Nanocomposites and nanomaterials

Overheated surfaces emergency cooling using the nanofluids

Moraru V.N.[1], Bondarenko B.I.[1], Sydorenko S.V.[1], Komysh D.V.[1], Khovavko A.I.[1], Gudkov N.N.[1]

[1] *Gas Institute of NAS of Ukraine. 39, Degtyarivska str., Kiev-03113, Ukraine.*
E-mail: ahova2005@ukr.net

The principled possibility of NFs use for emergency cooling of a superheated heat exchange surfaces was studied. For this it was created the automatic unit for simultaneous recording of NFs boiling curves and the changes of the main parameters of heat transfer (heat flux, heat transfer coefficient and temperature of the heating surface) in a real time at conditions of a constant rise of a velocity of specific heat load. The effectiveness of emergency cooling of a superheated heat transfer surface by NFs addition into boiling water in the case of boiling crisis was explored. Two NFs were created on the base of natural mixture of aluminium silicates of Ukrainian deposits (AlSi-7) and titanium dioxide (NF-8) with high thermal parameters and cooling performance were tested.

It was found that the introduction of small portions of NFs into a boiling coolant (distilled water) in a state of film boiling (t_{heater} > 500 ^{o}C) can dramatically reduce the temperature of a heat transfer surface to the level of 130-150^{o}C, which corresponds to the transition to a safe bubble boiling regime with no reduction in a heat flux. Thus it's very important that this mode continues long enough at a specific heat load exceeding the critical heat flux for water and at the t_{heater} = 125-130^{o}C. This makes it possible to prevent a potential accident (e.g., like LOCA – loss of coolant accident) resulting in a damage to the nuclear reactor vessel) and to ensure the uninterrupted operation of the equipment or perform the accident-free stoppage.

We have obtained the convincing evidence that increased heat transfer and cooling capability of NFs at their boiling in comparison with water is associated with the changing of a nature and microrelief of a heating surface due to the deposition of a structured layer of nanoparticles, providing the stable bubble boiling regime.

It is shown that the cooling of power equipment with the use of aluminosilicate NFs is a very real and cost-effective process because of their high thermal parameters and stability to the influence of radiation and multiple cycles of boiling-cooling, availability and environmental safety.

On the other hand it is known that many nuclear power plants with water cooling have limited power reserve till arising of a critical flux (CHF) and heat transfer crisis during boiling. Our research has shown that the use of NFs as a cooling agent not only allows to increase CHF on 100-200%, but also to avoid a sudden boiling crisis, in contrast to a single-phase coolant (water). It promises not

only for direct economic benefits, but also to increase the level of NPP safety in general.