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Structural Material Innovation for Advanced Blanket Design–Current status and future prospect of ODS steels R&D–

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Materials development is essential for realization of fusion DEMO reactor and beyond. High performance materials R&D has been conducted for the last several decades, and there have been made some remarkable technology innovations of fusion blanket structural material including first wall material. Among the several candidate blanket structural materials, oxide dispersion strengthened (ODS) steels, which have been produced by means of mechanical alloying, are considered to be promising for advanced nuclear systems with high thermal efficiency, because the ODS steels have high-strength at elevated temperatures and good resistance to corrosion and irradiation degradation.

There are several sorts of ODS steels with different Cr contents: (9-12)Cr-ODS ferritic/martensitic steels and (14-16)Cr-ODS ferritic steels with and without Al addition [1]. The former two groups of ODS steels were developed for application to sodium cooled fast reactors and fusion reactors, and the last group of ODS steels were for so-called Generation IV nuclear systems. More recently, accident tolerant fuel R&D is progressing to apply high Cr/high Al ferritic ODS steels to fuel cladding of light water reactors because of "Fukushima Incident". It has been considered that the replacement of Zirconium alloys cladding with high-performance ferritic steels cladding may retard the hydrogen generation at a severer accident of nuclear reactors, resulting in a large time lag up to hydrogen explosion.

In this presentation, current status of ODS steels R&D is summarized and the impacts of some material innovations on the safety issue of nuclear technologies are addressed. Radiation tolerance mechanism of ODS steels is introduced in terms of trapping capacity for radiation defects caused by nano-scaled ultra-fine oxide particles dispersion. Furthermore, the recent experimental results on mechanical properties at elevated temperatures, aging effects, corrosion behavior in super critical pressurized water and liquid lead alloy eutectics and phase stability under ion-irradiation of ODS steels are shown to demonstrate that the ODS steels with nano-scaled oxide particles in high number density are promising for radiation tolerant nuclear material.

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