International role of nuclear fission energy generation, status and perspectives

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Abstract

The Fukushima incident in march 2011 caused worldwide a change in the perception of nuclear energy generation. Independent of the individual nation consequences drawn with respect to the future use of nuclear energy production the number of nuclear power plants (NPP) operated worldwide has hardly changed. Essential reasons are mainly rising feedstock prices, increased energy demands and the simultaneous aspiration to reduce substantially the CO_2-emission by fossil fuels. Especially emerging Asian economies are forced to an aggressive exploitation of all electricity generating technologies including nuclear to match their societal and economic demands. Nevertheless, the Fukushima accident initiated worldwide a new quality in the safety assessment and safety culture by considering additional man made or natural disasters. This process is almost other reflected in enhanced bilateral or international co-operations. One of the most striking consequences is that a safe NPP operation demands a continuous retrofitting and evaluation of the plant behavior based on the current state of science and technology, which is part of the German safety practice since the Three-Mile-Island (TMI) incident.

Within this article different new nuclear plant developments with enhanced safety features are presented. Although these concepts as well as their deployment options diverge considerably in desing and operational strategy the major nuclear protection goals in terms of confinement, coolability and reactivity control, which have to be met by any plant design, remain the same. Regarding the operational safety increased computational capabilities allow by means of coupled multiphysics and multi scale method to identify design weaknesses down to the pin scale of a fuel assembly both for steady state and also for transients of the plant. To master severe accidents the different plant concepts, however, yield to a considerably larger diversity of technical solutions mainly, for which nearly all are based on passive physical natural laws. A sustainable use of nuclear fuel avoiding large scale long term resistant repositories inherently implies a closed fuel cycle and the deployment of fast spectrum reactors, so-called Generation –IV reactors, for which similar nuclear postulations in terms of safety on all levels have to be demonstrated. Within the article for both operational safety and severe accident measures examples are presented to illustrate the main functionality and operational principle.