International Workshop

SUPERCRITICAL WATER AND STEAM IN NUCLEAR POWER ENGINEERING: PROBLEMS AND SOLUTIONS

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STATEMENT

In the near-term and mid-term, nuclear power development will rely on existing light water reactor technologies and their evolution. However, to increase the role of nuclear in energy supply, it is necessary to resolve some problems that may otherwise impede the advancement of the nuclear power sector.

Nuclear designers are challenged to:

- increase the efficiency and capacity factor of the new plants;
- reduce unit investments in plant construction;
- achieve more efficient use of fuel;
- close the fuel cycle;
- provide adequate management of the radioactive waste;
- support the non-proliferation regime.

Furthermore, these problems should be resolved with due regard for all safety aspects.

Nuclear community has been reviewing recently six most promising reactor technologies, in the framework of the International Forum G-IV. One of the technologies covers reactors with supercritical coolant parameters. The potential benefits of this technology, that can be expected judging from the experience of the supercritical fossil plants, inspired the countries with well-developed nuclear industry to undertake design studies in this area. The studies have proved the feasibility of the expected benefits (i.e. high thermal efficiency owing to the supercritical steam pressure and temperature over 500 ^{o}C; more simple configuration of the plants due to a once-through cycle, which makes it possible to exclude large expensive components such as steam generators, separators, main circulation pumps, etc.). At the same time, they revealed a number of challenges specific to this technology, that need to be properly addressed to attain the benefits of the supercritical coolants.

In Russia, design studies on coolants with supercritical parameters were performed for vessel-type and pressure-tube reactors (at Gidropress, NIKIET, IPPE, Kurchatov Institute). The findings of these studies have been presented at the workshop. One of the studies that raised interest was the concept of a high-temperature reactor with solid coolant, presented jointly by NPO “Lutch” and SEC NRS.

It was pointed out at the workshop that many problems associated with the use of a supercritical coolant in nuclear reactor are common to vessel-type and pressure-tube technologies. Therefore, it would be worthwhile for designers and engineers working in different countries and organisations to join their efforts to solve the problems related, in particular, to:

- materials;
- water chemistry;
- fission and corrosion product transport;
- radiolysis and coolant purification;
- experimental investigations into the heat transfer and fluid dynamics;

- development of the thermal hydraulic codes for computer simulation of processes taking place in the loops with supercritical coolants, and for a coupled neutronic and thermal hydraulic analysis of the core;
- development and testing of new fuel;
- in-pile tests.

To resolve these problems, it is necessary to study in depth and put to use the formidable experience of supercritical coolant application at fossil plants and missile facilities, as well as the experience in the high-temperature steam reheating at AMB reactors and loop facilities at the Beloyarsk NPP and in the vessel-type US reactor Pathfinder. The workshop participants believe that it would be useful to carry out a post-irradiation examination of the fuel assemblies and steam reheating channels PPK-C still kept in the Beloyarsk SNF storage pools.

Development of the thermal hydraulic codes to analyse processes occurring in the loops and cores with a supercritical coolant calls for a broad verification base. The existing data are insufficient; therefore, it is necessary to establish an experimental programme for studying the thermal hydraulics of the supercritical coolants; the radiation, erosion and corrosion resistance of structural materials; coolant chemistry; develop a programme for an in-pile testing of fuel rods and fuel assemblies. The problems specific to the cores of vessel-type and pressure-tube reactors with supercritical coolants should be investigated as well.

The workshop presentations and discussions have demonstrated that the most efficient way of developing supercritical coolant technologies for nuclear reactors lies through the international collaboration, exchange of experience and investigation results. Russia should join the relevant international programmes and bring in its expertise in this field.

The participants think that reactors with supercritical coolants and related R&D should be included into the Russian federal programme “Nuclear power technologies of the new generation for 2010-2020” being developed at present.