11. Fusion Engineering Research Center

The researches in Fusion Engineering Research Center are categorized into (1) basic research for liquid blanket, (2) R&D for low activation materials and (3) fusion-relevant research for superconducting magnet with emphasis on radiation effects. Major efforts of the liquid blanket research are the compatibility of structural materials with molten-salt Flibe and liquid Li as a basic study for Flibe and liquid Li blanket.

Compatibility of Reduced Activation Ferritic/ Martensitic Steels (RAFM) with Flibe was investigated by static immersion tests as a collaboration with U. of Tokyo. The corrosion of RAFM in Flibe highly depends on the impurity level. Purification of Flibe is being carried out as essential technology for the corrosion tests. Also carried out was the corrosion test of RAFM in flowing HF gas atmosphere. The corrosion of RAFM was shown to be a competing process of fluoridation and oxidation. A forced flow Flibe convection loop was designed in the previous year. In this year, some fundamental R&Ds for developing the loop facility were carried out such as compatibility of Flibe with SUS316L which is the structural material for the designed loop.

Compatibility of RAFM with liquid Li was studied in static pots and a thermal convection loop. The exposure of RAFM to liquid Li at high temperature induced depletion of carbon from the steel and resulting martensitic - to - ferritic phase transformation. The weight loss and the formation and extension of the area of the phase change were enhanced in flowing lithium. The level of N in Li was also shown to influence strongly the corrosion loss.

Neutronics investigation of the liquid blankets were carried out using Fusion Neutronics Source of JAEA. The activation and transmutation of Li/V blanket was tested by simulating the blanket neutron spectra using Li blocks. The uncertainty of neutron activation cross section of Er was evaluated by comparison with the Monte-Carlo neutron transport analysis.

As the new technology for fabrication of MHD insulator coating and T barrier coating, Metal Organic CVD was applied to coating Er_2O_3 on vanadium substrate. High crystalline, high purity coating of Er_2O_3 was fabricated by controlling the substrate temperature and the flowing rate of the carrier gas. A new effort started to develop an on-line hydrogen sensor using proton conductors for application to liquid blankets. The applicability of $CaZr(In,Hf)O_3$ sensors to the hydrogen partial pressure identical to those in liquid Li and Flibe blankets was demonstrated.

As the fundamental study for enhancing high temperature strength of vanadium alloys, microstructural processes of creep deformation of V-4Cr-4Ti strengthened by precipitation and cold-rolling were investigated. The dislocations observed were mixture of a<100> and a/2<111> types in the specimens with only thermal aging, but predominantly of a/2<111> type in the specimens after the creep deformation. With the change of the dislocation type, coarsening of the precipitates started.

Ageing behavior of RAFM steels were investigated for Japanese candidate (JLF-1) and Chinese candidate (CLAM) materials. The results showed increase in hardness and improved creep properties after ageing at 823 K/2000 h for the both steels, implying the strengthening. However, softening and degradation of creep properties occurred after ageing 973 K/100 h. Lower normalization and tempering temperature of CLAM steel were suggested to be responsible for higher hardness and tensile strength, lower minimum creep rate and longer rupture time, and for higher susceptibility to the thermal ageing than those of JLF-1.

The V_3Ga multifilamentary wires were fabricated through the new route Powder-In-Tube (PIT) process using various high Ga content compounds and their high magnetic field properties were examined. The typical R (Resistance)-B (Magnetic Field) curves of samples using high Ga content Cu-Ga compound showed that the normal transition magnetic field was improved with increase of Ga content of filament compound. It was confirmed that H_{C2} property was improved about 23 T by the high Ga content of the precursor and its value was about 2.0 T higher than that of conventional processed samples when used the 50 at%Ga composition powder.

Under the recognition of the necessity of neutron irradiation investigation on property changes, an attempt of forming collaboration network among related research fields has been obtained. Core affiliations of the network are NIMS, Osaka University, Tohoku University, NIFS and JAEA. The neutron irradiation facilities are FNS and JRR-3 in JAEA and BR2 in Belgium. IMR Oarai center in Tohoku University plays a role of connection center to JRR-3 and BR2. FNS equips a D-T reaction target. Also, there is GM refrigeration system keeping the samples at 4.5 K during neutron irradiation. The samples for neutron irradiation were NbTi, Nb_3Sn, Nb_3Al wires, Bi2223 tapes and electric insulation materials with glass fiber reinforced clothes. The critical current, the critical temperature and the critical magnetic field were measured before and after irradiation in some samples. The insulation materials have a matrix of an epoxy resin, and (cyanate ester + epoxy) blended resin. The interlaminar shear strength was evaluated with the short beam method at room temperature and 77 K.

Radiation shielding performance for protection of a superconducting magnet system is one of important issues in fusion blanket designs. Investigations of the shielding performance of liquid Flibe cooled and Li cooled advanced blanket systems proposed in the FFHR2 helical reactor design have been conducted by neutron and gamma-ray transport calculations. It has been confirmed that the DPSS (Discrete Pumping with Semi-closed Shield) concept is significantly effective for improvement of radiation shielding performances of helical reactors.

Fundamental study on solid breeders was carried out. The retention behavior of deuterium implanted into Li_2TiO_3 was investigated by means of Thermal Desorption Spectroscopy (TDS) and X-ray Photoelectron Spectroscopy (XPS). It was concluded that formation of O-T bond would affect tritium inventory and might restrict tritium recovery.

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