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Guest Editorial

Special Issue: Selected Papers from the 8th International Symposium on Supercritical Water-Cooled Reactors

Thomas Schulenberg

This special issue of the ASME *Journal of Nuclear Engineering and Radiation Science* comprises selected papers from the eighth International Symposium on Supercritical Water-Cooled Reactors (ISSCWR-8), held from Mar. 13 to 15, 2017, in the Celebrity City Hotel, Chengdu, China, 17 years after the first international symposium, which was held on this topic in Tokyo, Japan. Like in previous years, the international symposium attracted more than 90 participants from nuclear industry, research centers, and universities mainly from China, Canada, Europe, South Korea, Japan, and Russia. Within three days, around 90 presentations were given on design, safety issues, materials, thermal-hydraulics, and qualification tests of Generation-IV nuclear-reactor concept, providing a worldwide forum for information exchange on innovative nuclear research and technologies.

The supercritical water-cooled reactor (SCWR) is a nuclear technology of Generation IV, which had never been built in the past, but it is based on a long history of subcritical-pressure water-cooled reactors, which comprise the largest group of current operating nuclear-power reactors (in total 96% of 444 nuclear-power reactors in the world: pressurized water reactors (PWRs) (64%), boiling water reactors (BWRs) (18%), pressurized heavy water reactors (PHWRs) (11%), and light-water graphite-moderated reactors (LGRs) (3%)) and supercritical pressure (SCP) fossil-fired power plants, trying to exceed the current limits of nuclear power plants (NPPs) thermal efficiencies, while lowering the plant construction costs. It may feature a once-through steam cycle, such that supercritical "steam" is produced inside the reactor core, to be supplied directly to a high-pressure steam turbine. The former limits of a boiling crisis are physically excluded by increasing the system pressure beyond the critical one. Moreover, as supercritical water is a single-phase fluid, steam separators and dryers are not required nor does the system need any reactor coolant pump besides the feedwater pumps, making the nuclear island most cost effective. The other components of the steam cycle take advantage of the experience with SCP fossil-fired power plants, where supercritical steam cycles had been foreseen already since the 1990s.

Despite the fascination of simplicity, such SCWR concepts remain to be a challenge. At supercritical pressure, the turbine inlet temperature must be at least 500 °C to avoid moisture condensation inside the turbine, which does not sound like a material challenge compared with latest coal-fired power plants. The peak temperatures inside a reactor core, however, are significantly higher and the wall thickness of a fuel cladding is significantly smaller than those of boiler tubes, such that the tolerable corrosion thickness is smaller by an order of magnitude. Nickel-base alloys, though having an excellent high temperature creep and corrosion resistance, suffer from neutron embrittlement, limiting their application. Cladding materials and their water-chemistry requirements are thus among the key technologies to be developed for SCWRs.

Though being a single-phase fluid, supercritical water is significantly different by its thermophysical properties and behavior from those of ordinary liquids or gases, especially, within the critical or pseudocritical regions. Such conditions exist inside the reactor core even at normal operation, causing a challenge for heat-transfer predictions. All the fluid properties are changing significantly then inside the boundary layer, and all the conventional methods predicting heat transfer become obsolete. Technologies known from SCP fossil-fired power plants are not applicable since the heat flux of a nuclear-reactor core is about four times higher. Up to now, not even sophisticated computational fluid dynamics (CFD) with a fine resolution of the boundary layers could reach the prediction uncertainty of less than 10%, which is known from SCP coal-fired power plants.

The symposium gave an excellent overview on the state-of-the-art of these technologies, and the papers selected for this special issue discussed latest results. Like in previous symposia (i.e., ISSCWR-7), the development of new technologies was accompanied by reactor-design studies, indicating the expected parameters and conditions and guiding the international SCWR-research programs toward the envisaged application. The focus of this eighth symposium was on a pressure tube reactor concept at supercritical pressure, which had recently been studied in Canada, and on a pressure-vessel-type reactor producing 1000 MW electric power, which is currently being studied in China. Design details of these two quite different concepts gave an indication of the complexity and of technical issues and defined priorities for future technology development.

Far more urgent than these new technologies is the need of qualified nuclear experts, especially, but not only in countries with a rapid increase of nuclear power like China. The ambitious targets of SCWR concepts are challenging to leave the conventional path and to try unconventional, new solutions. They motivate to question well-known solutions of water-cooled reactors and even to try the impossible. We were happy to see so many young scientists, researchers, engineers, and students during this symposium, who presented their recent results on design and analyses of SCWR concepts, knowing that they will become the future generation of leading experts in the nuclear industry and in research institutions.

Since 2003, the international collaboration on SCWRs is coordinated by the Generation IV International Forum (GIF), with their joint projects on thermal-hydraulics and safety, on materials and chemistry, and on system integration and assessment. Representatives from Canada, China, Europe, Japan, and Russia in the SCWR steering committee are tuning their national programs to enable synergies and to share resources. They worked out a joint system research plan, prepared project agreements between member states, and initiated these International Symposia on SCWR design and technologies every two years.

Another central contact point, disseminating SCWR technologies to interested parties outside the SCWR System Arrangement, is the International Atomic Energy Agency (IAEA). Today, more than 20 member states of the IAEA have R&D projects related to SCWRs. Since 2008, the IAEA has launched several projects on SCWR technologies to facilitate collaboration and information exchange, including coordinated research projects (CRPs), technical meetings, and training courses on thermal-hydraulics, materials and chemistry, and on conceptual design.

Like all previous SCWR symposia, the ISSCWR-8 was open to everybody interested in this innovative technology, and the presentations given there provide an excellent overview of the worldwide status of the SCWR development. We want to thank all the participants for their fascinating contributions and the technical program committee, in particular, its Chair Dr. Y. P. Huang from the Nuclear Power Institute of China (NPIC), for organizing this symposium.

Thomas Schulenberg
Professor
Associate Editor
Institute for Nuclear and Energy Technologies,
Karlsruhe Institute of Technology (KIT),
Karlsruhe 76131, Germany