SENSITIVITY ANALYSIS OF COUPLED CRITICALITY CALCULATIONS

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ABSTRACT

Perturbation theory based sensitivity analysis is a vital part of today's nuclear reactor design. This paper presents an extension of standard techniques to examine coupled criticality problems with mutual feedback between neutronics and an augmenting system (for example thermal-hydraulics). The proposed procedure uses a neutronic and an augmenting adjoint function to efficiently calculate the first order change in responses of interest due to variations of the parameters describing the coupled problem.

The effect of the perturbations is considered in two different ways in our study: either a change is allowed in the power level while maintaining criticality (power perturbation) or a change is allowed in the eigenvalue while the power is constrained (eigenvalue perturbation). The calculated response can be the change in the power level, the reactivity worth of the perturbation, or the change in any functional of the flux, the augmenting dependent variables and the input parameters. To obtain power- and criticality-constrained sensitivities power- and k-reset procedures can be applied yielding identical results.

Both the theoretical background and an application to a one dimensional slab problem are presented, along with an iterative procedure to compute the necessary adjoint functions using the neutronics and the augmenting codes separately, thus eliminating the need of developing new programs to solve the coupled adjoint problem.

Key Words: Sensitivity analysis, adjoint sensitivity analysis procedure, coupled problems, Krylov methods

1. INTRODUCTION

Sensitivity analysis is a very useful tool in modern reactor design which provides means of calculating changes in responses of interest due to variations in parameters describing the system being investigated. In neutron transport calculations the most common responses are the critical eigenvalue and functionals of the flux, both for which perturbation methods are well established - perturbation theory for the critical eigenvalue and generalized perturbation theory (GPT) respectively [1–3]. These methods have the advantage that once an appropriate adjoint problem is solved and a specific adjoint function is obtained, the change in the response caused by any