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Effect on heat transfer of surface modifications caused by pool boiling using α-Al_2O_3-water nanofluid

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Abstract – The applicability of nanofluids containing nanoparticles to obtain an increase in the pool boiling heat transfer coefficient (h), the critical heat flux (CHF) and the heat surface wettability has been receiving considerable attention from many research groups, with conflicting results. The experimental setup consists of an environment with controlled temperature, atmospheric pressure and a test section consisting of a horizontal copper heated surface. The partial boiling curves were obtained for pure water and a water-based nanofluid, with an α-Al_2O_3 volume concentration of 1%. The effect of the nanofluid was a decrease in h and an increase in CHF.

This study addresses the intensification of the pool boiling heat transfer of nanofluids. In the tests a heated copper block with an end surface of 12 mm diameter was cooled by the subcooled pool boiling process using distilled water or a nanofluid (distilled water with the addition of 1% by volume of alumina nanoparticles).

To perform the experiment, three essential steps were followed: polishing and measuring the copper surface roughness; plotting the boiling curves of the polished surface tests; and analyzing the copper surface after running the tests. A sample of the preliminary results is shown in Figure 1, where four partial boiling curves are plotted: two for water and two for the α-Al_2O_3-water nanofluid, with subcooling degrees of 20°C (pool liquid at 80°C) and 70°C (pool liquid at 30°C). The results show that the subcooling effect for these test cases was negligible in the region of nucleate boiling and there was only a considerable variation in the Critical Heat Flux (CHF), in agreement with Carey [1].

The effect of the nanofluid was a decrease in the boiling heat transfer coefficient (h), as is shown by the shift in the nanofluid boiling curves to the right, in Fig. 1, and an increase in the CHF, although this value was obtained in our tests only for distilled water at 80°C. These results are similar to those reported by Bang and Chang [2] and Kim *et al*. [3]. A possible cause for the increase in the CHF is the change in the heated surface roughness, as reported in [4].

The high oxidation of the copper surface and a possible deposition of alumina on it increased the average roughness (Ra) from 0.08μm to 0.31μm. The optical microscopy analysis revealed a large increase in the depression points. Figures 2b and 2c show the pictures of the copper surface before and after the tests. In Fig. 2a a large accumulation of alumina on the external surface of the coil condenser and in the glass tube of the test chamber can be observed, preventing, initially, the use of alumina nanoparticles in heat pipes and microchannels.

As a continuation of this work, further investigations on the deposition of nanoparticles on heat surfaces are required, through analyzing the effect of copper-alumina diffusion under different conditions. It will then be necessary to repeat the tests and to further investigate the effective applications.

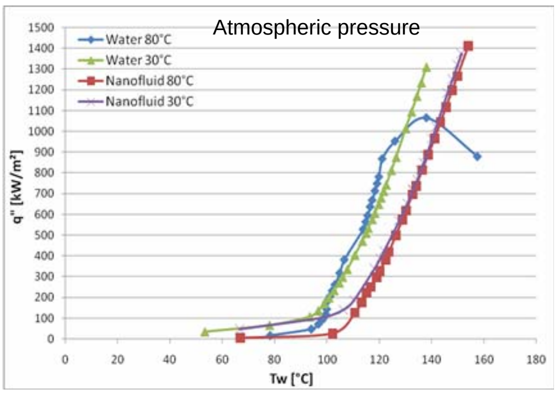

Figure 1: Partial boiling curves of water and Al_2O_3-water nanofluid

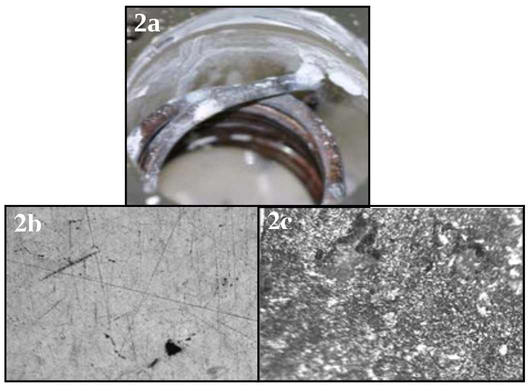

Figure 2: a) Condenser coil and glass tube after tests. Photomicrographs: **b)** Surface before tests (magnification: 100x) **c)** Surface after tests (magnification: 100x).

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