5 - 1 Advanced Nuclear Material Research at the Laboratory of Nuclear Engineering Materials

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Achieving Accelerator Driven Advanced Nuclear Energy System (ADANES) presents a formidable challenge to the field of material science, which is to provide a suite of sustainable materials in close integration to the Spent fuel combustion, separation and reprocessing and other applied technologies. The technological challenge presented by the conceptual future ADANES is the inability of current materials and components to withstand the harsh nuclear environment. The overall goal of ADANES material program is firstly to provide the applied materials science support and material understanding for burner engineering construction of China Initiative Accelerator Driven System (CiADS) project, in parallel with developing materials for spent fuel cycle systems.

The task of Laboratory of Nuclear Engineering Materials (LNEM) is aimed at developing and qualifying engineering materials that be able to meet the engineer applications of CiADS project, especially for spallation target and future advanced lead-based alloy cooling reactor. In order to fulfill the strategic requirements of key engineering materials, relying on the Heavy Ion Research Facility in Lanzhou (HIRFL) and Advanced energy science and technology Guangdong laboratory, engineering-oriented work at our lab in this year particularly focus on two parts below.

The first is the continue long-running program to pursue development of low activation structural materials, with the greatest effort directed at the SIMP steels and other alloys (including Ti/Al alloys, new concept radiation-resistant materials high/medium entropy alloys). Tasks within SIMP steel related portfolio are pursuing several options for its applications: These include development of SIMP steel heat exchanger, welding technology, exploratory work on beam and lead-bismuth eutectic (LBE) target window. Parallel to this is the increased emphasis on high temperature water and LBE corrosion[1,2], radiation effects[3−7] and their synergistic effects[8], and the study and understanding of the irradiation performance of other structural materials (including T91 martensitic and 316L austenitic steels). Continuing efforts also support the ceramic core reactor for ADANES on composite ceramics[9−12].

The second part is technological improvement and laboratory construction. Newer efforts on TiAlN gradient coating technic that promise improved radiation resistance and liquid metal compatibility[13]. Continuing work supported by Instrument Special Project of Chinese Academy of Sciences is measurement and control technology of oxygen in LBE. A limited effort is directed at examining and exploratory on synergistic (irradiation and corrosion) effects of structural materials.

References

[1] C. Liu, P. Jin, T. L. Shen, et al., Corrosion Science, 207(2022)110557.
[2] Z. W. Ma, T. L. Shen, T. Zhou, et al., Materials and Corrosion, (2022)1.
[3] P. Jin, T. L. Shen, J. Li, et al., Nucl. Sci. Tech., 33(2022)79.
[4] P. Jin, T. L. Shen, J. Li, et al., Vacuum, 207(2023)111639.
[5] L. L. Pang, Pe. F. Tai, L. Q. Zhang, et al., Journal of European Ceramic Society, 42(2022)7421.
[6] M. Cui, P. Jin, T. Shen, et al., Metals, 13(2023)60.
[7] Z. Q. Su, Z. D. Quan, T. L. Shen, et al., Materials, 15(2022)6565.
[8] C. F. Yao, H. P. Zhang, H. L. Chang, et al., Corrosion Science, 195(2022)109953.
[9] Y. B. Zhu, J. L. Chai, Z. G. Wang, et al., Journal of European Ceramic Society, 42(2022)2567.
[10] Y. B. Zhu, Z. X. Qin, J. L. Chai, et al., Metallurgical and Materials Transactions A, 53A(2022)1188.
[11] J. L. Chai, Y. B. Zhu, X. Gao, et al., Ceramics International, 48(2022)23258.
[12] J. L. Chai, Y. B. Zhu, P. Jin, et al., Materials Characterization, 193(2022)112328
[13] P. F. Tai, L. L. Pang, T. L. Shen, et al., Surface & Coatings Technology, 441(2022)128494