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THE APPLICATION OF NANO FLUID TECHNOLOGY ON MHD EFFECT OF LIQUID METAL TRITIUM BREEDER BLANKETS

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The breeding blanket is the key nuclear component for power extraction, tritium fuel sufficiency and radiation shielding in fusion reactors. Using pure lithium (Li) or Li-containing liquid metal (e.g. eutectic alloy lead-lithium, PbLi) in fusion blankets as breeder is a very attractive option due to their high heat removal, adequate tritium breeding ratio, relative simple design, potential attractiveness of economy and safety. All liquid-metal blankets have special features associated with the nature of liquid breeders, including their high chemical reactivity, and especially interaction with the plasma-confining magnetic field. Flowing liquid breeder under magnetic field would result in various magnetohydrodynamic (MHD) phenomenon such as huge MHD pressure drop, quasi-two dimensional turbulence. It would be an effective way to reduce MHD effects by reducing electric conductivity of liquid metal breeder.

A potential technology to reduce electric conductivity is nano fluid technology, which adds functionalized nanoparticles into fluid to change its physical property. We demonstrated that it is possible to reduce electric conductivity of liquid metal by adding electrically insulating nanoparticles. The liquid metal we tested was eutectic alloy of GaInSn, which is liquid at room temperature. The nanoparticle we chose was SiO2, whose electric conductivity was several orders of magnitude lower than that of liquid metal and had a good wetting property with GaInSn. SiO2 nanoparticles smaller than 200 nm in diameter were added into liquid metal GaInSn, forming dilute suspensions called nanofluids, which aimed to reduce the electric conductivity of the liquid metal. The nanoparticle weight fraction dependences of electric conductivity for GaInSn with fractions 0.05%, 0.1%, 0.2%, 0.5%, 1% were investigated and the electric conductivity measured from electrochemical workstation monotonically decreased with increasing nanoparticle fraction. The nanoparticle scale dependences of electric conductivity for GaInSn with particle nanometer scales 10nm, 20nm, 50nm, 100nm, 200nm were investigated and showed a weak relation. The best result we got was the case of 10nm with 0.5% weight fraction, where the electric conductivity was reduced by 4.25 times.

Based on this study, we evaluated the MHD pressure drop of typical liquid metal blankets such as DCLL and DFLL blanket, and the pressured drop was significantly reduced, which means that nano fluid technology was fit for liquid metal blankets. Further planning was scheduled for tritium breeder PbLi and Li.

Eligible for student paper award?

No

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