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Experimental study of cryogenic fluid flow in porous thermal insulation materials

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Porous thermal insulation materials, such as polyurethane foam, glass wool or glass fiber, have been widely used in the field of cryogenic storage and transportation systems. In situations where cracks or holes occur in the package wall layer, the stored cryogenic liquid will leak and penetrate into the porous media. The liquid evaporates and diffuses in the porous media and absorbs a large amount of latent heat of vaporization from the surroundings, which may even cause system damage. Therefore, in order to predict the influence caused by the leakage process on the cryogenic storage and transportation system, it is very important to investigate the fluid dynamics and diffusion characteristics of cryogenic fluid in porous media. In this study, an experimental se-up was built based on a typical kind of LNG cargo containment system to explore the cryogenic leakage behavior inside the porous thermal-insulation materials. The transient temperature and pressure fields were studied under different inlet conditions. The experimental results indicated that the transient temperature is greatly influenced by the inlet conditions and the properties of the fluids. As the liquid content at the inlet increases, the minimum temperature inside the porous media decreases. The lowest temperature of the hull plate reaches 78K in 30 minutes when liquid nitrogen is injected through a 4mm diameter hole at an inlet pressure of 0.04MPa. The pressure field is nonlinear in the glass wool, and the pressure drop is the largest in the entrance region.The results of this study are helpful in predicting the leakage problem and determining the leakage level that will occur during the operation of the containment system. .

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