ABSTRACT

In this thesis, the finite element method (FEM) is extended into hierarchical higher order bases and the inexact Helmholtz decomposition. With the help of hierarchical basis functions, the approach can well adopt into *p* version adaptive process. On the other hand, the inexact Helmholtz decomposition enhances the stability of the finite element procedure when the operating frequency is low, or the element size is very small compared to the wavelength. This approach can also enhance the *h* version adaptive mesh refinement process since the process may cause very small elements near a singular region. To accomplish the inexact Helmholtz decomposition for the edge elements, the lowest order curl conforming basis functions, the tree-cotree splitting is utilized, and the general procedure is presented. As a result, a combination of hierarchical higher order basis functions with the inexact Helmholtz decomposition can improve the efficiency and the stability of the *hp* adaptive mesh refinement process. The accuracy and the stability of the improved FEM are also discussed through numerical examples.