

# Alleviating mesh constraints: meshless simulations and related topics

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The numerical modeling of forming processes requires powerful numerical tools able to describe the multi-physics and multi-scale encountered, the large 3D transformations, ... but also the mechanical descriptions of material and process. Many difficulties have been identified, all of them being the topic of active researches today. Between them we can highlight: (i) the identification of constitutive laws in extreme conditions, (ii) the development of multi-scale approaches -in space and time- and the associated micro-macro strategies, (iii) the accurate description of large 3D geometrical transformations involving localization, (iv) the continuum-discrete bridge and the intermediate kinetic theory descriptions, (v) the model reduction (a priori or/and a posteriori) of the thermo-mechanical models, (vi) the moving interfaces descriptions and evolving discontinuities (PU, Level Sets, tracking versus capturing), (vii) the accurate accounting of multi-physics, ...

In this work we explore some alternatives based on the use of meshless techniques and other related techniques that allow alleviating the mesh constraints. The first approach consists of the use of the natural element methods [1] [2], whose place in the previous scenario will be deeply analyzed. On the other hand, accurate models of polymer materials are today defined in the kinetic theory framework. Kinetic theory models involving the Fokker-Planck equation, can be accurately discretized using a mesh support (Finite Elements, Finite Differences, Finite Volumes, Spectral Techniques, ...). However these

techniques involve a high number of approximation functions. In the finite element framework, widely used in complex flow simulations, each approximation function (also known as shape function) is related to a node that defines the associated degree of freedom. When the model involves high dimensional spaces (including physical and conformation spaces and time) standard discretization techniques fail due to an excessive computation time required to perform accurate numerical simulations. One appealing strategy that allows circumventing this limitation is based on the use of reduced approximation basis within an adaptive procedure. The new approximation functions are defined in the whole domain and they contain the most representative information of the problem solution. Thus, the number of degrees of freedom involved in the resolution of the Fokker-Planck equation is drastically reduced. The construction of those new approximation functions is done with an 'a priori' approach, which combines a basis reduction (using the Karhunen-Loève decomposition) with a basis enrichment based on the use of some Krylov subspaces. This strategy has been successfully applied, in some of our former works [3].

An important drawback of one such approach is the fact that the approximation functions are defined in the space domain, and until now, the simplest form to represent one such function is given its value in some points of the domain of interest, being its value defined in any other point by interpolation. Some times the treated model results highly multidimensional, as encountered in usual polymer models, and in this case the possibility of describing functions from their values at the nodes of a mesh or a grid in the domain of interest results simply prohibitory. Thus, a new strategy able to operate in these conditions must be proposed, validate and finally applied. A new numerical strategy able to circumvent some of the difficulties lying in the multidimensional character of kinetic theory models will be presented [4].

## References

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