ADVANCED ENERGY SYSTEM WITH NUCLEAR REACTORS AS AN ENERGY SOURCE

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ABSTRACT

About two-thirds of the energy generated in a light water reactors (LWRs) core is currently dissipated to the ocean as lukewarm water through steam condensers; more than half the energy in helium (He) gas turbine high temperature gas cooled reactors (HTGRs) is dissipated through pre-coolers and intercoolers. The new waste heat recovery system1) efficiently recovers the waste heat from reactors using boiling heat transfer of 20°C liquid carbon dioxide (CO2) instead of conventional sea water as a cooling medium. The CO2 gasified in the cooling process is used directly as a working fluid of mechanical heat pumps for hot water supply. In LWRs, the net energy utilization fraction to total heat generation in the core exceeds 85% through the waste heat recovery. This cogeneration system is about 2.5 times more effective than current systems in reducing global warming gas emissions and long half- life radioactive material accumulation. It also increases uranium resource utilization relative to current LWRs. In the HTGR cogeneration system, the waste heat is also useful for cold water supply by introducing an adsorption refrigeration system since the gas temperature is still as high as about 190°C. When the heat recovery system is incorporated into the HTGR, the electricity to heat-supply ratio of the HTGR cogeneration system accommodates the demand ratio in cities well; it would be suited to dispersed energy sources. The heat supply cost is expected to be lower than those of conventional fossil-fired boilers beyond operation of about four years. The waste heat recovered is able to be utilized not only for local heat supply but also for methane and methanol production from waste products of cities and farms through high-temperature fermentation, e.g., garbage, waste wood and used paper that are produced in cities, along with excreta produced through farming. The methane and methanol can be used to generate hydrogen for fuel cells. The new waste heat recovery system is also applicable to a fast reactor (FR) with a supercritical CO2 gas turbine2) that achieves higher cycle efficiency than conventional sodium cooled FRs with steam turbines. The FR will eliminate problems of conventional FRs related to safety, plant maintenance, and construction costs. The FR consumes efficiently trans-uranium elements (TRU) produced in light water reactors as fuel and reduce long-lived radioactive wastes or environmental loads of long term geological disposal3).

An Advanced Energy System (AES) with nuclear reactors as an energy source has been proposed which supply electricity and heat to cities. The AES has three objectives:

1. Save energy resources and reduce green house gas emissions, attaining total energy utilization efficiency higher than 85% through waste heat recovery and utilization.
2. Foster a recycling society that produces methane and methanol for fuel cells from waste products of cities and farms.

3. Consume TRU produced in LWRs as fuel for FRs, and reduce long-lived radioactive wastes or environmental loads of long term geological disposal.

References

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