DESIGN OF CATALYTIC RECOMBINERS FOR SAFE REMOVAL OF HYDROGEN FROM FLAMMABLE GAS MIXTURES

Reinecke, E.-A., Kelm, S., Struth, S., Granzow, Ch., Schwarz, U.*
Forschungszentrum Juelich GmbH
Institute for Energy Research - Safety Research and Reactor Technology, IEF-6
52425 Juelich, Germany
e.reinecke@fz-juelich.de

* RWTH Aachen University
Chair for Reactor Safety and Reactor Technology, LRST
52062 Aachen, Germany

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Abstract

Several today's and future applications in energy technology bear the risk of the formation of flammable hydrogen/air mixtures either due to the direct use of hydrogen or due to hydrogen appearing as a by-product. If hydrogen may be released accidentally into closed areas countermeasures have to be implemented in order to mitigate the threat of an explosion. Especially when considering the public acceptance of hydrogen as a future energy carrier, safety devices for avoiding such threats will play an important role. Fuel cell or hydrogen powered cars are the most prominent amongst numerous examples for future applications of hydrogen that will be confronted with closed and semi-closed areas like garages, tunnels etc. Providing solutions for these applications means a great challenge with regard to the safety design of products and applications.

In the field of nuclear safety passive auto-catalytic recombiners (PAR) are a well-known device for reducing the risk of a hydrogen detonation in a nuclear power plant (NPP) in the course of a severe accident. As a consequence of chemical reactions during the core-melt sequence hydrogen is released into the containment forming a gaseous mixture with air. PAR boxes distributed inside the reactor containment of the NPP convert the hydrogen into steam and heat by means of catalytic recombination. Hydrogen and oxygen react on catalyst materials like platinum or palladium already far below conventional ignition limits.

In general, a PAR represents a safety measure that may be used complementary to other techniques, e.g. venting or inerting, or as stand-alone measure. However, the demands on PAR for non-nuclear applications can be quite different. With an increasing number of hydrogen applications numerous different scenarios with regard to possible release amount and rates, flow and process conditions etc. have to be considered. PAR designs will have to reflect the respective boundary conditions.

The most important concern with regard to the utilisation of hydrogen recombiners is the adequate removal of the reaction heat. Already low hydrogen concentrations may increase the system temperature beyond the self-ignition limit of hydrogen/air mixtures and may lead to an unintended ignition at hot parts of the PAR. Development work performed at FZJ include investigations on specifically designed catalysts and on passive cooling devices. Recently, both approaches have been successfully tested. In a design study both approaches are combined in order to provide means of efficient and safe removal of hydrogen. The paper contains a description of the recent developments and modelling approaches.