Sensitivity Analysis Based Multi-Scale Optimisation

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ABSTRACT

Optimisation enables improvement of products with respect to given criterion and is becoming important tool in engineering because of limited material resources. Additionally, new manufacturing techniques like additive manufacturing makes it possible for complicated optimised geometries to be produced. Here idea for sensitivity analysis based multi-scale gradient optimisation is summarised.

Previous work on optimisation with AceFEM and AceGen in connection with imperfections of constructions can be seen in [1]. Optimisation was extended to multi-scale methods implemented in AceFEM, homogenisation technique FE^2 and domain decomposition method MIEL, for detail see [2]. Implementation in AceFEM enables analytical sensitivity analysis [3], which was used both for implementation of multi-scale methods and optimisation.

In case of MIEL second order sensitivity analysis is needed and was used two times. Firstly, first and second order sensitivity with respect to essential boundary conditions was used as a mean to calculate R_M residual and K_M tangent matrix of macro element, as an alternative to Schur complement. Secondly shape sensitivity was used to get $\partial R_M/\partial \phi$, sensitivity of previously calculated residual with respect to optimisation parameter ϕ, where ϕ was parameter that described geometry of the problem. With $\partial R_M/\partial \phi$ micro and macro scale were connected for purpose of optimisation procedure.

In case of FE^2, at micro level, meaning the RVE level, components of the stress tensor and its derivatives with respect to the components of strain tensor were calculated with use of essential boundary condition sensitivity analysis. For gradient based optimisation additionally shape sensitivity needed to be done, to be able to calculate sensitivity of stress tensor on shape parameter ϕ, which was needed for optimisation.

Different possibilities for use of sensitivity analysis were presented on example of multi-scale gradient based optimisation. On one hand sensitivity was used for communication between scales and on the other for optimisation.

REFERENCES

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