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Fast Boundary Element Method for Shape Optimization of RPV Nozzles

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Summary

A three-dimensional fast boundary element solver is developed for the shape optimization of nozzles of nuclear reactor pressure vessels (RPVs). In a RPV, pressure and mechanical loads may lead to high stress concentration due to the discontinuity of the structure, especially at the inner surface of the cold/hot legs. This work aims to minimize these stress concentrations by optimizing the geometry of the openings using modern shape optimization techniques and fast boundary element method. Shape optimization methods based on the principle of biological adaptive growth are incorporated into a boundary element method program and used to optimize the design of the RPV. The fast multipole method is adopted to accelerate the three-dimensional boundary element solution with large scales. In the numerical examples, the influence of the design variables on the convergence and efficiency is studied. Compared with the conventional design, the stress level at the in the optimized design is reduced significantly.