Modeling of the Behaviour of Catalytic Recombiners in Containment System Code RALOC-MOD4

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Use of catalytic recombiners for the removal of hydrogen from the containments of nuclear power plants following a hypothetical severe accident appears to be very promising due to successful demonstration of their performances. Several such experimental programs have been reported in Germany, Canada and former USSR. Three different types of recombiners viz. 1) sandwich plate type, 2) box-type using thin catalytic foils and 3) box type using beds of catalyst coated granulates are tested for their performance in Germany. Although in general there has been a good progress on the experimental side, very little efforts appear to have been put in for the development of analytical model to enable prediction of their behaviour. The present paper describes a model developed for the sandwich plate type recombiner (developed by GRS/KfA) in conjunction with containment system code RALOC-MOD4.

The model is based on the use of modified Arrheneus equation to describe the kinetics of oxidation reaction of hydrogen on the catalytic plates. The exothermic heat of reaction is considered to be partly absorbed by the catalytic plates and partly dissipated to the surrounding gas mixture by convection and radiation and to the adjoining structures directly by radiation. The catalytic foils can be represented by conventional method of describing the heat slabs in association with the adjacent gas volume (zones) which may be a part of the network of other volumes and junctions in RALOC-MOD4. The model is capable of considering catalytic plates which may be covered with HEPA filter to protect them from deposition of aerosols or other fatty materials.

The model has been successfully validated using the data of experiments performed with sandwich type catalytic plates in 10 cubic meters capacity spherical vessel of HDR. The validation calculations have ban carried out for all the three tests viz. HDR-11-8-1, HDR-11-8-2 (convection tests) and HDR-11-7 (demonstration test) considering single volume as well as network of multiple volumes to represent the spherical vessel. The comparison between experimental data and model prediction has been generally satisfactory for the convection tests. For the demonstration test results of the calculations by the model were found to be in good agreement only when it was considered that some part of the foils were deactivated during the test at certain time. The partial deactivation of the foils during the tests appeared to be obvious from the nature of the measured experimental data. The model is found to be capable of predicting, in general, catalyst plate temperature and hydrogen conversion rates quite satisfactorily. The influence of discretising the geometry does not seem to be very appearent from agreement between the results of single zone and multizone calculations. Some sensitivity studies have also been carried out to investigate the influence of chosen empirical constants in the model.

The paper presents the model description and the results of validation of the HDR test data in details.