THE P-VERSION IN PROFESSIONAL PRACTICE: AN OVERVIEW

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Although various implementations of the *p*-version are available in a number of commercial finite element computer codes, its widespread application in professional practice has been limited by three factors:

1. The infrastructure of the most widely used FEA software products was designed for the *h*-version, and cannot be readily adapted to meet the technical requirements of the *p*-versions.
2. In typical industrial problems finite element meshes are generated by automatic mesh generators that produce very large numbers of tetrahedral elements mapped by low order (linear or quadratic) polynomial mapping functions. When the mapping functions are of low degree then the use of high order elements is generally not justified. Nevertheless, numerous computational experiments have shown that *p*-extension performed on tetrahedral meshes up to $p = 4$ or $p = 5$ provides efficient means of verification for the computed data when the mappings are proper, that is, the Jacobian determinant is positive over every element. Experience has shown that many commercial mesh generators produce improperly mapped elements. As mesh generators improve and produce fewer elements and more accurate mappings, this obstacle will be gradually removed.
3. The demand for verified information in industrial applications of finite element methods has been generally weak, however as computed information is becoming an increasingly important part of the engineering decision-making process, the demand for verified data, and hence the importance of the *p*-version, is likely to increase.

At present the *p*-version is employed in industrial applications mainly where it provides unique technical capabilities. Some examples are: (a) Analysis of mechanical and structural components comprised of plate- and shell-like regions where dimensional reduction is applicable and solid regions where fully three-dimensional representation is necessary. (b) Two- and three-dimensional linear elastic fracture mechanics where *p*-extensions on geometric meshes, combined with advances extraction procedures, provide verified data very efficiently. (c) Analysis of structural components made of composite materials where special care must be exercised in choosing the mathematical model; large aspect ratios must be used and geometric as well as material nonlinear effects may have to be considered. (d) Interpretation of experimental data where strict control of the errors of discretization, (as well as the experimental errors) is essential for proper interpretation of the results of physical experiments.