Interpolation/penalization applied for strength design of 3D thermoelastic structures

With design independent loads and only a constrained volume (no local bounds), the same optimal design leads simultaneously to minimum compliance and maximum strength. However, for thermoelastic structures this is not the case and a maximum volume may not be an active constraint for minimum compliance. This is proved for thermoelastic structures by sensitivity analysis of compliance that facilitates localized determination of sensitivities, and the compliance is not identical to the total elastic energy (twice strain energy). An explicit formula for the difference is derived and numerically illustrated with examples. In compliance minimization for thermoelastic structures it may be advantageous to decrease the total volume, but for strength maximization it is argued to keep the total permissible volume. Linear interpolation (no penalization) may to a certain extent be argued for 2D thickness optimized designs, but for 3D design problems interpolation must be included and not only from the penalization point of view to obtain 0-1 designs. Three interpolation types are presented in a uniform manner, including the well known one parameter penalizations, named SIMP and RAMP. An alternative two parameter interpolation in explicit form is preferred, and the influence of interpolation on compliance sensitivity analysis is included. For direct strength maximization the sensitivity analysis of local von Mises stresses is demanding. An applied recursive procedure to obtain uniform energy density is presented in details, and it is shown by examples that the obtained designs are close to fulfilling also strength maximization. Explicit formulas for equivalent thermoelastic loads in 2D and 3D finite element analysis are derived and applied, including the sensitivity analysis.