A computational monolithic approach to thermo-structure interaction in rocket nozzles

In the present work, a monolithic solution approach based on a finite element method for the problem of thermo-structure interaction (TSI) in rocket nozzles is proposed. The structural and thermal fields are independently discretised. For the monolithic TSI scheme, an iterative solver (generalised minimal residual method) and an algebraic multigrid-based preconditioner are used, based on a Block-Gauss-Seidel approach. The proposed method is tested for the second Danilovskaya problem, and good agreement of the numerical results with results from the literature is observed. Furthermore, it is shown that the monolithic algorithm exhibits improved stability compared to fully-coupled partitioned algorithms. This novel computational method is developed for enabling improved designs of rocket nozzles for the application in overexpansion (on ground) and underexpansion (in vacuum) as well as against internal (pressure or temperature) and external loads (buffeting or booster radiation).