fields such as in structural design when a geometric feature of the computed structure lead to a stress concentration. This problem is however not much addressed in the literature for machining modelling [1, 2] although it is crucial for the quality of the results and the predictive aspect of the model.

In this work, an orthogonal cutting model of the titanium alloy Ti6Al4V is exploited. Experiments [3] provide reference cutting force values and show that the chip is segmented for the cutting conditions adopted. The model formulation is Lagrangian and a damage criterion with eroding elements is used. A strong sensitivity of the results to the size of the elements is observed. Contrary to the expectations, the results do not converge when the size of the mesh decreases. Indeed, strain localization occurs in the primary shear zone; it is accentuated by the machined material properties and the cutting conditions. This complicates the choice of the size of the elements to be adopted for the model and calls for improvements.

To address this issue, a non-local damage criterion that involves a characteristic length that reduces the mesh dependence of the results [4] is introduced. The material constitutive model is consequently adapted to still represent accurately the behaviour of the material when damage initiation occurs (this time, crack propagation is modelled in two steps: initiation and propagation). The results show a strong decrease of their dependence to the size of the mesh. The recommendation is to use elements length that is not too far from the size of the grains of the material to avoid a dramatic increase of the computing time for very small elements and the absence of converged results for too large elements.

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