SESSION I SUMMARY / DISCUSSION

Moon H. Chang

Korea Atomic Energy Research Institute (*mhchang@kaeri.re.kr*)

SEssion I of the GIF symposium 2009 was composed of several presentations on R&D activities in two areas, the Crosscutting R&D Working Groups and the VHTR system. The presentations were focused on the major achievements made since R&D activities were launched and also, the expectations of achievement for the next five years.

Crosscutting R&D Working Groups

Three Crosscutting R&D Working Groups have been taking an active role in developing relevant methodologies for supporting the development of Generation IV systems. The methodologies developed by each WG were independently tested, evaluated, and then provided to each system to be used for system evaluation and development.

The EMWG (Economic Methodology Working Group) has developed a cost estimating guideline and verified a software package (G4-Econs) against benchmark models. Two approaches for the cost estimation were adopted for application to different levels of system design. The methodology was then applied to the JSFR for the purpose of analyzing its capability by comparing it with various different methodologies and to prove its reliability. The EMWG released the SW package for use by GIF SSC, IAEA, universities and the public for evaluation of the cost of their systems and to receive feedback from users.

The PRPP WG (Proliferation-Resistance and Physical Protection Working Group) has developed the PRPP methodology by identifying and implementing several important elements to be considered concerning the PRPP evaluation. Workshops and interactions with other spheres of activity contributed to further define the methodological approaches and the needs of users. The Safeguard by Design (SBD) concept is recommended as a mechanism for proliferation risk reduction assessment. Efforts are on-going to seek harmonization and the potential for synergy between GIF-PRPP methodology and INPRO initiatives.

An Integrated Safety Assessment Methodology (ISAM) for the safety evaluation of Generation IV systems was developed through the tremendous effort of the RSWG (Risk and Safety Working Group). Five principle postulates for an integrated philosophy are established and implemented into the methodology. The methodology also defined three design attributes for achieving safety goals. The PSA-based ISAM can be used at any stage of concept development and during the design phases of the system. The ISAM is not intended to measure the level of safety, but to contribute to achieving safety objectives during design development.

Discussions

The economic aspect is a fundamental element of importance together with the safety aspect in evaluating the merits and/or demerits of the system and associated technologies. Therefore, the highly reliable estimating capability of the economic evaluation tool is held in high confidence by users. It is thus advisable that the EMWG considers various mechanisms for promoting further broad interactions with other national and international projects and also performs case studies of various advanced nuclear system developments as ways to enhance the reliability and trustworthiness of the methodologies.

The PRPP is considered as a very difficult and challenging area with respect to getting consensus and agreement from the associated stakeholders. Various different strategic understandings among stakeholders may exist in dealing with the methodology and in interpreting the results of the analysis of the PRPP applications. The reliability and applicability of the methodology may be strongly dependent on the perspectives of the stakeholders of the PRPP. Close communication and interaction might be needed for increasing the common understanding and harmonized agreement within the society of the stakeholders.

Very High Temperature Reactor (VHTR) System and Technology

Several on-going national mid-term projects of the GIF member countries for the period of 2015-2025 were introduced and emphasis was placed on strengthening future R&D efforts to resolve various technical issues and to advance technologies. There are three R&D projects in the VHTR system currently on-going through collaboration within participating member countries: the VHTR Fuel and Fuel Cycle Project, the Hydrogen Production Project, and the VHTR Material Project.

The technology development for the TRISO coated fuel and studies concerning the back-end closed fuel cycle management are the main R&D areas of interest in the VHTR Fuel and Fuel Cycle project. Major on-going activities in the project cover a wide spectrum of R&D areas through collaboration with participating member countries. The activities include: pyrocarbon irradiation tests (PYCASSO program) and AGR-2 experiments, measurements of basic properties of TRISO fuel materials and experiments for fuel performance modeling, R&D and tests for long-term direct disposal of coated particles and feasibility evaluations for the graphite reuse, and the deep-burn program (PUMA) for burning the Pu fuel and Minor Actinide (MA) in VHTR.

The Hydrogen Production project is currently at the stage of compiling data and results concerning hydrogen production and also the technology of the system coupling between the reactor and hydrogen production system. For the Sulphur-Iodine (SI) process, major progress has been achieved in the areas of material screenings, tests of component performance, and bench-scale experiments. Efforts are being pursued to scale-up the process and to further collaborate on a pilot-scale plant construction. The R&D efforts for developing technologies for the High Temperature Electrolysis (HTE) process have been focused on R&D for hydrogen production while increasing the core outlet temperature to around 950 degrees, and even higher. As potential alternative processes, the Cu-Cl cycle and hybrid sulphur (HyS) cycle were investigated. The economic evaluation for these various processes is being performed. The technology of coupling the hydrogen production system with a nuclear reactor is technology of importance with reference to the safety, reliability, and performance of the coupled system. The coupling technologies are also under evaluation.

The R&D efforts in the VHTR Materials project have been focused on the work packages of three different materials – graphite, high-temperature metals, ceramics and composite - for use in different components of the reactor system. As an on-going R&D activity, the graphite study work package selected several candidate materials satisfying the selection criteria, and those selected materials are under various irradiation tests for evaluation. The design codes and standards are also being developed for material qualification. For the metal study work package, R&D programs for the selected materials have been defined, and performance studies for those selected materials are underway. The studies for the ceramic and composite work package have been concentrated on major issues such as standardization and codification of materials along with mechanical and thermal evaluation efforts. Further, a dedicated web-based database has been developed for harmonized use in VHTR development.

The priorities concerning the VHTR system and technology development for the next five years will be the following activities.

- The VHTR viability phase will be completed by 2010 by optimizing the design features and operating parameters of the VHTR systems.
- Further assessment for the range of candidate applications of VHTR with variable core outlet temperatures will be carried out.
- High temperature process heat for various industrial applications is an important domain of study.
- For the hydrogen production work package, efforts will be pursued to resolve the feasibility issues (process, technologies), and the priorities concerning R&D needs and pre-industrial projects will be updated.
- For material work packages, efforts will be pursued to resolve the feasibility issues (qualification, manufacturing) for core and cooling systems, and there will be an update of R&D priorities.
- For the fuel work package, major efforts will be pursued to establish performance margins and FP source terms of TRISO fuel particles.

Discussions

It is agreed that much valuable achieve–ments arising from R&D efforts for the VHTR system and technology have been made in all the currently on-going projects. Most of the participating members in the VHTR system are conducting near-term deployment national projects and are providing their valuable output to the joint collaborative project. The experiences and lessons learned over past years in various types of gas-cooled reactor technologies have also been very effectively utilized in establishing guidance for the direction of the current R&D efforts to develop and advance the technologies necessary for the VHTR system.

The goal and objective of joint collaboration for the Generation IV VHTR system is to develop a baseline model system with very high coolant outlet temperature and other associated technologies. From the viewpoint of the GIF philosophy of collaboration among participating member countries, it is thus important to consider how to effectively harmonize and utilize the contributions provided from those near-term national projects for developing a GIF baseline model. Also careful consideration should be made on how to share the commercial technologies, information, and experiences of participating members without infringing on intellectual property rights.

The computational methods development project, the launch of which is still under discussion between provisional members, is considered, in general, to be a fundamental and essential project for a reactor and its components development. The methodologies developed and proved through this R&D project must be utilized to assess, analyze, develop, and design the system. Although various elements and considerations need to be discussed and there should be a consensus on how to initiate this project, it is strongly recommended that a common understanding is reached as early as possible among the provisional participating members with respect to the important role of the project in system development.

One of the elements receiving increased attention and concern from the nuclear society as well as from non-nuclear societies when considering the use of nuclear energy is the reasonable and employable mechanisms for managing spent fuel. The VHTR system is recognized as a reactor system producing a tremendous amount of spent fuel due to its operating characteristics compared to the other Generation IV systems. Thus, it is highly recommended that much more emphasis is placed on this area, and that focused R&D considerations for spent fuel management must be taken into account when defining further R&D activities.

As discussed above, the development of the Generation IV baseline model technology may take advantage of information and outputs contributed from the near-term deployment of national projects. However, in contrast to the initial target for the coolant outlet temperature of the Generation IV VHTR system, most of those national projects design their reactor system with the outlet temperature at around 750 degrees which is a much lower temperature than the Generation IV initial target around 950 degrees and/or even higher. In other words, it seems that the target coolant outlet temperature has been lowered in comparison with the original Generation IV philosophy and objectives without generally agreed consensus within collaborative environments. In a certain sense, this may be an acceptable strategic approach to create more confidence in the VHTR system development by assuring the reliability of the technology through the relatively low-temperature HTR experiences. However, it is still strongly desired that the initial target temperature of VHTR should be aimed at as a technical challenge for the development of the Generation IV VHTR system.

The material availability and reliability in circumstances of very high temperature may become an Achilles' heel concerning the successful development and commercial realization of VHTR technology. Although most of the material R&D activities have been focused on those aspects so far, further strengthened and comprehensive collaborative efforts are needed to concentrate on material development and qualification that is practically applicable in very high temperature environments.