Adaptive mesh refinement: Quantitative computation of a rising bubble using COMSOL Multiphysics®

T. PRENEY[1], P. NAMY[1], J. D. WHEELER[1]
1. SIMTEC, 155 Cours Berriat, 38000 GRENOBLE, France

Introduction: The Adaptive Mesh Refinement (AMR) method implemented in COMSOL Multiphysics® can help to mitigate computational time while maintaining precision. Instead of using a fixed mesh throughout the simulation, the initial mesh is adapted to the solution while the simulation is computed. An example is presented in Figure 1, where the mesh is adapted to a rising bubble inside a liquid.

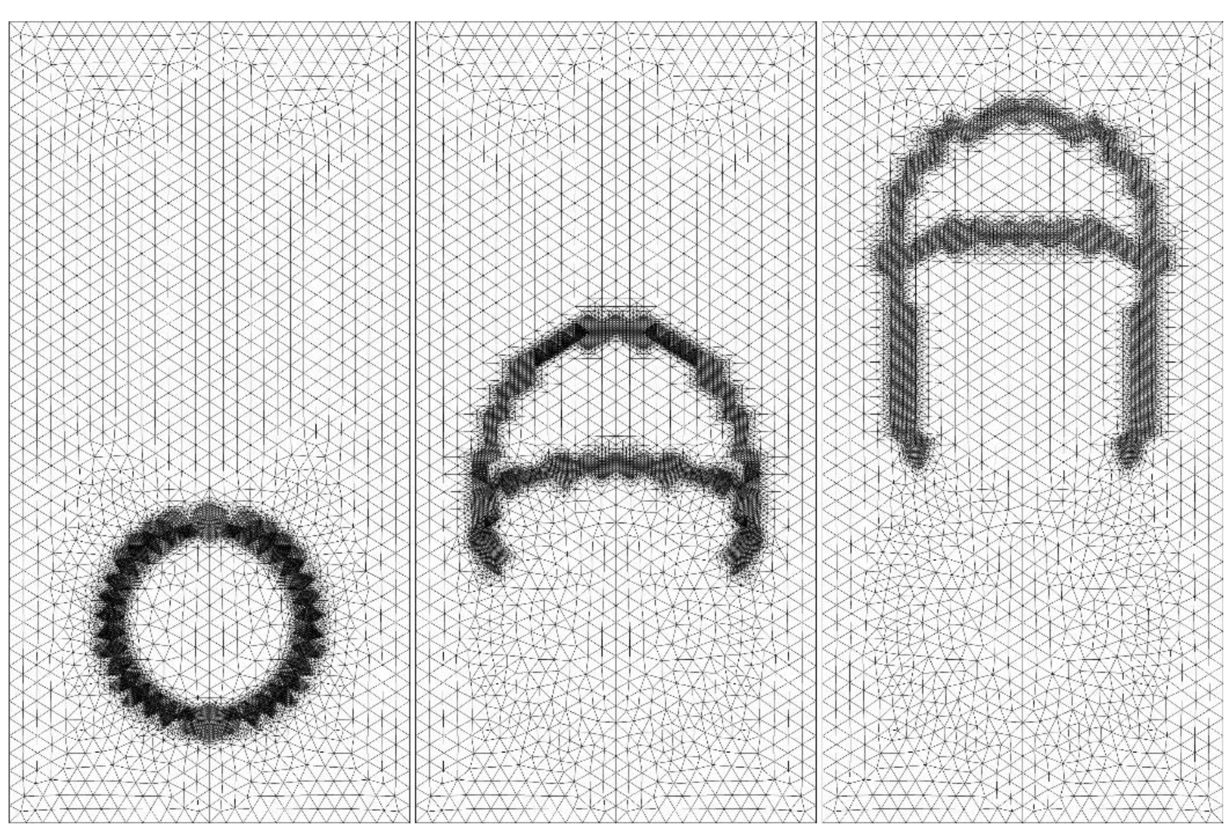

Figure 1. Meshes at different times adapted to a rising bubble

Configuration: To quantify the advantages of the technique, results obtained using the AMR technique are compared with results from a fixed mesh case and from literature [1]. The precision of the results and computational time are quantified to inform the FE analyst on the gain when using adaptive meshing.

Results: In Table 1, the number of degrees of freedom (DOFs) i.e. number of unknowns solved for, and computational times for both mesh case studies are reported. Even though the two models have an equivalent number of DOFs, the AMR method reduced the computational time by a factor of 5.

	Number of DOFs	Computational time
Fixed mesh	260 000	75 mins
Adaptive mesh	250 000	15 mins

Table 1. Computational times of fixed mesh vs. adaptive mesh

The shapes of the bubble domain from the fixed and adaptive meshes at t=3 s are compared in Figure 2.

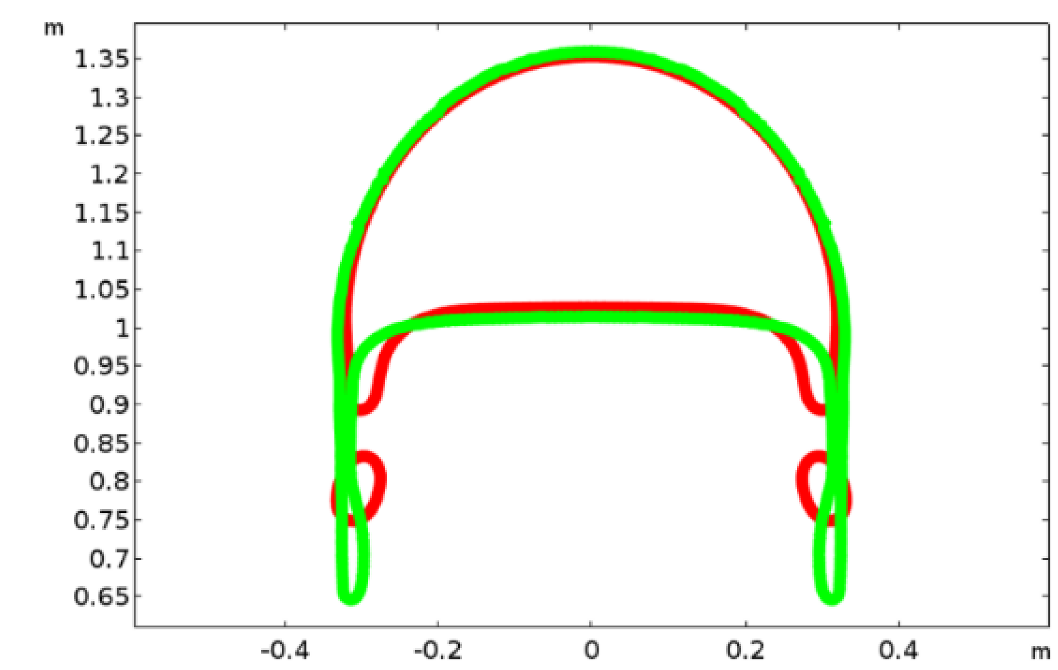

Figure 2. Shape of the bubble at t=3 s with a fixed mesh (red) and adaptive mesh (green)

In Figure 3, the difference in the position of the bubble centre of mass and the difference in the rise velocity between the results from the AMR method and benchmark are presented.The relative difference is less than 0,7% for the centre of mass and less than 4,5% for the rise velocity, hence the results are equivalent in precision.

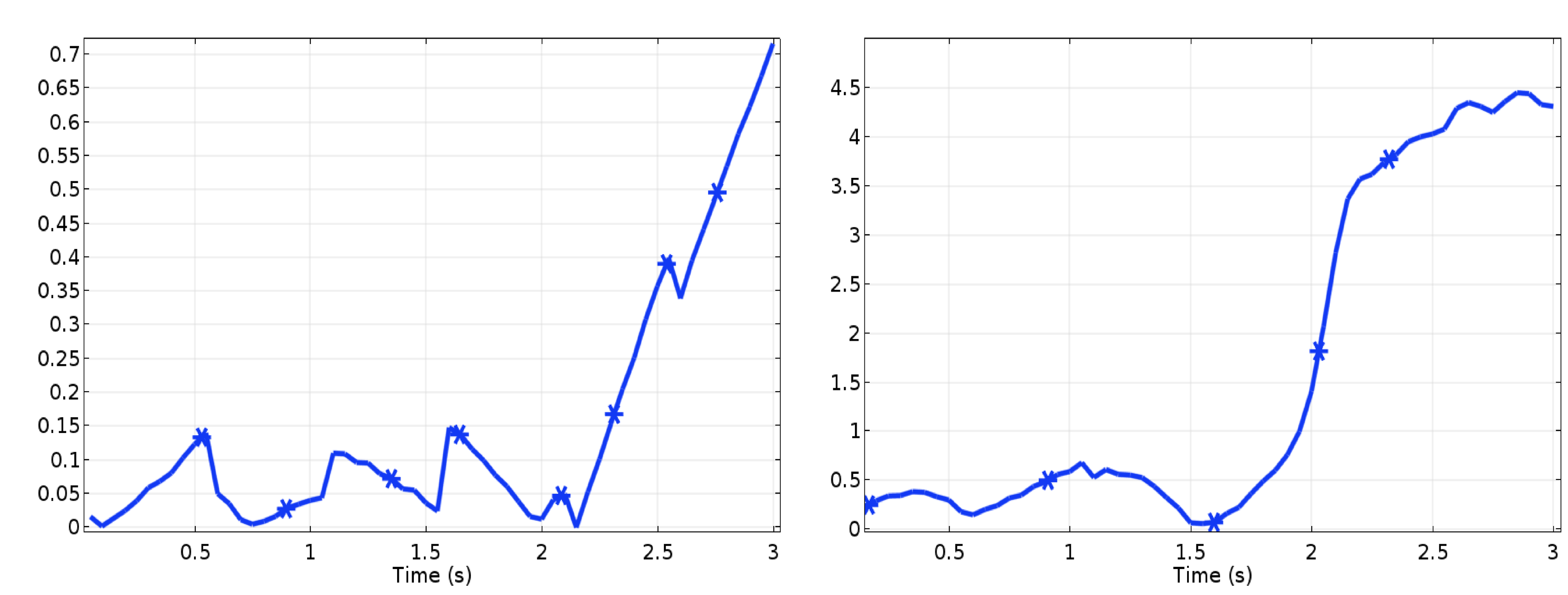

Figure 3. Difference in % of the position of the centre of mass (left) and the mean rise velocity (right) with respect to the benchmark

Conclusion: The results from the AMR method are in good agreements with the literature, highlighting the benefits in terms of precision as well as speed.

The method was validated and can now be used on complex industrials cases such as numerical simulations of welding or additive manufacturing.

References:

1. S. Hysing, S. Turek, D. Kuzmin, N. Parolini, E. Burman, S. Ganesan and L. Tobiska, “Quantitative benchmark computations of two-dimensional bubble dynamics”, *International Journal for Numerical Methods in Fluids*, vol. 60, pp. 1259-1288, 2009

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